Bank restructuring under asymmetric information: The role of bad loan disposals*

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May 13, 2023

Abstract

We study restructuring solutions to the debt overhang problem faced by banks with a deteriorated loan portfolio in the presence of asymmetric information on loan quality. Classical liability restructuring solutions fail to work because banks can overstate the severity of their bad loan problem to obtain additional concessions from existing creditors. A sufficiently large loan sale requirement to the restructuring banks discourages such an opportunistic behavior, so a suitably chosen menu of loan sales cum liability restructuring is able to solve the debt overhang. We discuss the implementation of such a solution for banks funded with insured deposits through loan sales to outside investors supported by an asset protection scheme sponsored by the deposit insurance fund.

JEL Classification: G01, G20, G28

Keywords: non performing loans, deposit insurance, debt overhang, optimal restructuring, state aid

*The views expressed in this paper are our own and do not necessarily coincide with those of the Bank of Italy. We would like to thank Paolo Angelini, Jean Edouard Colliard, Christian Eufinger, Hendrik Hakenes, Luc Laeven, Frederic Malherbe, Alberto Martin, Natalya Martynova, Giorgia Piacentino, Jorge Ponce, and Claudia Robles Garcia, as well as audiences at Bristol Worshop on Banking and Financial Intermediation, EuroFIT Conference at UCL, European Banking Center Network Conference, European Summer Symposium in Financial Markets in Gerzensee, Financial Intermediation in a Globalized World in Frankfurt, MadBar 2019, SAEe2019, and seminars at Bank of Italy, Bundesbank, Cass Business School, ECB, Esade, and Vienna for helpful comments. Contact e-mails: anatoli.seguravelez@bancaditalia.it and suarez@cemfi.es.

1 Introduction

Deteriorated loan quality and asymmetric information regarding the number and the identity of the bad loans constitute a common feature of banking crises.[1] In an initial phase, authorities' interventions during crises tend to be directed to address the risk of runs through the extension of guarantees on bank debt and/or lending of last resort. But once liquidity problems are addressed, long term solvency and viability concerns come to the forefront. As asset quality problems pose a threat to the solvency of the banks and a drag on their capacity to continue lending, banking crises enter a second, bank restructuring phase. Such a phase typically involves initiatives by public authorities for the recapitalization of the damaged banks and some plan for taking their bad loans (or other "toxic assets") away from their balance sheet (commonly through their sale to an asset management company, AMC, a bad bank or some other third party).[2] This paper is about this second phase of banking crises and the rationale for bank restructuring solutions that involve loan sales.

Liability restructuring is frequently understood as the response to the debt overhang problem of Myers (1977), which results from the excessive appropriation of the returns of new profitable investment opportunities by the preexisting senior creditors and, in its classical presentation, can always be solved, in the benefit both of creditors and shareholders, if the senior creditors make concessions in the form of debt write-downs or debt-for-equity swaps. From this perspective, asset sales are not necessarily part of the solution. In this paper, we show that the conclusion changes once asymmetric information about the quality of the legacy loans is added to the picture.

Specifically, we find that asset sales are necessary to avoid an excessive appropriation of

[1] Asymmetric information on the bad loan problem arises due to the opacity of banks' relationships with their borrowers and bank practices such as misreporting and evergreening.

[2] The Swedish banking crisis of the early 90s provides a prominent example of a solution to a bad loan legacy problem through the establishment of government owