Walking Wounded or Living Dead? Making Banks Foreclose Bad Loans[*]

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Abstract

Because of limited liability, insolvent banks have an incentive to roll over bad loans, in order to hide losses and gamble for resurrection, even though this is socially inefficient. We suggest a scheme that regulators could use to solve this problem. The scheme would induce banks to reveal their bad loans, which can then be foreclosed. Bank participation in the scheme would be voluntary. Even though banks have private information on the quantity of bad loans on their balance sheet, the scheme avoids creating windfall gains for bank equity holders. In addition, some losses can be imposed on debt holders.

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1 Introduction

During the recent financial crisis, there was a concern that some banks could become "zombies" and continue to operate even though insolvent. One of the main risks with zombie banks is that they have an incentive to roll over bad loans rather than foreclose them, in order to hide their losses. This zombie lending is also referred to as evergreening, or forbearance lending.

In this paper we suggest a scheme that regulators could use to solve this problem, even when banks have private information on the quantity of bad loans on their balance sheet. The scheme does not grant rents to bank equity holders. Avoiding such rents is important not only in order not to distort incentives for banks ex-ante, but also because such rents can represent a substantial expense (as the recent experience in Ireland shows, bank bailout schemes can easily bankrupt a country). Importantly, we show how the fundamental features of the problem that can cause the zombie lending in the first place, namely limited liability of banks and the risk inherent in hanging on to bad loans, are precisely the features of the problem that allow the elimination of rents to equity holders. In addition, we discuss when losses can be imposed on debt holders, to further reduce the cost of the scheme.

To illustrate zombie lending, consider the following example: Suppose a bank has lent $100m to some borrowers, say, real estate developers, and all of these loans are due to be rolled over now. Also, the bank has to repay debt of $60m in a year's time. The bank then finds out that some of the real estate developers are insolvent now (maybe because a real estate bubble just burst) and will never be able to repay. Suppose that the options for dealing with an insolvent developer are as follows: The bank can either foreclose on the developer, and seize assets, e.g. undeveloped land, which at current real estate prices can be sold at 50 cents on the dollar. Or, the bank can roll over the loan of an insolvent developer for another year. In this case, since the bank knows that the developer will never be able to repay, the bank will end up foreclosing and seizing assets in a year's time. However, over the course of a year, real estate prices might move. Suppose that with probability .1, they go up such that the assets could be sold at 70 cents on the dollar, and with probability .9, they go down such that they could be sold at 30 cents on the dollar. In expectation, rolling over bad loan produces 34 cents on the dollar in a year's time, and therefore clearly destroys value. Would a bank ever roll over bad loans?

The answer is yes, if a large enough fraction of its borrowers is insolvent, and the *bank* is therefore sufficiently insolvent. For example, consider the (rather extreme) case in which *all* of the real estate developers are insolvent. If the bank forecloses on all of them, it gets 50% of $100m, which is insufficient to pay off the debt of $60m. The only way in which the

bank can survive is by rolling over bad loans, and hoping that real estate prices go up. In doing so, the bank deliberately exposes itself to real estate price risk in order to transfer value from debt holders to equity holders (or, if debt is insured implicitly or explicitly by the government, from the government to equity holders).[1] Conversely, if a small enough fraction of borrowers is insolvent, the bank will not have incentives to roll over bad loans, because this also destroys value.

There is formal evidence that such zombie lending took place in Japan during the 1990s. Consistent with our example, Peek and Rosengren (2005) show that insolvent firms were more likely to received additional credit. Also, it was precisely the more insolvent banks that provided this additional credit. Sekine, Kobayashi, and Saita (2003) show that this behavior was more prevalent in industries such as construction and real estate, in which a bubble had occurred. For firms in these industries, the larger their initial stock of debt, and the larger the amount of additional lending they received, the lower was their return on assets. In fact, throughout the 1990s, lending to the manufacturing industry declined substantially whereas lending to the real estate sector grew until 1997 even though this did not finance substantial new investment (see Hoshi (2000), as cited in Sekine, Kobayashi, and Saita (2003)).

The credit misallocation towards insolvent borrowers can have very bad economic consequences, as zombie firms that should go bankrupt are kept alive. Caballero, Hoshi, and Kashyap (2008) argue that zombie lending in Japan crowded out efficient entrants, causing the Japanese 'lost decade' of growth.

For the recent crisis, there is no formal analysis yet, but some anecdotal evidence. For example, in Spain, there is a concern that banks are not transparent about the number of bad loans on their books, and in fact are hiding them by rolling them over.[2] Similarly, in Ireland (arguably one of the worst hit countries), zombie banks are keeping alive zombie hotels in order to avoid crystallizing losses on loans to these hotels. This is causing major damage to the solvent competitors.[3]

The prevention of zombie lending should constitute an important goal of policy makers. Since the distortions arise when banks are insolvent, the obvious way to remove the distortions is to make banks solvent again. A general problem with schemes that restore

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[1]In fact, if the bank can increase the amount lent to insolvent borrowers, the bank should do so as a form of doubling up its bet.

[2]" Instead of disclosing troubled credit, many Spanish lenders have chosen to refinance loans that could still prove faulty and to report foreclosed or unsold homes as assets, often without posting their drop in market value." See "Zombie Buildings Shadow Spain's Economic Future," The Wall Street Journal, September 16, 2010.

[3]See "Zombie Hotels Arise in Ireland as Recession Empties Rooms," http://www.bloomberg.com, Aug 30, 2010.

solvency, however, is that it is often hard to know whether a given bank is part of the "walking wounded" (a bank that has taken a hit but is still fundamentally solvent) or the "living dead" (a bank that has taken a hit and is now insolvent), since a bank that is rolling over loans can always claim that the loans are good and that the borrowers will be able to repay.

When the extent of a bank's solvency problem is private information, bank equity holders may reap significant information rents from schemes aimed at restoring solvency. For example, if the regulator asks banks to reveal how insolvent they are, and then transfers an amount of money to all banks to make them just solvent, then it is likely that the "walking wounded" will claim to be "living dead" in order to receive higher transfers.

Alternatively, consider an asset buyback - a transaction in which a regulator sets up a special purpose vehicle which then buys bad assets from banks, typically at inflated prices so as to implicitly recapitalize them. In order for insolvent banks to part with the bad assets, the regulator has to pay more than fundamental value (in the above example, the insolvent bank implicitly values loans at 70 cents on the dollar, whereas the fundamental value is 50 cents on the dollar). Here, especially the "living dead" who have many bad assets to get rid of can benefit from the price above fundamental value.[4]

Such information rents for bank equity holders gains are politically problematic because the public can perceive them as a reward to banks that have taken unnecessary risks. In addition, they can distort ex-ante incentives of banks to screen borrowers properly. Lastly, they are socially costly because of the taxation necessary to finance them.

In this paper, we design a scheme that avoids these pitfalls. We consider a situation in which banks have private information on the quantity of bad loans on their balance sheet. Banks will choose to participate in the proposed scheme voluntarily, they will reveal their private information, remove or foreclose their bad loans, but will end up no better off than they would be in the absence of the scheme. That is, the scheme affords *no* information rents to bank equity holders.[5]

In our model, banks have good and bad loans on their balance sheet, but the proportion of each type of loan is private information. Good loans always generate a higher expected return than bad loans. Banks decide how many bad loans to foreclose. When banks foreclose a bad loan, they realize an immediate loss. When banks roll over a bad loan, this means

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[4]In fact, the asset buybacks proposed in the US during the financial crisis by the then Treasury Secretary Henry Paulson and the one implemented in Ireland have been critized for this reason. Prominent critics of the Irish scheme include Joseph Stiglitz, who stated that the transfer of wealth from the general population to the financial sector as implicit in the Irish scheme was something that frequently happened in "banana republics", see "Nama is highway robbery", Sunday Business Post, Oct 11, 2009.

[5]Although schemes with mandatory as opposed to voluntary participation (such as a full scale nationalizations of all banks) typically cost less and may pose less of a problem in their design, they are often politically infeasible. We therefore focus our attention on examining schemes with voluntary participation.

delaying the resolution of uncertainty about the loss on the loan. We assume that in expected net present value terms, foreclosing a bad loan produces a smaller loss than rolling it over. In the absence of a scheme, banks that have few bad loans foreclose all of their bad loans, and banks that have many bad loans foreclose none of them, and engage in zombie lending as a gamble for resurrection. As in the example above, this happens because of convexities introduced by limited liability.

In the simplest implementation of our scheme, the regulator offers banks a menu of two-part tariffs. In each tariff, a bank pays an initial flat fee to participate, and then receives a subsidy per unit of loans that it forecloses. Alternatively, our scheme can be interpreted as an asset buyback scheme, in which a bank pays an initial flat fee to participate, and then receives an associated price for each loan that it sells to a special purpose vehicle, which then forecloses it. The role of the subsidy (or the price in case of the asset buyback) is to induce foreclosure, and the role of the fee is to claw back (some or all of) the increase in equity value produced by the subsidy or price.

Naturally, one will want to structure the menu such that higher subsidies are associated with higher flat fees. When faced with this menu, banks with a higher proportion of bad loans will select contracts with a higher subsidy and a higher flat fee. This is because they have more bad loans to sell, and therefore care more about obtaining a higher subsidy (or price) for their loans.

We show that under such a scheme, banks have incentives both to *overstate* their proportion of bad loans and *understate* their proportion of bad loans. On the one hand, for a given positive subsidy, banks with a higher proportion of bad loans benefit more from that subsidy since they can collect it on each of their bad loans. A regulator could charge such banks a higher participation fee without discouraging them from participating. Banks therefore have an incentive to pretend to have a lower proportion of bad loans, in order to be charged a lower participation fee. On the other hand, banks with a higher proportion of bad loans are more insolvent and their limited liability put is more valuable. A regulator would have to charge such banks a lower participation fee to convince them to participate. Banks therefore also have an incentive to pretend to have a higher proportion of bad loans, in order to be charged a lower participation fee.

These *countervailing incentives* can be played off against each other to reduce information rents. In fact, in our model, the optimal contract can exactly balance these incentives. This means that the regulator can get banks to truthfully report the proportion of bad loans on their balance sheet, without having to bribe them with *any* information rents. We show that the properties of the model that make this exact balancing possible are the very same properties that lead to the gambling behaviour in the first place, namely, limited liability

and risk.

One concern is that if banks anticipate that a scheme will be implemented, this might give them weaker incentives to screen their borrowers properly going forward. This is not the case with our proposed scheme, precisely because we eliminate information rents. For any arbitrary proportion of bad loans, the value of equity under our scheme is exactly equal to the value of equity in the absence of intervention. This means that under our scheme, banks have incentives to be as careful in screening borrowers as in the absence of intervention. Note that this is not always the case for alternative schemes. Consider, for example, a naive implementation of an asset buyback (with a single price and no participation fee). In that case, larger information rents are paid to banks with a larger proportion of bad loans. If those rents are anticipated, banks will have less incentives to screen borrowers carefully ex-ante.

In the baseline version of our scheme, debt that is initially risky becomes risk-free for the participating banks. This implies that debt holders benefit from the scheme, even when equity holders do not. This implicit rent to debt holders increases the cost of the scheme. With a slightly modified version of the scheme, we illustrate that whether or not debt holders can be made to accept losses is likely to depend on the ability of the regulator to commit to punishing debtholders who do not accept losses, by not bailing out their banks. If the regulator can commit, the cost of the scheme can actually become negative because the regulator can appropriate the increase in value generated from stopping banks from gambling. If the regulator cannot commit at all, the losses that can be imposed on debt holders are limited by what the regulator does when debt holders do not accept losses. For instance, debt holders could be made to accept losses if the regulator is unable to bail out a large number of banks in the absence of concessions. Essentially, an inability to fund large bailouts can create a form of commitment.

Also, in the baseline version of our model, the benefit of getting banks to foreclose stems from preventing the destruction of net present value associated with rolling over bad loans, and the costs are simply the transfers necessary to get a given bank to foreclose. We show that in this case it is optimal to bail out only the less insolvent banks. Alternatively, one might, for example, consider a situation in which bank failure per se produces a social cost, or a situation in which debt has already been insured by the government (e.g. in the form of deposit insurance), or a situation in which rolling over bad loans keeps zombie firms alive which crowd out more efficient entrants (as in Caballero, Hoshi, and Kashyap, 2008). We study these variations and show that although they may change the set of banks that a regulator would optimally bail out, a version of our scheme can always be used to completely eliminate the information rents to equity holders.

We finish by touching upon some additional potential issues that might arise when im-

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plementing this type of scheme in practice, in an informal discussion.

Related literature   There is a growing literature of papers that are are motivated by the recent crisis and apply ideas from mechanism design to the problem bailing out insolvent banks. For example, Philippon and Schnabl (2009) consider a debt overhang problem. In their setting, banks differ and have private information across two dimensions: the probability of a high-payoff state of their in-place assets, and the value of their new investment opportunities. They emphasize heterogeneity along the second dimension. In the optimal intervention, banks sell warrants because the willingness to part with warrants can reveal information about the value of new investment opportunities. In contrast, we emphasize heterogeneity in the quantity of bad loans. In our optimal intervention, the willingness of banks to part with a given quantity of loans can reveal information about the quantity of bad loans on the bank's balance sheet.

Bhattacharya and Nyborg (2010) also consider a debt overhang problem. They generalize the setting of Philippon and Schnabl (2009) by considering a situation in which banks not only differ in the probability of the high-payoff state of their in-place assets, but also in the size of the payoff in the low-payoff state, in a way such that in-place assets of different banks can be ranked in a first-order stochastic dominance sense. They then show that a menu of equity injections can separate the banks, and that if a monotonicity condition on payoffs and probabilities is satisfied, information rents can be eliminated.[6]

It turns out that in our setup, the counterpart of their monotonicity condition is naturally satisfied, due to the limited liability assumption, and the assumption that rolling over bad loans delays the resolution of uncertainty. These are, of course, precisely the two assumptions needed to produce the gambling for resurrection behavior. We prefer to couch the argument in terms of *countervailing incentives* so as to make explicit the link to the wider mechanism design literature.

Philippon and Skreta (2010), Tirole (2010), and House and Masatlioglu (2010) consider a situation in which the main problem is one of adverse selection in markets relevant for the funding of banks. Via some scheme, the regulator provides an alternative source of funds. Here, the participation decisions of banks affect which banks will remain funded by the market, and consequently the degree of adverse selection in this market. Since the market for funding is the outside option of all banks, their participation constraint in the scheme becomes endogenous. The optimal scheme needs to take this into account. Although this is an interesting issue, we abstract from such problems here to focus on our core message.

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[6]They also argue that in their base case, equity injections and asset buybacks are equivalent. This is because each bank only has a single type of asset; giving up some units of the asset or giving up equity in a bank that owns only this asset are, in that case, essentially the same thing.

There is also a literature that views asset buybacks as a solution to the problem of fire-sale discounts. For example, Diamond and Rajan (2009) argue that in a situation in which banks can be hit by liquidity shocks that force them to sell assets at a fire-sale discount, and current private buyers anticipate the potential future fire-sale discount, the regulator can ensure bank liquidity in the future by buying assets now, at prices above those that current private buyers are willing to pay, but below the fundamental value of the asset. In the same spirit, but in a general equilibrium setting, Gorton and Huang (2004) show that it can be more efficient for the government rather than the private sector to provide liquidity by buying up bank assets. In the context of providing liquidity via asset purchases, some work has also been done on how to design auctions to ensure that the regulator does not overpay for the assets that it is buying.[7]

In contrast, in our model, asset buybacks are a solution to the problem of inefficient gambling for resurrection by banks. Since distressed banks want to gamble, anyone attempting to buy a bad asset will necessarily have to pay more than fundamental value in order for such a bank to part with the bad asset. As we show, overpaying for the bad asset does not necessarily imply windfall gains for bank equity holders.

Many papers, including those of Mitchell (1998), Corbett and Mitchell (2000), and Mitchell (2001) examine models in which the proportion of bad debt on a bank's balance sheet is private information and bank managers can hide bad loans via rolling them over. In the same type of setting, Aghion, Bolton, and Fries (1999) argue that there is a tradeoff between having "tough" closure policies for banks, which gives incentives to hide problems ex-post but provides incentives not to take risks ex-ante, and having "soft" closure policies for banks, which does not give incentives to hide problems ex-post, but provides incentives to take risks ex-ante. Although not the main focus of their paper, they also sketch a second-best scheme that involves transfers conditional on the liquidation of non-performing loans.

Our paper is also related to the general mechanism design literature. The two-part tariff implementation of our optimal contract turns out to be mathematically similar to the original problem of Baron and Myerson (1982), except that we have a type-dependent outside option. This creates what Lewis and Sappington (1989) referred to as "countervailing incentives". In our case, though, the type-dependent outside option is not concave but convex in types, due to the convexity introduced by limited liability, which means that information rents can be eliminated as in Maggi and Rodríguez-Clare (1995) or Jullien (2000).

In Section 2, the basic model is set up. In section 3, we examine the optimal contract: In order to provide intuition, we first derive the optimal menu of two-part tariffs, and later show that this implements the solution of the more general contracting problem. Section 4

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[7]See, for example, the schemes proposed by Ausubel and Cramton (2008) or Klemperer (2010).

examines to what extent different implementations of the optimal contract are robust to a situation in which banks can foreclose good loans in order to obtain higher transfers. Section 5 studies under which conditions losses can be imposed on debt holders. Section 6 studies other social welfare functions. Section 7 informally discusses some additional issues that could arise when trying to implement a scheme of this type in practice. Section 8 concludes. All proofs are in the appendix.

2   The model

Consider an economy with two dates $t = 1, 2$. There is no discounting across periods. There exists a continuum of risk-neutral banks, that operate under limited liability and maximize the expected value of their equity. All banks have debt with face value D, where $0 < D < 1$. The face value of debt is due to be paid at $t = 2$. All banks have a measure 1 of loans. Loans can be either good or bad. At date $t = 1$, each bank learns what proportion θ of its loans are bad loans, and what proportion $1 - \theta$ of its loans are good loans. The proportion θ varies across banks and is private information. The distribution of θ in the population of banks is denoted as $\Psi(\theta)$ with density $\psi(\theta)$.

At $t = 1$, after learning θ, banks can decide what amount γ of bad loans they want to foreclose, where $\gamma \in [0, \theta]$. The remaining bad loans, an amount $\theta - \gamma$, is rolled over. Any loan that is foreclosed at $t = 1$ produces a recovery of ρ. We assume that the bank cannot pay dividends at $t = 1$ such that the proceeds from foreclosure are carried forward until $t = 2$.

At $t = 2$, any good loan pays off 1. Bad loans that were not foreclosed but instead rolled over at $t = 1$ are foreclosed now, producing a random recovery of ε. The realization of ε is the same for all such loans of a given bank. The distribution of ε has full support in $[0, 1]$ and is denoted by $\Phi(\varepsilon)$, and its density by $\phi(\varepsilon)$. We assume that $E[\varepsilon] < \rho$, such that foreclosure maximizes net present value.[8]

In the next section, we will also introduce a risk-neutral regulator that aims to influence the foreclosure decisions of banks. To afford an information advantage to banks vis-a-vis the regulator, we assume that a bank knows its θ whereas the regulator only knows the distribution of θ in the population. Furthermore, the regulator will neither observe the value of assets of a bank at $t = 2$, nor the realization of ε. This means that the regulator will also not be able to indirectly infer the proportion of bad loans on a bank's balance sheet. We will assume, though, that the amount of bad loans being foreclosed, γ, is observable and

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[8]This ordering can plausibly arise, for example, if "bad loans" are loans to firms that themselves have incentives to destroy value by gambling for resurrection.

verifiable, and focus on contracts in which banks foreclose an amount γ in exchange for a transfer T that may or may not depend on γ. This includes, for example, contracts that pay a subsidy per foreclosed loan, or a buyback scheme in which the regulator sets up a special purpose vehicle that buys bad loans from a bank and then forecloses.

If in the second period the realized ε is sufficiently low, a bank will not be able to repay its existing debt. A bank that chooses to foreclose an amount of bad loans γ will survive if

$$1 - \theta + (\theta - \gamma)\varepsilon + \gamma\rho > D.$$

That is, a bank will survive if it can repay D in full with the return of the good loans together with the return from bad loans that have been rolled over – which depends on the realized ε – and the return from the foreclosed loans. In other words, the bank will be able to repay D as long as the realized ε is sufficiently high, or if

$$\varepsilon \geq \bar{\varepsilon}_0 \equiv \frac{\theta - \gamma\rho - (1 - D)}{\theta - \gamma}. \tag{1}$$

As expected, a lower proportion of bad loans, a lower debt level, and a higher recovery upon foreclosure will increase the probability that the bank survives.

We can now write the expected value of equity of a bank that holds bad loans θ as

$$\int_{\bar{\varepsilon}_0}^{1} \left(1 - \theta + (\theta - \gamma)\varepsilon + \gamma\rho - D\right)\phi(\varepsilon)d\varepsilon. \tag{2}$$

As it turns out, the value of equity is convex in γ due to the bank's limited liability. It implies that banks are interested in either foreclosing all bad loans or none. In particular, banks with few bad loans foreclose all bad loans ($\gamma = \theta$), and banks with many bad loans foreclose no bad loans ($\gamma = 0$). The intuition for this result is straightforward. Banks that are likely to survive (low θ) have a valuation of rolled-over bad loans that is close to their true expected value, and hence prefer to foreclose. Banks that are not very likely to survive (high θ) have a valuation of rolled-over bad loans that only reflects their large positive returns in the state in which they survive, and hence do not foreclose. This is the typical gambling for resurrection behavior, and we will therefore refer to the banks that roll over their bad loans (do not foreclose) as *gambling banks*. We denote as $\hat{\theta}$ the critical value of θ above which banks will gamble. The "walking wounded" here are the banks with $\theta < \hat{\theta}$ who have incentives to foreclose, whereas the "living dead" are the banks with $\theta > \hat{\theta}$ who have incentives to gamble.

Below, we let

$$\pi_0^G(\theta) = \int_{1-(1-D)/\theta}^{1} (1 - \theta + \theta\varepsilon - D)\phi(\varepsilon)d\varepsilon \tag{3}$$

denote the value of equity when gambling ($\gamma = 0$, and hence $\bar{\varepsilon}_0 = 1 - (1 - D)/\theta$), and

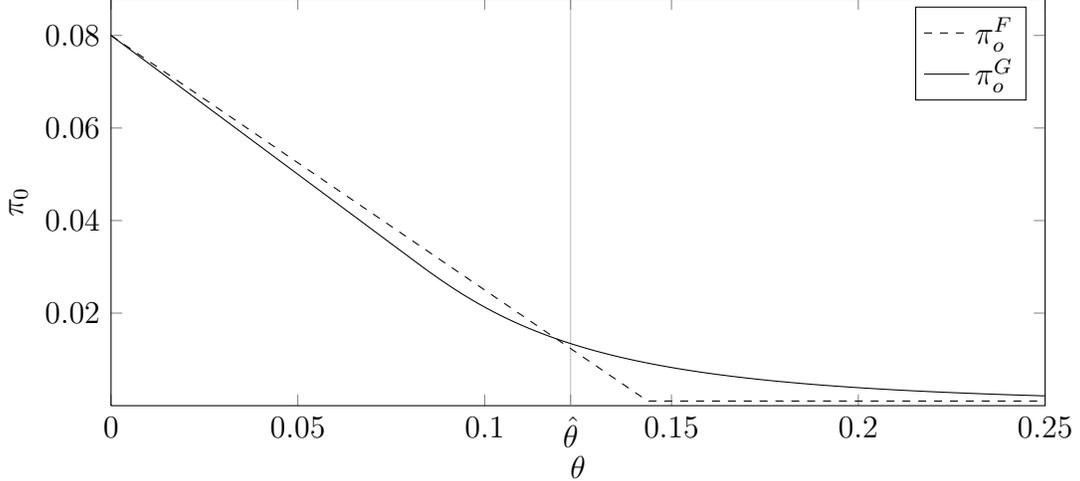$$\pi_0^F(\theta) = \max(1 - \theta + \theta\rho - D, 0) \tag{4}$$

Figure 1: Equity value as a function of θ
Equity values for banks as a function of θ when banks foreclose (dashed line, $\pi_0^F(\theta)$), and when banks gamble (solid line, $\pi_0^G(\theta)$). Banks choose whichever is higher. Banks with $\theta > \hat{\theta}$ gamble, and banks with $\theta < \hat{\theta}$ foreclose. Parameters are $1 - D = 0.08$, $\rho = 0.45$, and $\varepsilon \sim \text{Beta}(2,3)$, which implies $E[\varepsilon] = 0.40$.

denote the value of equity when foreclosing ($\gamma = \theta$). In terms of $\pi_0^G(\theta)$ and $\pi_0^F(\theta)$, the value of equity, taking into account that banks will choose γ optimally, can then be written as

$$\pi_0(\theta) = \max(\pi_0^G(\theta), \pi_0^F(\theta)). \tag{5}$$

Figure 1 illustrates this discussion, and Lemma 1 summarizes it formally.

Lemma 1. *The value of equity is convex in γ. As a consequence, a bank with a proportion of bad loans θ will decide to foreclose an amount $\gamma(\theta)$ given by*

$$\gamma(\theta) = \begin{cases} \theta & \text{if } \theta \leq \hat{\theta}, \\ 0 & \text{if } \theta > \hat{\theta}, \end{cases}$$

where $\hat{\theta}$ is defined as the value of $\theta > 0$ that solves

$$\pi_0^F(\theta) = \pi_0^G(\theta).$$

Note that in our basic setup, we do not allow banks to foreclose good loans. For the discussion of the case where this is possible, please see Section 4.

3 The regulator's scheme

In the model described in the previous section, banks with a large proportion of bad loans — the "living dead"— have insufficient incentives to foreclose, even though rolling over destroys

net present value. This destruction of net present value is socially suboptimal. Could Coasian bargaining between private parties without the involment of the regulator solve the gambling problem by a reorganization of the capital structure (Haugen and Senbet, 1978)? Here, the fact that equity holders have private information can mean that such negotiations might not take place, as in Giammarino (1989). In addition, it is reasonable to believe that banks would have incentives ex-ante to choose debt structures which would make such ex-post bargaining impossible, as argued by Bolton and Scharfstein (1996). That is, even though in the baseline model there are no externalities, it is plausible to assume that private parties would not solve the gambling problem ex-ante or ex-post. Also, there are many versions of the model that could be formulated in which the gambling produces an externality beyond the bank, e.g. the crowding out effects proposed by Caballero, Hoshi, and Kashyap (2008), which private parties would never internalize, see Section 6. Here, however, we stick to the baseline model to simplify the exposition, and consider interventions by the regulator aimed only at aligning the incentives of "living dead" with the interests of the claim holders of the bank.

In this section, we first state the general optimal contracting problem that the regulator faces (Subsection 3.1). The solution to this optimal contracting problem will involve asking participating banks to foreclose all of their bad loans, and paying a transfer that makes them just indifferent between participating or not, such that there are no information rents. In order to make it easier to provide some intuition for why it is possible to eliminate information rents, we will initially restrict ourselves to a specific class of contracts, namely, two-part tariffs, which consist of a subsidy per foreclosed loan and a participation fee (or a price paid per loan transferred to a special purpose vehicle, and a participation fee), and derive the optimal contract within that class (Subsection 3.2). We then show that, in fact, the optimal two-part tariff implements the optimal contract for the general problem (Subsection 3.3).

3.1 The regulator's problem

We have assumed that the amount foreclosed by a bank, γ, is observable and verifiable. This allows the regulator to transfer resources to the bank contingent on this variable, $T(\gamma)$. As usual, given the private information on θ, it is more convenient to consider direct revelation mechanisms under which a bank of type θ truthfully reports its type, and is then assigned a contract under which it forecloses an amount $\gamma(\theta)$, and in return receives a transfer $T(\theta)$ at $t = 2$.[9]

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[9]We restrict ourselves to deterministic mechanisms. From a purely technical point of view, stochastic mechanisms that improve welfare exist, but they are very implausible.

Banks facing a menu of contracts will choose the one that maximizes the value of their equity. We will denote the value of equity of a participating bank of type θ that reports type θ^R as $\Pi(\theta, \theta^R)$, given by

$$\Pi(\theta, \theta^R) = \int_{\bar{\varepsilon}}^{1} \left[1 - \theta + \left(\theta - \gamma(\theta^R) \right) \varepsilon + \gamma(\theta^R)\rho - D + T(\theta^R) \right] \phi(\varepsilon)d\varepsilon, \tag{6}$$

where

$$\bar{\varepsilon} = \frac{\theta - \gamma(\theta^R)\rho - (1 - D) - T(\theta^R)}{\theta - \gamma(\theta^R)}. \tag{7}$$

Since we consider schemes with voluntary participation, the net transfer $T(\theta)$ for a bank of type θ will have to be non-negative for that bank to participate, and might have to be positive for that bank to foreclose. This implies that, in general, the scheme will not be costless. We assume that each dollar that the regulator transfers to a bank generates an associated dead-weight loss $\lambda > 0$. This loss arises, for example, if in order to finance this scheme the government needs to rely on distortionary taxation. Thus, for a given amount of foreclosed loans, the regulator will be interested in minimizing the cost of the rescue scheme.

We can then state the formal problem as follows:

$$\max_{\gamma(\theta),T(\theta)} \int_{0}^{1} \left[1 - \theta + \theta E[\varepsilon] + (\rho - E[\varepsilon])\gamma(\theta) - \lambda T(\theta) \right] \psi(\theta)d\theta, \tag{W}$$

subject to

$$\Pi(\theta, \theta) \geq \Pi(\theta, \theta^R), \quad \forall \theta, \theta^R \tag{IC}$$

$$\Pi(\theta, \theta) \geq \pi_0(\theta), \quad \forall \theta. \tag{PC}$$

$$\text{and} \quad 0 \leq \gamma(\theta) \leq \theta, \quad T(\theta) \geq 0.$$

These equations can be interpreted as follows. The objective function, (W), states that the regulator chooses the schedules $\gamma(\theta)$ and $T(\theta)$ to maximize expected welfare. The contribution of a given bank to welfare corresponds to the total value of its assets, which will be divided between its equity holders and debt holders at $t = 2$, net of the deadweight loss associated with the transfers it receives. The total value of the bank's assets are maximized when it forecloses. The main trade-off here is therefore between inducing foreclosure in order to maximize the value of assets, versus the deadweight loss associated with the transfers that induce foreclosure. In Section 6, we consider alternative social welfare functions that take into account other social benefits and costs of foreclosure.

The menu of contracts that the regulator offers has to induce banks to truthfully report their type, producing the incentive compatibility constraint, (IC). It also has to lead to

at least the same value of equity as when not participating, producing the participation constraint (PC).

As described in the introduction, the optimal contract here will involve asking participating banks to foreclose all of their bad loans, and making transfers such that these banks are just indifferent between participating and not participating (such that information rents are zero). Although it is possible to directly show that this is the solution to the problem, it is illustrative to initially solve for the optimal scheme within a specific class of contracts, namely two-part tariffs. This will allow us to highlight the features of the problem that make the complete elimination of information rents possible, and along the way, provide some intuition. For ease of exposition, we will initially only focus on the "foreclosure subsidy" version of the two-part tariff mentioned in the introduction.

3.2   A menu of two-part tariffs

Consider the following alternative scheme: Suppose the regulator offers a menu of two-part tariffs, where each two-part tariff consists of (i) a (positive) subsidy s that the bank receives per loan that it forecloses, and (ii) a (positive) participation fee F that the bank promises to pay. Banks do not have to commit to foreclosing a specific amount, and can privately choose the amount of loans they want to foreclose. In this scheme, the role of the subsidy will be to induce banks to foreclose, and the role of the fee will be to claw back (some or all of) the increase in the value of equity of a bank that is derived from the subsidy.

As before, it is more convenient to consider direct revelation mechanisms under which a bank with type θ is meant to truthfully report its type and then receive the contract $(s(\theta), F(\theta))$. According to this notation, a bank that reports a type θ^R accepts to pay a fixed fee $F(\theta^R)$ in return for a subsidy $s(\theta^R)$ per foreclosed loan and, thus, receives a net transfer $T(\gamma) = s(\theta^R)\gamma - F(\theta^R)$, that indirectly depends on the amount γ that the bank chooses to foreclose under the tariff.

Consider a "living dead" bank, that is a bank with a proportion of bad loans $\theta > \hat{\theta}$, that decides to participate in the scheme and picks the contract indexed by θ^R, and that subsequently forecloses a share γ of bad loans. In that case, the counterpart of the expected value of equity (6) under this scheme is

$$\max_{\gamma} \int_{\bar{\varepsilon}(\gamma)}^{1} \left[1 - \theta + (\theta - \gamma)\varepsilon + \gamma(\rho + s(\theta^R)) - D - F(\theta^R)\right] \phi(\varepsilon)d\varepsilon, \tag{8}$$

where

$$\bar{\varepsilon}(\gamma) = \frac{\theta - \gamma(\rho + s(\theta^R)) - (1 - D - F(\theta^R))}{\theta - \gamma}.$$

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As before, it is easy to see that the value of equity is convex in γ leading to a corner solution. Under the scheme the bank will either foreclose all of its bad loans ($\gamma = \theta$) or not foreclose any ($\gamma = 0$).

In addition, it is easy to see that a bank will never want to participate just to pay a positive fee, and not receive any subsidy in return. Thus, a participating bank that pays the fee will necessarily always plan to foreclose some bad loans. But because of the convexity, we know that any participating bank will in fact want to foreclose *all* bad loans.[10] Also, since it can always get a positive equity value by not participating, the value of equity from participating must always be positive.

This allows us to considerably simplify the expression for the value of equity from participating. For a bank of type θ that picks the contract indexed by θ^R, this is

$$\Pi(\theta, \theta^R) = 1 - \theta + (\rho + s(\theta^R))\theta - D - F(\theta^R). \tag{9}$$

The participation constraint (PC) and the incentive compatibility constraint (IC) for the two-part tariff case can now be stated in terms of this expression.

In the rest of our discussion, it will be convenient to denote as $U(\theta)$ the increase in the value of equity that a bank obtains when it participates and chooses the contract intended for its type, over the value of equity when it does not participate. That is,

$$U(\theta) \equiv \Pi(\theta, \theta) - \pi_0(\theta). \tag{10}$$

This expression can be interpreted as the information rents that a bank obtains from participating in the scheme. Obviously, for a bank with type θ to participate, $U(\theta) \geq 0$.

Inserting the expression for $\Pi(\theta, \theta)$ we can also express the information rents as

$$U(\theta) = \underbrace{s(\theta)\theta - F(\theta)}_{T(\theta)} - \underbrace{(\pi_0(\theta) - (1 - \theta + \theta\rho - D))}_{\Delta\pi_0(\theta)}. \tag{11}$$

In words, this states that the information rents of a bank with type θ will consist of the net transfer it receives, minus the decrease in the value of equity associated with taking now the privately non-optimal action, foreclosing. Below, we will refer to $\Delta\pi_0(\theta)$ as the *loss from foreclosing*. Notice that in the expression for $\Delta\pi_0(\theta)$, the part $1 - \theta + \theta\rho - D$ may be negative. For a bank that has a value of total assets when foreclosing $1 - \theta + \theta\rho$ less than the face value of debt D, any transfer made to the bank needs to be used to satisfy the claim of debt holders first, before any remainder can go to equity holders. (Of course, unless this remainder is positive, equity holders will not in general want to participate in the scheme.)

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[10]For a formal proof, see Lemma A1 in Appendix A.

The loss from foreclosing plays an important role below because it indicates a critical size of the net transfer: When the net transfer is equal to the loss from foreclosing, banks are exactly as well off when participating as when not participating. From the definition of $\Delta\pi_0(\theta)$ (see also the definition of $\pi_0(\theta)$ in (3), (4), and (5)), it is easy to see that the loss from foreclosing is zero for the walking wounded (for whom $\theta < \hat{\theta}$), and positive, increasing and convex in θ for the "living dead" (for whom $\theta > \hat{\theta}$), since by limited liability, $\pi_0^G(\theta)$ is convex and bounded below by 0, whereas the second term decreases linearly.

We can now state necessary and sufficient conditions for incentive compatibility to hold locally and globally, in terms of the information rents.

Lemma 2. *Necessary and sufficient conditions for a two-part tariff scheme* $\{s(\theta), F(\theta)\}$ *to be incentive compatible are*

   i) monotonicity: $s(\theta)$ *is non-decreasing,*
   ii) local optimality:
$$\frac{dU(\theta)}{d\theta} = s(\theta) - \frac{d\Delta\pi_0(\theta)}{d\theta}. \tag{12}$$

The proof for these conditions, although sketched in the appendix for completeness, is standard. The first part of Lemma 2 can be interpreted as stating that banks with more bad loans should receive higher subsidies under an implementable scheme. Intuitively, banks with more bad loans care more about the size of the subsidy, and hence in any incentive compatible scheme they will need to receive higher subsidies. Of course, the higher subsidies will have to be associated with higher fees. Under a scheme that provides a higher subsidy against payment of a higher fee, banks with a low proportion of bad loans will then choose to pay a low fee and receive a low subsidy, whereas banks with a high proportion of bad loans will choose to pay a high fee and receive a high subsidy.

The second part of Lemma 2 can be interpreted as stating that to induce truth-telling, the regulator has to provide information rents that vary with the proportion of bad loans θ. The two components of the expression reflect two *countervailing incentives* that banks face, to both overstate as well as understate their type, which change with θ, as we now describe.

First, suppose the loss from foreclosing $\Delta\pi_0(\theta)$ was constant, such that the second term in (12) would be zero for all θ. Then, since the subsidy $s(\theta)$ must be positive, information rents $U(\theta)$ would have to be higher for banks with higher θ. This is because banks with high θ would otherwise understate their type, to pretend that they benefit less from the positive subsidy and in this way manage to pay a lower fee to the regulator. This incentive to understate is stronger the larger is $s(\theta)$.

Second, suppose the subsidy $s(\theta)$ were zero for all θ. Then, since the loss from foreclosing $\Delta\pi_0(\theta)$, is increasing in θ (for $\theta > \hat{\theta}$), information rents $U(\theta)$ would have to be higher for

banks with lower θ. This is because banks with low θ would otherwise overstate their type, to pretend that they are incurring larger losses from foreclosing and in this way manage to pay a lower fee to the regulator. This incentive to overstate is larger the larger is $\frac{d\Delta\pi_0(\theta)}{d\theta}$.

The incentives to overstate and understate are in conflict, of course. A regulator that is interested in minimizing the cost of the scheme can pick $s(\theta)$ to play off the incentives for banks to overstate against the incentives to understate, in order to reduce information rents, subject to the constraints that $s(\theta)$ needs to be increasing, and $U(\theta)$ cannot be negative.

Since $d\Delta\pi_0(\theta)/d\theta$ is an non-decreasing function of θ we can pick an non-decreasing function $s(\theta)$ so that the incentives to understate and overstate exactly cancel out, and leave information rents constant. In order to minimize information rents, the regulator can then set the constant level as $U(\theta) = 0$.[11]

The following proposition describes the optimal menu of contracts that results from the previous discussion and satisfies the necessary and sufficient conditions for incentive compatibility of Lemma 2, as well as the participation constraint $U(\theta) \geq 0$:

Proposition 1. *Consider the menu of two-part tariffs* $\{s^*(\theta), F^*(\theta)\}$, *where*

$$s^*(\theta) = \frac{d\Delta\pi_0(\theta)}{d\theta}, \tag{13}$$

$$F^*(\theta) = -\Delta\pi_0(\theta) + \theta s^*(\theta). \tag{14}$$

Under this menu, any bank with a proportion of bad loans θ *will choose the corresponding contract* $(s^*(\theta), F^*(\theta))$, *foreclose the amount* $\gamma = \theta$, *satisfy its incentive compatibility constraint, and satisfy its participation constraint with strict equality.*

What are the fundamental features of the model that make this two-part tariff scheme work? The scheme works because the difference in the values of equity when gambling and not gambling is *convex* in θ, which means that a scheme that pays higher subsidies to banks with more bad loans can play off the incentives to overstate and understate such that they exactly cancel out.[12] This convexity in turn is produced by limited liability and the fact that rolling over bad loans delays the resolution of uncertainty. Since these were the two features that led to the gambling behavior in the first place, it is therefore likely that in *any* model in which banks gamble for resurrection because of limited liability, countervailing incentives will allow the regulator to eliminate (or substantially reduce) the information rents.

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[11]This is a special case of the argument of Maggi and Rodríguez-Clare (1995) who point out that, in general, decreasing convex outside opportunities can lead to optimal contracts that eliminate information rents for a range of agents. Remarkably, in our model this property holds globally due to the convexity of the value of equity in γ.

[12]Note that this menu includes banks with $\theta < \hat{\theta}$, for which $\Delta\pi_0(\theta) = 0$ and hence $s^*(\theta) = 0$ and $F^*(\theta) = 0$.

3.3 The general solution to the regulator's problem

The two-part tariff scheme suggests a candidate solution for the general problem of $\gamma^*(\theta) = \theta$, and $T^*(\theta) = \Delta\pi_0(\theta)$. With this candidate solution, the benefit from getting a bank with type θ to foreclose is maximized, since it forecloses the maximum amount of bad loans, $\gamma^*(\theta) = \theta$. Similarly, subject to the participation constraint, the cost of getting that bank to foreclose is always minimized, since $T^*(\theta) = \Delta\pi_0(\theta)$ just covers the participation constraint.

Below, we will state the optimal contract, using this candidate solution. Before we do so, we define some terminology: we say that a bank *participates* if it receives a positive transfer and is induced to foreclose — the next lemma then shows that the regulator is not constrained by incentive compatibility when choosing which set of banks shall *participate*.

Lemma 3. *Let $\Theta_P \subseteq [\hat{\theta}, 1]$ denote an arbitrary set of* participating *banks. Then consider the contract*

$$\gamma^*(\theta) = \begin{cases} \theta & \text{for } \theta \in \Theta_F \\ 0 & \text{for } \theta \notin \Theta_F \end{cases}, \quad T^*(\theta) = \begin{cases} \Delta\pi_0(\theta) & \text{for } \theta \in \Theta_P \\ 0 & \text{for } \theta \notin \Theta_P \end{cases}, \tag{15}$$

where $\Theta_F = \{\theta : (\theta < \hat{\theta}) \cup (\theta \in \Theta_P)\}$ denotes the set of banks that foreclose. Under this contract, the incentive compatibility constraint (IC) *is satisfied for all banks, and the participation constraint* (PC) *is satisfied for all banks with equality.*

It is obvious that this contract satisfies the participation constraint (with equality): Banks either take their privately optimal action and receive zero transfer, or foreclose and receive a positive transfer that makes them just indifferent between participating and not participating. To see that the contract is incentive compatible, consider the situation in which we offer the full foreclosure subsidy menu for all banks as described in Proposition 1, for example with a set of participating banks $\Theta_P = [\hat{\theta}, 1]$. We know that this contract is incentive compatible, and leaves all banks at their participation constraint. If we now delete points on the menu corresponding to some $\theta \in \Theta_P$, the banks whose point on the menu has been deleted will now prefer not to participate: By incentive compatibility of the full menu and the fact that the full menu satisfied the participation constraint with equality, they cannot obtain a higher value than their non-participation value by picking a point on the reduced menu not intended for them. Hence the reduced menu is still incentive compatible, and again leaves all banks at their participation constraints.

We now turn to the optimal contract for the social welfare function postulated above. Since $\Delta\pi_0(\theta)$ is increasing and strictly convex in θ for banks with $\theta > \hat{\theta}$ that gamble, it is possible that the social cost $\lambda T(\theta)$ of getting a bank with a large proportion of bad loans θ to foreclose is larger than the benefit $(\rho - E[\varepsilon])\theta$, which is increasing and linear in θ. This

suggests that there will be an upper limit, that we denote as θ^*, of the proportion of bad loans for which banks should be made to foreclose.

Proposition 2. *The optimal contract* $\{\gamma^*(\theta), T^*(\theta)\}$ *that solves* (W) *subject to* (IC) *and* (PC) *is given by*

$$\gamma^*(\theta) = \begin{cases} \theta & for \ \theta \in \Theta_F \\ 0 & for \ \theta \notin \Theta_F \end{cases}, \quad T^*(\theta) = \begin{cases} \Delta\pi_0(\theta) & for \ \theta \in \Theta_P \\ 0 & for \ \theta \notin \Theta_P \end{cases}, \tag{16}$$

where $\Theta_P = [\hat{\theta}, \theta^*]$ *denotes the set of banks that optimally participate and* $\Theta_F = \{\theta : (\theta < \hat{\theta}) \cup (\theta \in \Theta_P)\}$ *denotes the set of banks that foreclose. Here,* θ^* *solves*

$$(\rho - E[\varepsilon])\theta^* \equiv \lambda\Delta\pi_0(\theta^*) \ and \ \theta^* \geq \hat{\theta}. \tag{17}$$

Given Lemma 3, it is clear that this contract grants no information rents, and is incentive compatible. It also obviously maximizes (W) subject to (PC). There are two types of banks that do not participate: the "walking wounded" (with $\theta \leq \hat{\theta}$), who foreclose all of their bad loans anyway and hence need not receive a transfer, and some of the "living dead" with a very large proportion of bad loans (with $\theta > \theta^*$), for whom the required transfer would be too costly. As expected, an increase in the cost of public funds λ results in a smaller set of banks that participate.

The result regarding which banks optimally participate may change with other specifications of the welfare function. If, for example, bank failures generate a significant externality, the optimal contract could also prescribe that banks with very large proportions of bad loans θ should participate. We discuss this and other cases in Section 6. In general, in these situations, information rents can still be eliminated, as indicated by Lemma 3.

Finally, it is also useful to discuss the implications that the optimal contract has for the incentives of banks to carefully screen borrowers ex-ante. For the sake of the argument, suppose that more effort in screening borrowers ex-ante leads to an ex-post draw from a better distribution of θ in the first order stochastic dominance sense. We can intuitively see that the higher the value of equity that banks obtain for low values of θ and the lower the value of equity for high values of θ, the stronger are the incentives to exert effort. Notice that compared to the case without intervention, our mechanism provides identical incentives, since for any arbitrary value of θ, the value of equity is the same in both cases. This result is in contrast with what occurs with standard asset buybacks: If there is a single fixed price per bad loan sold (and no participation fee), information rents are granted to firms with higher ex-post values of θ. If banks anticipate this, they will respond by reducing their effort to screen borrowers ex-ante.[13]

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[13]In the class of schemes with voluntary participation, the only general way of improving on the incentives

The optimal contract in Proposition 2 can be implemented in many different ways. For example, although maybe not the main focus of their paper, Aghion, Bolton, and Fries (1999) propose a scheme that can be interpreted as an alternative way of implementing the optimal contract here, although they do not study which features of the problem allow information rents to be eliminated. In their model, banks can have four different types (proportions of bad loans), and banks with the highest two types want to gamble. They show that a particular scheme that pays a foreclosure subsidy that is non-linear in the proportion of bad loans can induce both gambling types to foreclose, without paying information rents to either.

This can be translated into the terms of our model as follows: Consider a subsidy $z(x)$ that is received for foreclosing the additional, infinitesimal amount of bad loans dx, where $z(x)$ varies with amount of foreclosed loans as given by

$$\int_0^\gamma z(x)dx \equiv \Delta\pi_0(\gamma),$$

so that

$$z(x) = \frac{d\Delta\pi_0(x)}{dx}.$$

Since the subsidy associated with foreclosing an amount γ, $\int_0^\gamma z(x)dx$, is non-concave in γ the value of equity when participating would still be convex, and banks would either foreclose all bad loans, or no bad loans. But by construction, banks are again indifferent between foreclosing all bad loans or none. Under this subsidy, banks therefore participate, foreclose all bad loans, and satisfy their participation constraint with equality. Hence, this is another way of implementing the optimal contract.

Another alternative implementation would be an asset buyback variant of the two-part tariff considered in Subsection 3.2. Suppose that a bank that reports a type θ^R commits to pay a fixed fee $F(\theta^R)$, in return for a price $p(\theta^R)$ per loan that it sells to the regulator. The regulator forecloses all loans that it buys. Following the argument in Subsection 3.2, the participation profits for a bank reporting type θ^R under this implementation are

$$\Pi(\theta, \theta^R) = 1 - \theta + p(\theta^R)\theta - D - F(\theta^R),$$

and the information rents of a bank that truthfully reports its type can be expressed as

$$U(\theta) = p(\theta^R)\theta - F(\theta^R) - (\pi_0(\theta) - (1 - \theta - D)).$$

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produced by our scheme would be to reward banks that end up having a low proportion of bad loans with positive information rents. It can be shown that due to global incentive compatibility constraints, this necessarily also implies paying positive (although smaller) information rents to all banks that have a larger proportion of bad loans, reducing the appeal of such a mechanism. Under schemes with mandatory participation, incentives could be improved without necessarily increasing cost, but the improvement would be limited by the non-concavity of participation profits. Details are available from the authors upon request.

The menu of two-part tariffs $\{p^*(\theta), F^*(\theta)\}$ under which any bank with a proportion θ will choose the right contract, sell all bad loans, and satisfy its participation constraint with equality, corresponding to the menu of contracts in Proposition 1, is given by

$$p^*(\theta) = 1 + \frac{d\pi_0(\theta)}{d\theta} < 1, \tag{18}$$

$$F^*(\theta) = -(\pi_0(\theta) - (1 - \theta - D)) + \theta p^*(\theta). \tag{19}$$

This implementation has as a main advantage over the foreclosure subsidy discussed in Subsection 3.2 that neither $p^*(\theta)$ nor $F^*(\theta)$ depend on ρ. For instance, as we show in the next section, if banks could foreclose good loans and obtain a recovery ρ_G that is substantially higher than ρ, a foreclosure subsidy could entice banks to overstate their proportion of bad loans. Under an asset buyback scheme this situation cannot arise and the optimal contract can still be implemented.

4   Foreclosing good loans

So far, we have assumed that banks can only foreclose bad loans. This is a realistic assumption if one thinks that bad loans are loans on which some default has occurred, and good loans are loans on which no default has occurred. In this case, there would be a legal basis only for foreclosing bad loans. It could be argued that in some instances, however, some good loans might be in "technical default," that is, in a situation in which a financial covenant other than that requiring the timely payment of interest or principal is breached.[14]

In this section, we discuss to what extent our optimal contract is robust to a situation in which banks can also foreclose good loans — a bank might want to do so to pretend to be of a worse type, and hence receive higher transfers. In other words, we discuss to what extent our optimal contract is still incentive compatible when good loans can be foreclosed. We argue that an asset buyback implementation of our optimal contract is robust in this situation, and that a foreclosure subsidy implementation is only robust as long as the recovery on good loans is not "substantially" higher than that on bad loans.

Suppose that foreclosing a good loan produces a recovery ρ_G, potentially different from the recovery obtained when foreclosing a bad loan, ρ. Suppose also that $\rho_G < 1$, so that foreclosing good loans is costly. As a result, banks would never foreclose good loans in the absence of a scheme. This is because, conditional on survival, the change in the value

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[14]For example, loan contracts can stipulate that a firm maintain a minimum current ratio, defined as the ratio of current assets to current liabilities. If the current ratio falls below this level, the contract is breached. Such covenants are used in many loan contracts, are typically set very tight, and are hence frequently violated. Chava and Roberts (2008), for example, report that in their sample of loans to U.S. corporations between 1995 and 2005, about 15% of borrowers were in technical default at any point in time.

of equity from foreclosing an additional good loan $\rho_G - 1$ is always negative. In contrast, conditional on survival, the change in the value of equity from foreclosing an additional bad loan $\rho - E[\varepsilon|\varepsilon > \bar{\varepsilon}]$ is positive if the firm is likely to survive, and negative if it is likely to fail – this is the source of the gambling incentives (here, $\bar{\varepsilon}$ denotes the relevant threshold recovery on bad loans that is necessary for the bank to survive).

In the presence of a scheme, however, things are not so clear. When a transfer is contingent on foreclosing a certain quantity of loans, and a regulator cannot distinguish between a foreclosed good loan and a foreclosed bad loan, a bank might choose to foreclose some good loans in addition to or instead of its bad loans, to obtain a higher transfer.

Consider a foreclosure subsidy implementation of the optimal contract. If a bank is targeting a given transfer and therefore has to foreclose a given amount of loans, it will foreclose good loans if the opportunity cost of doing so is lower than the cost of foreclosing bad loans. That is, if

$$\rho - E[\varepsilon|\varepsilon > \bar{\varepsilon}] < \rho_G - 1, \tag{20}$$

or

$$\rho_G - \rho > 1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]. \tag{21}$$

We show in Appendix B that if $\rho_G - \rho$ is "large enough," banks may have incentives to foreclose good loans to overstate their type and receive higher transfers. In this case, the foreclosure subsidy implementation of our optimal contract would not be incentive compatible. Conversely, if $\rho_G - \rho$ is positive but "small enough,", or non-positive, banks do not have incentives to overstate their type, and our optimal contract is incentive compatible.

The value of equity when foreclosing good loans is always increasing in the reported type (as long as the reported type receives a positive transfer under the scheme). This means that banks only consider foreclosing good loans if the value of equity they obtain from pretending to be of the "highest possible type" exceeds the value of equity from reporting truthfully. This determines the critical upper limit for $\rho_G - \rho$. The "highest possible type" might be determined by the maximum number of good loans that can be foreclosed because they are in technical default, or by θ^*, the highest type that still receives a positive transfer in the baseline version of our scheme.

It is worth noting, however, that if the scheme is implemented as an asset buyback as discussed above, banks will never have incentives to overstate their type. Intuitively, this happens because under an asset buyback, the recovery when a loan is foreclosed accrues to the regulator, and not to the bank. Therefore, even if $\rho_G > \rho$, the bank does not benefit from the higher recovery on the good loan when foreclosing this instead of a bad loan, but the regulator does. Under a buyback implementation, banks therefore do not have incentives to sell good loans.

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5 Imposing losses on debtholders

In the baseline version of our scheme, equity holders do not benefit from the scheme. However, debt becomes risk-free for the participating banks, implying that debt holders do benefit. This is a feature of almost any scheme that restores bank solvency. For this reason, there has been much debate about making debt holders contribute to the cost of bank rescues.[15] In this section we use a specific modified version of our scheme to explore to which extent a regulator can impose losses on debt holders, in a situation in which their consent is necessary for this. Although our discussion here is not intended to be a general treatment of this issue, it indicates that the ability to impose losses on debt holders is likely to crucially depend on the commitment power of the regulator.

Consider the following situation: Suppose that debt holders are atomistic and that they have the same information the regulator has. The regulator now not only offers a contract to the bank itself, but also to its debt holders. To simplify, we restrict ourselves to contracts for which the decision of debt holders is only whether to accept or reject an offer of the regulator. We also suppose that the timing is as follows: The regulator offers a contract to both debt holders and the bank. Debt holders decide first. On observing the decision of the debt holders, the regulator can then *revise* the offer to the bank (but not to debt holders). We will consider the two extreme cases, in which the regulator either can or cannot commit ex-ante to not revising contracts such that debt holders that reject offers are punished.

To be specific, the regulator offers banks a menu of contracts that specifies transfers to be received as a function of quantity of foreclosed loans, as before — in terms of the previous terminology, the regulator offers a schedule $T(\gamma)$. The regulator also asks debt holders of each bank to grant her a call option on the debt with strike price $(1 - h)D$ (where D is the face value of debt as before), that can be exercised when their bank "participates", that is, if their bank chooses a contract from the menu $T(\gamma)$ under which it receives a non-zero transfer.[16] We will refer to the parameter $h \in [0, 1]$ as the *haircut*, to be imposed on debtholders in the case that the bank chooses to participate.[17] The idea here is that debt holders of participating banks will be asked to contribute towards the cost of bailing out the bank.

It is important to note that the contract a bank picks from the menu $T(\gamma)$ does *not*

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[15]See, for example, Alan Greenspan's proposal mentioned in "Hire the A-Team," The Economist, August 7, 2008.

[16]Equivalently, the regulator can offer to exchange the old debt claim for a new debt claim that is equivalent in all respects except that it includes the call option.

[17]Although it would be possible to condition the haircut on the θ revealed by the participating bank, doing so would not allow the regulator to extract additional rents, since debt holders are assumed to possess no private information.

depend on whether or not debt holders agree to grant the option, since from the point of view of the bank, it does not matter whether private parties or the regulator end up holding the debt.

We start with the case in which the regulator can commit (we use the superscript C to denote parameter values specific to this case). Suppose the regulator announces a menu of contracts $T(\gamma)$ for which banks with $\theta \in [\hat{\theta}, \theta^C]$ will want to participate, but commits to only allowing a bank to participate when the bank's debt holders unanimously agree to a haircut h. What is the maximum haircut h^C that the regulator can impose in this case?

Let U_0^D denote the value of debt for a debt holder that does not accept the exchange offer. We can see that since the regulator has committed in this case to not letting the bank participate in the scheme, the value of debt becomes

$$U_0^D = D\Psi\left(\hat{\theta}\right) + D \int_{\hat{\theta}}^1 R_0^D(\theta)\psi(\theta)d\theta, \tag{22}$$

where $R_0^D(\theta)$ is the expected fraction of face value recovered from a bank with bad assets θ when it is not bailed out,

$$R_0^D(\theta) = (1 - \Phi(\bar{\varepsilon}_0)) + \frac{1}{D}\int_0^{\bar{\varepsilon}_0}(1 - \theta + \theta\varepsilon)\phi(\varepsilon)d\varepsilon.$$

The value U_0^D accounts for the fact that debt holders obtain face value if the bank in question ends up having few bad loans $(\theta < \hat{\theta})$, and obtain an expected recovery otherwise.

U_0^D also describes the payoff to a debt holder that does accept, when the required unanimity is not attained. However, if all debt holders accept, the value of their debt (denoted as U^D) becomes

$$U^D(h, \theta^C) = D\Psi\left(\hat{\theta}\right) + (1-h)D\left[\Psi\left(\theta^C\right) - \Psi\left(\hat{\theta}\right)\right] + D\int_{\theta^C}^1 R_0^D(\theta)\psi(\theta)d\theta. \tag{23}$$

The maximum haircut h^C that can be imposed is the one that makes debt holders just indifferent between accepting or rejecting and sets $U_0^D \equiv U^D(h, \theta^C)$. This is summarized in the next proposition:

Proposition 3. *When the regulator can commit, the optimal contract consists of the menu described in Lemma 3, with the set of participating banks equal to $\Theta_P = [\hat{\theta}, 1]$. Furthermore, the haircut h^C is such that $U^D(h^C, 1) = U_0^D$ or*

$$h^C = 1 - \int_{\hat{\theta}}^1 R_0^D(\theta)\frac{\psi(\theta)}{1 - \Psi(\hat{\theta})}d\theta = 1 - E\left[R_0^D(\theta)\middle| \theta > \hat{\theta}\right].$$

The intuition for this result is quite straightforward. The decision of debt holders affects the bank only insofar as it might not be allowed to participate. If it is allowed to participate, the menu of contracts described in Lemma 3 still induces participating banks to foreclose, and eliminates all information rents, such that bank equity holders are exactly as well off under the scheme as outside the scheme. Furthermore, under the scheme, all debt holders are exactly as well off as outside the scheme: the haircut is exactly equal to the expected losses if the bank is not allowed to participate.

The positive haircut reduces costs. It can be shown that since the participation utilities of equity holders and debt holders are equal to their outside utilities, the regulator can appropriate all of the increase in the net present value produced by the foreclosure of bad loans for any "living dead" bank (that gambles) at zero cost. This makes the net cost of having any "living dead" participate negative, and hence it is optimal to have all "living dead" participate in the contract.

We now turn to the opposite case in which the regulator cannot commit at all (we use the superscript NC to denote parameter values specific to this case). The regulator announces a menu of contracts $T(\gamma)$ for which banks with $\theta \in [\hat{\theta}, \theta^{NC}]$ will want to participate, and states that only banks whose debt holders unanimously agree to a haircut h will be allowed to participate. However, the regulator now cannot commit to following through on this threat. What is the maximum haircut h^{NC} that the regulator can impose in this case?

Proposition 4. *When the regulator cannot commit, the optimal contract consists of the menu described in Lemma 3, with the set of participating banks equal to $\Theta_P = [\hat{\theta}, 1]$. Furthermore, the haircut h^C is such that $U^D(h^{NC}, 1) = U^D(0, \theta^*)$ or*

$$h^{NC} = \frac{1 - \Psi(\theta^*)}{1 - \Psi(\hat{\theta})} - \int_{\theta^*}^1 R_0^D(\theta) \frac{\psi(\theta)}{1 - \Psi(\hat{\theta})} d\theta = \Pr(\theta > \theta^* | \theta > \hat{\theta}) \left(1 - E\left[R_0^D(\theta) \big| \theta > \theta^*\right]\right)$$

The intuition for this result is similar to that for the preceding result. Again, the decision of debt holders affects the bank only insofar as it might not be allowed to participate. If it is allowed to participate, the menu of contracts described in Section 3 still induces participating banks to foreclose, and eliminates all information rents, such that bank equity holders are exactly as well off under the scheme as outside the scheme.

However, debt holders now have a better outside option: If they refuse, in the second stage, the regulator will have to implement the optimal contract of the baseline version of our scheme (see Proposition 2) which means a zero haircut and that only banks with $\theta \in [\hat{\theta}, \theta^*]$ participate. This produces an expected value of debt which is lower than face value, but higher than the value of debt in the absence of intervention.

If the regulator wants to impose a positive haircut, it has to offer debt holders something in return. The only thing it can do, here, is to increase the set of banks that participate. It

can do this such that the total expected transfers to debt holders remain constant. However, as more banks participate and foreclose bad loans, this creates additional net present value, which the regulator can appropriate, since debt holders and equity holders are held to their outside option. This means that the cost of the scheme is decreasing in the number of banks that participate, and hence the regulator optimally has all banks participate. The haircut is then set exactly equal to the expectation of the losses that the debtholders would have faced for banks that would not have participated if the regulator had implemented the baseline scheme in the second stage.

As a corollary, the higher the social cost of funds, and hence the smaller the set of banks that participates if the regulator implements the baseline scheme in the second stage, the larger is the haircut that can be imposed on debt holders.

This argument highlights two points: First, in cases in which the consent of debt holders is necessary, one key to imposing losses on debt holders is likely to be the ability of the regulator to commit (that is, the ability to create a form of credible threat). Second, in such cases, if commitment is not possible, the limit to imposing losses on debt holders is in a sense determined by the ability of the regulator to fund a bail out banks when debt holders do not make concessions. Essentially, an inability to fund bailouts can be a form of commitment.

This suggests that in order to more easily impose losses, regulators should either look for ways of creating commitment, or find ways of relaxing the requirement of debt holder consent. Indeed, the current policy debate seems to revolve around the latter, as the discussion about contingent capital suggests (Flannery, 2009). The argument here also highlights that regardless of whether losses on debt holders can be imposed or not, information rents of equity holders can be eliminated via a version of our baseline scheme.

Finally, it is important to mention that in our model we treat debt holders as outside investors. Very often, however, many of the debt holders may themselve be banks or nonbank financial institutions. Thus, a haircut imposed on the debt of one bank might decrease the value of assets of another bank, and hence increase the need to bail out other banks.

6   Alternative welfare functions

In this section we discuss several variations of the social welfare function that we have used in the baseline model. We first consider how deposit insurance, social costs of bank failure, and crowding out effects could increase the attractiveness of getting banks to foreclose bad loans. We then discuss how valuable long-run relationships between banks and their customers or situations in which the recovery on a foreclosed loan is a function of how many loans are foreclosed in the aggregate could decrease the attractiveness of getting banks to foreclose

bad loans. Although these variations affect the set of banks that optimally participate in the scheme, they do not affect the mechanism design argument substantially, and the same type of contract can be used to eliminate information rents. Finally, as an example of a variation that complicates the mechanism design argument substantially, we consider how publicly observed participation decisions by banks might affect the possibility of bank runs.

As we pointed out in the previous section, in our baseline model bank debt holders benefit from the scheme. This is because bank debt becomes safe once banks stop gambling. The positive transfer that is necessary to induce banks to stop gambling is in fact an implicit transfer to debt holders. However, if the regulator already has some pre-existing commitments to make transfers to debt holders if a bank defaults (which can only happen when the bank gambles), then the *incremental* (expected) transfer to debt holders implied by the scheme over and above the expected transfers from pre-existing commitments, and hence the true *incremental* cost of the scheme, is lower.

Deposit insurance is such a pre-existing commitment to make transfers to (some) debtholders in the case of bank default. Suppose that insured deposits make up a fraction $\alpha \in [0, 1]$ of total bank debt D and that, for simplicity, α is the same across all banks. Assume that deposits are senior to other forms of debt, as is likely to be the case in practice, such that the regulator has to make insurance payments only if the remaining assets of a defaulting bank are less than αD. The expected deposit insurance cost associated with a bank with a proportion of bad loans θ that does not participate and decides to gamble is

$$DI(\theta) = \int_0^{\bar{\varepsilon}_{DI}} [\alpha D - (1 - \theta + \theta \varepsilon)] \phi(\varepsilon) d\varepsilon,$$

where $\bar{\varepsilon}_{DI}$ is the highest value of ε for which the remaining assets of the bank are not enough to repay αD. That is,

$$1 - \theta + \theta \bar{\varepsilon}_{DI} = \alpha D.$$

It is immediate that

$$DI'(\theta) = \int_0^{\bar{\varepsilon}_{DI}} (1 - \varepsilon) \phi(\varepsilon) d\varepsilon > 0,$$

$$DI''(\theta) = (1 - \bar{\varepsilon}_{DI}) \phi(\bar{\varepsilon}_{DI}) \frac{1 - \alpha D}{\theta^2} > 0,$$

so that the cost of deposit insurance increases in θ more than linearly.

The change in the incremental social cost of the scheme, which now becomes $\lambda(T(\theta) - DI(\theta))$, alters the cost-benefit balance. This means that in general it will be optimal to have a different (larger) set of banks participate. In particular, it is not necessarily true that the regulator will make only banks with a relatively low proportion of bad loans participate, and let banks with a high proportion of bad loans gamble, with the marginal type determined

by an equation such as (17). This is because now the cost of making a bank participate, $\lambda\left(\Delta\pi_0(\theta) - DI(\theta)\right)$, is not necessarily convex in θ. Depending on the exact shape of $DI(\theta)$, which depends on α and the distribution of ε, it is possible, for example, that the regulator will make banks with low and high proportions of bad loans participate, but let those with medium proportions gamble. This could arise if the expected deposit insurance costs on banks with a medium proportion of bad loans were low, but the expected deposit insurance costs for banks with a high proportion of bad loans were high.

We now consider a situation in which bank failure might be costly *per se* from a social point of view. For simplicity, assume initially that there is a constant social cost $B > 0$ that is incurred whenever a bank fails. Now, making a bank participate and foreclose not only leads to an increase in social welfare derived from efficient foreclosure of the bad loans, $(\rho - E[\varepsilon])\theta$, but also to an increase in social welfare derived from the reduction of the probability of bank failure to zero. The expected social cost of bank failure is reduced from $B\Phi(\bar{\varepsilon}_0)$ to 0. The total social benefit of making a bank with type θ foreclose is now $(\rho - E[\varepsilon])\theta + B\Phi(\bar{\varepsilon}_0)$, non-linear in θ. Depending on the distribution of ε, it it is again possible that the regulator will find it optimal, for example, to let banks with a low and high proportion of bad loans participate, but let those with medium proportions gamble. This could arise if, absent any intervention, the probability of bank failure for banks with a high proportion of bad loans is very high, so that the regulator will make such banks participate to ensure that they do not fail.

A more complicated version of the welfare function would arise if B, the social cost of bank failure, were to depend on the number (or type) of failing banks — as it plausibly might if the regulator is worried about an element of systemic risk. This would produce yet another set of banks that should optimally participate in the scheme.

One could also argue that the prevention of rolling over loans of insolvent borrowers and hence keeping them alive is important because it facilitates creative destruction and prevents crowding out of efficient entrants (Caballero, Hoshi, and Kashyap, 2008). A very simple way to acknowledge this in our social welfare function would be to impute an additional social benefit to each foreclosed loan, over and above the increase in net present value that this generates. Again, a more complicated version of the same argument would have that benefit be a function of the aggregate number (or type) of loans that are foreclosed. This would also produce another (larger) set of banks that should optimally participate in the scheme.

In all of the cases discussed so far, the set of banks that optimally participates in the scheme is different from that in the baseline version of the model. It is clear from Lemma 3, however, that in in all of these cases, the same type of optimal contract can be used to eliminate information rents.

Similarly, one can also consider variations of the social welfare function that might decrease the attractiveness of getting banks to foreclose bad loans. For example, in the Japanese crisis, it has been argued that long-run relationships between a borrower and its bank have a significant intrinsic value. Foreclosing loans might destroy this intrinsic value, and hence inducing foreclosure might be less valuable than we suggest (see Berglöf and Roland (1997)).

Another simplifying assumption we have maintained throughout the paper is that the recovery from a foreclosed bad loan is constant, and independent of the aggregate quantity of bad loans being foreclosed. If we think of the assets being seized as undeveloped real estate as in the example in the introduction, however, then real estate prices should react to the quantity of land being sold, and recovery would decrease as more assets are dumped in the market. In that situation, the social benefit from each foreclosure diminishes as the total quantity of foreclosed bad loans increases.[18]

Finally, the social cost of funds, λ, might not be constant but increasing in the total funds required for the scheme — in essence, assuming a linear cost of funds is an approximation that is reasonable in the context of small localized interventions, but it could be argued that it is not a reasonable for bailouts of the entire banking system.

In any of these situations, benefits would be lower or costs would be higher, and less banks would be bailed out. However, as argued above, this does not affect the mechanism design argument substantially, and the same type of contract can be used to eliminate information rents.

Finally, we consider an example of a variation in the social welfare function that would complicate the mechanism design argument substantially. Consider a reduced form scenario in which banks are brought down by a bank run when their publicly perceived probability of default at $t = 2$, that we could denote as q, is above a certain threshold $\overline{q}$, and suppose that this produces a social cost.[19] In our context, the decision of a bank to participate reveals information about the probability of default of that bank. That is, if a bank participates, the probability of failure becomes 0. However, for banks that do not participate, depositors cannot distinguish whether this is because the bank was safe before (in our context, $\theta \leq \hat{\theta}$), or because the bank is in such a dire condition that participation would be too costly (in our baseline context, $\theta > \theta^*$). As a result, depositors would calculate a probability of default

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[18]In this context, it might make sense to set up an asset buyback scheme where the government creates a bad bank that buys bad loans at once, but forecloses them gradually over time. This was the solution adopted by the Swedish government during its financial crisis in the 1990s, where the bad bank, Securum, was granted up to ten years to dispose of all its bad assets (Englund, 1999).

[19]This could plausibly arise in a bank run model based on a global game (Goldstein and Pauzner, 2005), where the publicly perceived probability of default plays the role of the "fundamental."

conditional on a bank not participating, q_D, as

$$q_D = \frac{\int_{\theta^*}^1 \Phi(\bar{\varepsilon}_0)\psi(\theta)d\theta}{1 - \Psi(\theta^*) + \Psi(\hat{\theta})},$$

where $\bar{\varepsilon}_0$ is obtained from (1). If it turns out that $q_D > \bar{q}$, banks that do not participate would be brought down by a bank run. The regulator can potentially prevent this situation and increase social welfare by changing the set of banks that do and do not participate in the scheme. This would give an additional criterion for selecting the banks that participate in the scheme. However, as in Philippon and Skreta (2010) or Tirole (2010), the non-participation value of equity would then be endogenous, which would further complicate the mechanism design problem.

7   Discussion

In this section, we informally discuss some additional issues that might arise when implementing the scheme that we propose.[20] In particular, we discuss how the optimal contract can condition on observables, and to what extent it can accommodate situations in which bad loans are heterogeneous. We also briefly touch upon how the ideas in this paper could be used to tackle a problem of risk-shifting as opposed to zombie lending.

Our model is obviously very stylized. For instance, we assume that the level of debt or leverage D of all banks is the same. However, to the extent that leverage is observable by the regulator, the optimal contract could condition on it. Notice, for instance, that in the two-part tariff foreclosure subsidy implementation, the subsidy, s, does not depend on the leverage, whereas the fee, F, decreases in leverage. In practice, if leverage is observed, the regulator would simply charge a lower fee to banks with higher leverage.

Similarly, if bad loans are heterogeneous, but can be distinguished on the basis of observable characteristics, the optimal contract can adjust for that. For example, suppose that recoveries, ρ, on commercial real estate are different from those of residential real estate, or are different for loans with different loan-to-value ratios. Then a higher subsidy in the foreclosure subsidy implementation or a higher price in the asset buyback one would be offered for loans with the lower recovery values.

In terms of our analysis, things become more complicated if in addition, banks have private information about how bad loans differ. That is, if banks have private information on ρ or the distribution of ε. The former may be problematic for the foreclosure subsidy implementation of the optimal contract but it would be less of a problem for the asset

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[20]Formal arguments for many of the points are omitted for space reasons but are available from the authors upon request.

buyback implementation. This is because in an asset buyback, neither the prices nor the fees that need to be set depend on ρ, as discussed in Section 3.3. A caveat, however, is that for the welfare function in the baseline model, it is only the increase in net present value of $\rho - E[\varepsilon]$ from foreclosing a bad loan that produces a social benefit of foreclosing. Therefore, in the context of our baseline model, a regulator that does not know ρ would not know whether foreclosure necessarily increases net present value and hence welfare.

Regarding private information on the distribution of ε, a problem with our scheme is that it always requires knowledge of the non-participation value of equity, which in turn requires knowledge of the value of gambling, and hence the distribution of ε. If this is not known, the regulator does not know how high the fees can be set before banks will abstain from participating. Hence, a regulator that is uncertain about the distribution of ε might need to trade-off a higher probability that the contract is accepted against a higher probability that positive rents accrue to bank equity holders.

In this context, it is possible that certain auction designs could help in setting the fees. In the buyback implementation, one can interpret the transaction in which a bank obtains the right to sell an unlimited quantity of bad loans at a given price in exchange for the participation fee as the purchase of a put option. Instead of selling these put options, they could be auctioned off. The idea is that banks would bid up the fees for the various options, and in doing so, reveal the value that they attach to the options (and hence the value they attach to gambling, and about the distribution of ε). It is easy to show that in the context of our model, the bank that attaches the highest value to the right to sell bad loans at a given price would be the bank that is meant to sell at that price under our scheme, and for which a tangency condition as in (18) would be satisfied.

If an auction manages to allocate any given option to the bank that attaches the highest value to that option, and if the auction manages to extract most of the surplus, then it would be yet another way to implement something very close to our optimal contract, with the important difference that the regulator would not need to know the distribution of ε. There are two issues, though. First, ensuring a sufficient amount of competition in the auction is likely to be difficult, especially if the regulator would prefer all banks to participate in the scheme. Second, the regulator would need to have at least some minimum knowledge of the distribution of ε in order to determine the range of options (indexed by the associated prices for the bad loans) which should be auctioned off. A full discussion of an appropriate auction design, although interesting, is beyond the scope of this paper.

Finally, as mentioned in the introduction, empirical evidence indicates that one of the main drivers of the financial crisis in Japan in the 1990s was the fact that zombie banks were lending to zombie firms. The situation, however, was also made worse by policies focused on

stimulating bank lending. The more insolvent banks, in addition to not foreclosing bad loans, tended to give new additional loans to the riskiest borrowers. This is in fact a form of risk-shifting: a related, but slightly different distortion arising from limited liability. In a context of risk-shifting, a variation of our model suggests that a technically similar mechanism to the one we describe in this paper can be used to induce the appropriate allocation of funds. In particular, if banks had private information regarding their lending opportunities, a regulator could offer a menu of two-part tariffs, where in each two-part tariff, banks receive a fixed amount to participate, but are then taxed for each new loan that they originate. Such a mechanism would prevent banks from giving new loans for the purpose of risk-shifting, while leaving them at their participation constraint.[21]

8   Concluding remarks

It is well known that banks that are insolvent but still operating, that is, zombie banks, can have incentives to roll over loans of insolvent firms as a form of gambling for resurrection. In general, the more insolvent the bank, the greater the incentives to gamble. This zombie lending can have bad consequences for the economy, as was observed in Japan in the 1990s.

At the same time, a regulator is typically at an informational disadvantage vis-a-vis the bank, and cannot tell whether a given bank is part of the "walking wounded" or the "living dead". This means that schemes that aim to induce banks to foreclose potentially produce information rents. In this paper we have proposed a (voluntary) scheme that can either be interpreted as a form of asset buyback, or as a scheme that subsidizes the foreclosure of bad loans. Under the scheme (i) banks reveal their private information, (ii) remove and/or foreclose their bad loans, and (iii) are no better off than they would be in the absence of the scheme, and all information rents are eliminated.

The scheme utilizes the fact that banks have *countervailing incentives*: On the one hand, banks have incentives to overstate their proportion of bad loans, to indicate that they are more reluctant to foreclose, and hence that they should pay lower fees. On the other hand, banks have incentives to understate their proportion of bad loans, to indicate that they will benefit less from a given subsidy, and hence that they should pay lower fees. We show that the two features of the model that produce the gambling for resurrection in the first place, namely, limited liability and uncertainty about future losses on loans that are rolled over, produce incentives to both overstate and understate in a way that makes it possible to exactly balance the two incentives. This allows information rents to be completely eliminated.

In the baseline version of our scheme, debt holders benefit, as debt becomes risk-free.

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[21]Details of this model can be obtained from the authors upon request.

This implies a rent to debt holders, which a regulator might also try to eliminate. We show that if the regulator can commit to not bailing out banks whose debt holders do not agree to accept some losses, the regulator can in fact substantially lower the cost of the scheme (the cost becomes negative). If the regulator cannot commit, then the extent to which losses can be imposed on debt holders is limited by their outside option, which in turn is driven by what the regulator does if debt holders do not accept losses. For instance, since a higher social cost of funds reduces the ability of the regulator to bail out banks when debt holders do not accept losses, a regulator that faces a higher cost of funds can get debt holders to accept larger losses.

We show that in the baseline model, in which the regulator compares the efficiency gain from having bad loans foreclosed with the cost of inducing banks to foreclose, the optimal contract involves making banks with a relatively low proportion of bad loans foreclose, but letting banks with a relatively high proportion of bad loans gamble. This is because inducing banks with a high proportion of bad loans to foreclose can quickly become very costly. We argue that this result is sensitive to the choice of welfare function. For example, when bank failure generates a loss per se, or when deposit insurance covers a significant proportion of bank liabilities, letting banks that have higher proportion of bad loans participate can be optimal. However, even in these cases, information rents can always be eliminated with a version of our optimal contract.

The paper opens up some avenues for future research. For example, it would be interesting to explore how a technically similar mechanism to the one that we propose could be used to deal with risk-shifting rather than forbearance lending by banks, and to explore how auctions could be used to complement the mechanism we propose in this paper by eliciting additional information from banks on some dimensions that our paper abstracts from.

Appendix

A Proofs

Proof of Lemma 1: We first show that the value of equity is convex in γ: We note that the derivative of (2) with respect to γ is given by

$$\int_{\bar{\varepsilon}_0(\gamma)}^{1} (\rho - \varepsilon)\phi(\varepsilon)d\varepsilon, \tag{24}$$

and that the second derivative becomes

$$-(\rho - \bar{\varepsilon}_0(\gamma))\phi(\bar{\varepsilon}_0)\frac{\partial \bar{\varepsilon}_0}{\partial \gamma}. \tag{25}$$

To evaluate the sign of the second derivative, it is useful to note that

$$\rho - \bar{\varepsilon}_0(\gamma) = \frac{(1-D) - (1-\rho)}{\theta - \gamma} = -\frac{\partial \bar{\varepsilon}_0}{\partial \gamma}(\theta - \gamma). \tag{26}$$

Consider first banks for which $\theta = \frac{1-D}{1-\rho} \equiv \bar{\theta}$. For such banks, $\bar{\varepsilon}_0 = \rho$, regardless of γ, and hence the second derivative is always zero. Checking (24), however, we can see that for such banks, the first derivative will always be negative, and hence such banks will foreclose the minimum amount $\gamma = 0$ and gamble.

Consider now banks for which $\theta \neq \bar{\theta}$. For such banks, as indicated by (26), $\rho - \bar{\varepsilon}_0$ and $\partial \bar{\varepsilon}_0 / \partial \gamma$ have always of the opposite sign, and since $\phi(\varepsilon) > 0$, the second derivative is positive. As a result, the value of equity is convex in γ, such that the optimal choice of γ is either 0 or θ.

Furthermore, note that $\pi_0^F(0) = \pi_0^G(0)$, that $\pi_0^F(1) < 0$, that $\pi_0^G(1) = 0$, that $\pi_0^F(\theta)$ is continuous, decreasing, and linear in θ, that $\pi^G(\theta)$ is continuous, decreasing, and convex in θ, and that

$$\frac{d\pi_0^G(x)}{dx}\bigg|_{x=0} = -(1 - E[\varepsilon]) < -(1 - \rho) = \frac{d\pi_0^F(x)}{dx}\bigg|_{x=0} \tag{27}$$

since $E[\varepsilon] < \rho$. It follows that there exists a unique $\hat{\theta} > 0$ such that for $0 < \theta < \hat{\theta}$, $\pi_0^G(\theta) < \pi_0^F(\theta)$, and for $\hat{\theta} < \theta \leq 1$, $\pi_0^G(\theta) > \pi_0^F(\theta)$. Since $\pi_0^F(\bar{\theta}) = 0$, this also implies that $\hat{\theta} < \bar{\theta}$.

We can therefore see that in general, banks with $\theta < \hat{\theta}$ foreclose, banks with $\theta > \hat{\theta}$ gamble, and banks with $\theta = \hat{\theta}$ are indifferent between foreclosing and gambling. $\square$

Lemma A1 (Participation implies foreclosure). *Under any menu of two part tariffs with positive fees, participating banks will optimally foreclose all their bad loans.*

Proof of Lemma A1: In the foreclosure subsidy version of the two-part tariff, foreclosure leads to a higher value of equity if

$$1 - \theta + (\rho + s(\theta^R))\theta - D - F(\theta^R) \geq \int_{\bar{\varepsilon}(0)}^{1} (1 - \theta + \varepsilon\theta - D - F(\theta^R))\phi(\varepsilon)d\varepsilon. \qquad (28)$$

Notice that a necessary condition for a bank to be willing to foreclose is that the transfer F is sufficiently small (or s sufficiently large) for the bank to survive, since gambling always produces a non-negative value of equity.

Suppose that (28) is satisfied and the bank forecloses. We can now compare the value of equity from participating and foreclosing, and the value of equity from not participating and gambling. A bank would want to participate with the contract indexed by θ^R if

$$1 - \theta + (\rho + s(\theta^R))\theta - D - F(\theta^R) \geq \underbrace{\int_{\bar{\varepsilon}_0}^{1} (1 - \theta + \varepsilon\theta - D)\phi(\varepsilon)d\varepsilon}_{\pi_0^G(\theta)} \quad (> 0). \qquad (29)$$

Comparing (29) and (28), we can see that as long as $F(\theta^R) > 0$, (29) implies (28). (Also, by inspection of (29), we see that participation profits must be positive). $\qquad \square$

Proof of Lemma 2: As argued in the text, for positive transfers $F(\theta)$ participation profits are determined by (9). Using this expression the proof is standard (see for example. Fudenberg and Tirole (1991), Section 7.3). Here, we sketch a simple proof for completeness.

Write the incentive compatibility constraint

$$\Pi(\theta^R, \theta) \leq \Pi(\theta, \theta), \quad \forall \theta^R, \theta$$

as

$$s(\theta^R)\theta - F(\theta^R) \leq s(\theta)\theta - F(\theta), \quad \forall \theta^R, \theta. \qquad (30)$$

This says that telling the truth should maximize the net transfer to the bank.

Locally, incentive compatibility implies the first-order condition

$$s'(\theta^R)\theta - F'(\theta^R)\big|_{\theta^R = \theta} = 0 \qquad (31)$$

and the second-order condition

$$s''(\theta^R)\theta - F''(\theta^R)\big|_{\theta^R = \theta} \leq 0. \qquad (32)$$

Taking derivatives of (31) with respect to θ, inserting the result into (32) and rearranging terms yields

$$s'(\theta) \geq 0, \qquad (33)$$

i.e. the monotonicity condition is alternative way of stating the local second order condition.

From the first order condition, we also have the differential equation

$$F'(\theta) = s'(\theta)\theta. \tag{34}$$

Integrating by parts, we obtain

$$F(\theta) = \int_0^\theta s'(x)x\,dx = s(\theta)\theta - \int_0^\theta s(x)dx, \tag{35}$$

which implies that

$$F(\theta^R) - F(\theta) = s(\theta^R)\theta^R - s(\theta)\theta + \int_{\theta^R}^\theta s(x)dx \tag{36}$$

or, rearranging,

$$s(\theta)\theta - F(\theta) = s(\theta^R)\theta - F(\theta^R) + \int_{\theta^R}^\theta s(x)dx - (\theta - \theta^R)s(\theta^R). \tag{37}$$

The last two terms taken together are positive since

$$\int_{\theta^R}^\theta s(x)dx \geq (\theta^R - \theta)s(\theta^R), \tag{38}$$

due to the monotonicity condition,

$$s(\theta)\theta - F(\theta) \geq s(\theta^R)\theta - F(\theta^R), \tag{39}$$

so that local incentive compatibility plus monotonicity implies global incentive compatibility (modulo some technical integrability conditions).

Lastly, note that the first order condition (31) can also be written in terms of informational rents as

$$\frac{dU}{d\theta} = s(\theta) - \frac{d\Delta\pi_0(\theta)}{d\theta}. \tag{40}$$

So the lemma contains versions of the first and second order conditions for local incentive compatibility, which imply global incentive compatibility in this case. □

Proof of Proposition 1: First note that the chosen $s^*(\theta)$ is non-decreasing because $\Delta\pi_0(\theta)$ is convex, and hence satisfies the first part of Lemma 2. Next note that from (12), it is obvious that the chosen $s^*(\theta)$ produces $dU(\theta)/d\theta = 0$, and that the given $F(\theta)$ sets $U(\theta) = 0$, $\forall\theta$, which is consistent with $dU(\theta)/d\theta = 0$, and hence satisfies the second part of Lemma 2. We can therefore conclude that the scheme satisfies the incentive compatibility constraint. Furthermore, the zero information rents also satisfy the participation constraint $U(\theta) \geq 0$, and, as argued in the main text, participation implies foreclosure. □

Proof of Lemma 3: It is obvious that the proposed contract satisfies (PC) with equality, and that participating banks foreclose under the contract. It remains to be shown that the contract is incentive compatible.

Suppose we were to offer the contract under which all banks participate, with the set of participating banks as $\Theta'_P = [\hat{\theta}, 1]$ (the *full menu*). This implies that all banks foreclose, i.e $\Theta_F = [0, 1]$. Under this contract, the value of equity is continuous and (weakly) convex θ^R. To see this, substitute the proposed contract into (6), note that the result is continuous in θ^R, then take the second derivative with respect to θ^R to find that

$$\frac{d^2\Pi(\theta, \theta^R)}{(d\theta^R)^2} = -\left((\rho - \bar{\varepsilon}) + \frac{d\Delta\pi_0(\theta^R)}{d\theta^R}\right)\phi(\bar{\varepsilon})\frac{d\bar{\varepsilon}}{d\theta^R} + (1 - \Phi(\bar{\varepsilon}))\frac{d^2\Delta\pi_0(\theta^R)}{(d\theta^R)^2}, \qquad (41)$$

where $\bar{\varepsilon}$ is given by (7) with the proposed contract substituted in. Some algebra shows that the term $\left((\rho - \bar{\varepsilon}) + \frac{d\Delta\pi_0(\theta^R)}{d\theta^R}\right)$ always has the opposite sign as $d\bar{\varepsilon}/d\theta^R$ (this parallels the proof of Lemma 1). The first term is therefore always non-negative. The second term is always non-negative since $\Delta\pi_0(\theta^R)$ is convex in θ^R for $\theta^R > \hat{\theta}$ and flat in θ^R for $\theta^R \leq \hat{\theta}$. This implies that the second derivative is always non-negative.[22]

The convexity implies that all banks either report $\theta^R = 0$ or $\theta^R = \theta$. We note that (i) $\Pi(\theta, 0) = \pi_0^G(\theta)$, i.e. that reporting a type of 0 produces the same value of equity as when not participating and gambling, and that (ii) $\Pi(\theta, \theta) = \pi_0(\theta)$ by the definition of $\Delta\pi_0(\theta)$, i.e. that reporting truthfully produces the same equity value as when not participating and taking the privately optimal action (either foreclosing or gambling).

Banks with type θ such that $\theta \leq \hat{\theta}$ want to foreclose outside the scheme, since for them, $\pi_0(\theta) = \pi_0^F(\theta) \geq \pi_0^G(\theta)$. Here, this (trivially) means that $\Pi(\theta, 0) = \pi_0^G(\theta) \leq \pi_0(\theta) = \Pi(\theta, \theta)$ and therefore it is optimal for them to report their type truthfully. Banks with a type θ such that $\theta > \hat{\theta}$ (i.e. with $\theta \in \Theta'_P$) want to gamble outside the scheme, since for them, $\pi_0(\theta) = \pi_0^G(\theta)$ ($\geq \pi_0^F(\theta)$). By construction, $\Pi(\theta, \theta) = \pi_0^G(\theta)$ for such banks and they are therefore indifferent between truthfully reporting their type or lying and reporting a type of $\theta^R = 0$. Together, this implies that the *full menu* must be incentive compatible.

Now consider deleting an arbitrary subset Θ_{NP} from Θ'_P to obtain the smaller set Θ_P, such that $\Theta_P = \Theta'_P \setminus \Theta_{NP}$.

First, note that for banks with $\theta \in \Theta_P$, reporting $\theta^R \in \Theta_{NP}$ cannot be optimal, because it implies receiving no transfer, and taking an action that is not privately optimal. Such banks can therefore always obtain strictly higher values of equity by reporting their type truthfully.

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[22]As an alternative to the explicit derivation of the second derivative, note that to obtain the expression equivalent to (2) under the proposed contract, we need to substitute in $\gamma(\theta^R) = \theta^R$, and add $T(\theta^R)$ into the integrand. Since (2) is convex in γ, and $T(\theta^R)$ is (weakly) convex in θ^R, the resulting expression is obviously convex in θ^R.

Second, note that for banks with $\theta \in \Theta_{NP}$, previously, they would have always decreased the value of equity below $\pi_0^G(\theta)$ by reporting a $\theta^R \in \Theta_P'$ which differed from their true θ. This means that also now, they will always decrease the value of equity below $\pi_0^G(\theta)$ by reporting a $\theta^R \in \Theta_P$, because $\Theta_P \subseteq \Theta_P'$. However, if they report their type truthfully in Θ_{NP}, they obtain $\pi_0(\theta)^G$. This means that they will be indifferent between truthfully reporting their type or lying and reporting a type of $\theta^R = 0$.

Since Θ_{NP} is arbitrary, the contract for any arbitrary set Θ_P of participating banks is incentive compatible. $\qquad\square$

Proof of Proposition 2: It is obvious that the proposed optimal contract satisfies (PC) with equality. From direct consideration of the welfare function it is immediate that the proposed contract maximizes welfare, subject to the constraint (PC) (see the main text for a verbal argument). Apply Lemma 3 to see that the proposed contract is incentive compatible. $\qquad\square$

Proof of Proposition 3: Suppose that the regulator offers a menu of contracts that induces a set of banks with $\theta \in [\hat{\theta}, \theta^C]$ to participate. Since unanimity of debt holders is required for the scheme to be implemented, it is immediate from (22) and (23) that all debt holders will accept any haircut h less than $h(\theta^C)$ defined as

$$h \equiv 1 - \int_{\hat{\theta}}^{\theta^C} R_0^D(\theta) \frac{\psi(\theta)}{\Psi(\theta^C) - \Psi(\hat{\theta})} d\theta,$$

since they are ex-ante identical debt holders. Furthermore, since funds are costly, any haircut lower than $h(\theta^C)$ cannot maximize welfare.

Given $h(\theta^C)$ the problem that the regulator solves corresponds to

$$\max_{\gamma(\theta), T(\theta)} \int_0^1 \left[1 - \theta - \theta E(\varepsilon) + (\rho - E(\varepsilon))\gamma(\theta) - \lambda\left(T(\theta) - h(\theta^C)D\right)\right] \psi(\theta)d\theta.$$

Whether or not debt holders accept the haircut affects whether or not a bank can participate, but does not otherwise affect the value of equity. We can see that the contract described in Lemma 3 can again be offered to banks: this will eliminate the information rents of bank equity holders. Using the fact that $\gamma(\theta) = \theta$ for participating banks in this contract, we can express the regulator's program as

$$\max_{\theta^C} \int_{\hat{\theta}}^{\theta^C} \left[1 - \theta + \theta\rho - \lambda\left(T(\theta) - h(\theta^C)D\right)\right] \psi(\theta)d\theta,$$

where $T(\theta) = \Delta\pi_0(\theta)$, and $h(\theta^C)$ is as described above. Using these expresssions, and noting that by definition, $\Delta\pi_0(\theta) + DR_0^D(\theta) \equiv \theta(E[\varepsilon] - \rho) + D$, we can now compute the total cost

of the scheme as

$$\int_{\hat{\theta}}^{\theta^C} (T(\theta) - h(\theta^C)D)\psi(\theta)d\theta = -\int_{\hat{\theta}}^{\theta^C} \theta(\rho - E[\varepsilon])\psi(\theta)d\theta < 0.$$

Since the scheme has a negative cost and at the same time creates an increase in social welfare through foreclosure of bad loans, it becomes optimal to choose $\theta^C = 1$. □

Proof of Proposition 4: In the no commitment case, the regulator proposes a scheme in the first stage, including a haircut h^{NC} and a schedule $T(\gamma)$. Debt holders decide whether to accept the haircut or not. In the second stage, the regulator can revise the contract, but cannot make an offer to debtholders any more.

If some debt holders reject the contract in the first stage, the problem that the regulator faces in the second stage is identical to the one in the benchmark model, and thus the optimal contract in this last stage is described by Proposition 2, and banks $\theta \in [\hat{\theta}, \theta^*]$ will be asked to participate.

Therefore, in the first stage, debt holders will accept a haircut no higher than $h(\theta^{NC})$ as implicitly defined by

$$U^D(h(\theta^{NC}), \theta^{NC}) \equiv U^D(0, \theta^*),$$

where θ^{NC} is the bank with the highest value of θ that decides to participate. After some algebra, this haircut evaluates to

$$h(\theta^{NC}) = \frac{\Psi(\theta^{NC}) - \Psi(\theta^*)}{\Psi(\theta^{NC}) - \Psi(\hat{\theta})} - \int_{\theta^*}^{\theta^{NC}} R_0^D(\theta) \frac{\psi(\theta)}{\Psi(\theta^{NC}) - \Psi(\hat{\theta})} d\theta. \tag{42}$$

It is easy to show that this maximum haircut that debt holders will accept is positive only as long as $\theta^{NC} > \theta^*$. That is, debt holders are willing to accept a positive haircut when their bank participates, if more banks get to participate. Since funds are costly, any haircut lower than $h(\theta^{NC})$ cannot maximize welfare. The question is whether the regulator will choose $\theta^{NC} = \theta^*$ and a zero haircut, or $\theta^{NC} > \theta^*$ and the corresponding positive haircut.

Notice that whether a bank can participate or not depends on its debt holders accepting the haircut. Contingent on accepting, the value of equity is unaffected. Thus, we can see that the contract described in Lemma 3 can again be offered to banks: this will eliminate the information rents of bank equity holders. Using the fact that $\gamma(\theta) = \theta$ for participating banks in this contract, we can express the regulator's program as

$$\max_{\theta^{NC}} \int_{\hat{\theta}}^{\theta^{NC}} \left[1 - \theta + \theta\rho - \lambda \left(T(\theta) - h(\theta^{NC})D\right)\right] \psi(\theta)d\theta,$$

where $T(\theta) = \Delta\pi_0(\theta)$, and $h(\theta^{NC})$ is as described above. Using these expressions, and noting that by definition $\Delta\pi_0(\theta) + DR_0^D(\theta) \equiv \theta(E[\varepsilon] - \rho) + D$, we can now compute the total cost

of the scheme as

$$\int_{\hat{\theta}}^{\theta^{NC}} (T(\theta) - h(\theta^{NC})D)\psi(\theta)d\theta = \int_{\hat{\theta}}^{\theta^*} \Delta\pi_0(\theta)\psi(\theta)d\theta - \int_{\theta^*}^{\theta^{NC}} (\rho - E[\varepsilon])\theta\psi(\theta)d\theta \qquad (43)$$

The first term is the cost of the scheme if debt holders reject and the regulator offers the contract of Proposition 2 in the second stage. As the regulator raises θ^{NC} above θ^*, debt holders are willing to accept positive haircuts that leave the value of debt unchanged relative to that situation. This means that the total transfers to debt holders (the first term) remain the same. However, as additional banks are bailed out, this creates positive net present value, which the regulator can appropriate, since debt holders are held to their participation constraint (the second term). This implies that the total cost of the scheme is *decreasing* in θ^{NC} and hence the regulator chooses $\theta^{NC} = 1$. $\qquad\square$

B Foreclosing good loans

As explained in Section 4, we suppose that foreclosing a good loan produces a recovery $\rho_G < 1$, potentially different from the recovery obtained when foreclosing a bad loan, ρ. We consider the foreclosure subsidy implementation, and the asset buyback implementation of our optimal contract. We show that the foreclosure subsidy implementation of the contract in Proposition 2 is incentive compatible as long as $\rho_G - \rho$ is "small enough" (in a sense to be made precise below), and that the asset buyback implementation is always incentive compatible.

Foreclosure subsidy implementation Consider a foreclosure subsidy implementation of the optimal contract. If a bank is targeting a given transfer and therefore has to foreclose a given amount of loans, it will foreclose good loans if the opportunity cost of doing so is lower than the cost of foreclosing bad loans. That is, if

$$\rho - E[\varepsilon|\varepsilon > \bar{\varepsilon}] > \rho_G - 1, \qquad (44)$$

or

$$\rho_G - \rho < 1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]. \qquad (45)$$

As long as $\rho_G > \rho$, it is possible that some banks that are very unlikely to survive (and hence have a high $E[\varepsilon|\varepsilon > \bar{\varepsilon}]$) foreclose good loans before foreclosing bad loans. This happens when the probability of survival is so small ($\bar{\varepsilon}$ is so high) that the expected return conditional on survival of bad loans that are rolled is very similar to the return on good loans, and the recovery on good loans is much higher than the recovery on bad loans. Since foreclosing good

loans makes a bank even less likely to survive (increases $\bar{\varepsilon}$ and hence $E[\varepsilon|\varepsilon > \bar{\varepsilon}]$), a bank that starts foreclosing good loans would foreclose all good loans before considering foreclosing bad loans. If $\rho_G \leq \rho$, all banks will always foreclose all bad loans before considering foreclosing good loans.

We first consider the case where $\rho_G \leq \rho$, and then consider the case where $\rho_G > \rho$.

Case I: $\rho_G \leq \rho$. In this case, banks will only consider foreclosing good loans once they have already foreclosed all bad loans. Under our optimal contract, if a bank reports type θ^R, where $\theta^R > \theta$, it will therefore have to foreclose an amount $\theta^R - \theta$ of good loans in addition to foreclosing all of its bad loans. Its value of equity would then be

$$\Pi(\theta, \theta^R) = \underbrace{1 - \theta - (\theta^R - \theta)}_{\text{remaining good loans}} + \underbrace{(\theta^R - \theta)\rho_G}_{\text{foreclosed good loans}} + \underbrace{\theta\rho}_{\text{foreclosed bad loans}} - D + \Delta\pi_0(\theta^R) \qquad (46)$$

or, rearranging and inserting the expression for $\Delta\pi_0(\theta^R)$,

$$\Pi(\theta, \theta^R) = \pi_0(\theta^R) + (\rho_G - \rho)(\theta^R - \theta) \leq \pi_0(\theta^R) < \pi_0(\theta). \qquad (47)$$

Since the value of equity from participating and truthfully reporting is equal to $\pi_0(\theta)$, a bank would therefore never have incentives to overreport its type, and the optimal contract is robust in this case.

Case II: $\rho_G > \rho$. Here, we need to distinguish two subcases. Define the proportion of bad loans $\theta^\dagger$ as the proportion for which

$$1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}] = \rho_G - \rho. \qquad (48)$$

Since $\bar{\varepsilon}$ and hence $E[\varepsilon|\varepsilon > \bar{\varepsilon}]$ are increasing in θ, banks with $\theta < \theta^\dagger$ are so safe that for them, foreclosing bad loans is less costly than foreclosing good loans. Since foreclosing some bad loans makes them safer, they will foreclose all bad loans before foreclosing any good loans. Conversely, banks with $\theta > \theta^\dagger$ will be so risky that for them, foreclosing bad loans will be more costly than foreclosing good loans. Since foreclosing some good loans makes them even riskier, they will foreclose all good loans before foreclosing any bad loans.

Consider first the safer banks for which $\theta < \theta^\dagger$. Using the same argument as in the previous case, we can work out that such banks, when reporting θ^R, have a value of equity of

$$\Pi(\theta, \theta^R) = \pi_0(\theta^R) + (\rho_G - \rho)(\theta^R - \theta). \qquad (49)$$

We note that this expression is convex in θ^R, which implies that either, banks will want to report truthfully, or overstate their type as much as possible. Since the highest type that

still obtains a transfer is θ^*, we see that such banks will not want to overstate their type at all as long as the recovery ρ_G on good loans is not much larger than the recovery on bad loans ρ, or

$$\pi_0(\theta^*) + (\rho_G - \rho)(\theta^* - \theta) < \pi_0(\theta), \tag{50}$$

which can be rewritten as

$$\rho_G - \rho < \frac{\pi_0(\theta) - \pi_0(\theta^*)}{\theta^* - \theta}. \tag{51}$$

Consider now the riskier banks for which $\theta > \theta^\dagger$. We separately consider the case in which $\theta^R < 1 - \theta$, i.e. banks that foreclose some of their good loans but none of their bad loans, and the case in which $\theta^R > 1 - \theta$, in which banks foreclose all of their good loans and some of their bad loans.

When $\theta^R < 1 - \theta$, banks foreclose an amount θ^R of their good loans, and none of their bad loans. We can write the value of equity as

$$\Pi(\theta, \theta^R) = \int_{\bar{\varepsilon}}^1 \left(\underbrace{1 - \theta - \theta^R}_{\text{remaining good loans}} + \underbrace{\theta^R \rho_G}_{\text{foreclosed good loans}} + \underbrace{\theta \varepsilon}_{\text{remaining bad loans}} - D + \Delta\pi_0(\theta^R) \right) \phi(\varepsilon) d\varepsilon, \tag{52}$$

for a suitably defined $\bar{\varepsilon}$.

Rearranging and inserting the expression for $\Delta\pi_0(\theta^R)$, we obtain

$$\Pi(\theta, \theta^R) = \int_{\bar{\varepsilon}}^1 \left(\theta^R(\rho_G - \rho) - \theta(1 - \varepsilon) + \pi(\theta^R) \right) \phi(\varepsilon) d\varepsilon. \tag{53}$$

There is now a tradeoff: Foreclosing good loans means a higher recovery of (term in $\rho_G - \rho$), but also means exchanging the return on good loans against the return on bad loans (term in $1 - \varepsilon$).

Taking derivatives with respect to θ^R, we can see that

$$\frac{\partial\Pi(\theta, \theta^R)}{\partial\theta^R} = \int_{\bar{\varepsilon}}^1 \left((\rho_G - \rho) + \frac{d\pi_0(\theta^R)}{d\theta^R} \right) \phi(\varepsilon) d\varepsilon = (1 - \Phi(\bar{\varepsilon})) \left((\rho_G - \rho) + \frac{d\pi_0(\theta^R)}{d\theta^R} \right), \tag{54}$$

which is positive iff $\rho_G - \rho > -\frac{d\pi_0(\theta^R)}{d\theta^R}$. But since

$$-\frac{d\pi_0(\theta^R)}{d\theta^R} = \int_{1-(1-D)/\theta^R}^1 (1 - \varepsilon)\phi(\varepsilon) d\varepsilon = (1 - \Phi(\bar{\varepsilon}))(1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]), \tag{55}$$

we can see that

$$\rho_G - \rho > 1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}] > (1 - \Phi(\bar{\varepsilon}))(1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]), \tag{56}$$

i.e. this derivative is always positive. This means that such banks will foreclose as many of their good loans as possible.

When $\theta^R > 1-\theta$, banks foreclose all of their good loans, $1-\theta$, and an amount $\theta^R - (1-\theta)$ of bad loans. In other words, they roll over an amount $\theta - (\theta^R - (1-\theta)) = 1 - \theta^R$ of bad loans. We can write the value of equity as

$$\Pi(\theta, \theta^R) = \int_{\bar{\varepsilon}}^1 \left(\underbrace{(1-\theta)\rho_G}_{\text{foreclosed good loans}} + \underbrace{(\theta^R - (1-\theta))\rho}_{\text{foreclosed bad loans}} + \underbrace{(1-\theta^R)\varepsilon}_{\text{remaining bad loans}} - D + \Delta\pi_0(\theta^R) \right) \phi(\varepsilon)d\varepsilon \tag{57}$$

Rearranging and inserting the expression for $\Delta\pi_0(\theta^R)$, we obtain

$$\Pi(\theta, \theta^R) = \int_{\bar{\varepsilon}}^1 \left((1-\theta)(\rho_G - \rho) - (1-\theta^R)(1-\varepsilon) + \pi_0(\theta^R) \right) \phi(\varepsilon)d\varepsilon. \tag{58}$$

Taking derivatives with respect to θ^R, we can see that

$$\frac{\partial\Pi(\theta, \theta^R)}{\partial\theta^R} = \int_{\bar{\varepsilon}}^1 \left(1 - \varepsilon + \frac{d\pi_0(\theta^R)}{d\theta^R} \right) \phi(\varepsilon)d\varepsilon \tag{59}$$

$$= (1 - \Phi(\bar{\varepsilon}))\left((1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]) - (1 - \Phi(\bar{\varepsilon}))(1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]) \right) \tag{60}$$

$$= (1 - \Phi(\bar{\varepsilon}))\Phi(\bar{\varepsilon})(1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]) > 0, \tag{61}$$

i.e. this derivative is always positive. This means that such banks will want to overstate their type as much as is possible.

Since the highest type that still obtains a transfer is θ^R, we see that banks with $\theta > \theta^\dagger$ will not want to overstate their type as long as

$$\int_{\bar{\varepsilon}}^1 \left(\min(\theta^*, 1-\theta)(\rho_G - \rho) - \min(\theta, 1-\theta^*)(1-\varepsilon) + \pi_0(\theta^*) \right) \phi(\varepsilon)d\varepsilon < \pi_0(\theta), \tag{62}$$

$$(1 - \Phi(\bar{\varepsilon}))\left(\min(\theta^*, 1-\theta)(\rho_G - \rho) - \min(\theta, 1-\theta^*)(1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]) + \pi_0(\theta^*) \right) < \pi_0(\theta), \tag{63}$$

or

$$\rho_G - \rho < \frac{1}{\min(\theta^*, 1-\theta)} \left(\frac{\pi_0(\theta)}{1 - \Phi(\bar{\varepsilon})} - \pi_0(\theta^*) + \min(\theta, 1-\theta^*)(1 - E[\varepsilon|\varepsilon > \bar{\varepsilon}]) \right), \tag{64}$$

for suitably defined $\bar{\varepsilon}$. We note that the right-hand side of the previous expression is always bigger than zero.

We can see that in general, when $\rho_G \geq \rho$, as long as the difference $\rho_G - \rho$ is small enough, banks will not have incentives to overstate their type.

Asset buyback implementation   If the scheme is implemented as an asset buyback as discussed in Section 3.3, banks will never have incentives to overstate their type. Intuitively, this happens because under an asset buyback, the recovery when a loan is foreclosed accrues

to the regulator, and not to the bank. Therefore, even if $\rho_G > \rho$, the bank does not benefit from the higher recovery on the good loan when foreclosing this instead of a bad loan, but the regulator does. Under a buyback implementation, banks therefore never have incentives to foreclose good loans to obtain higher transfers. (We skip the formal argument here, but note that it is similar to the foreclosure subsidy argument for Case I: $\rho_G \leq \rho$ above.)

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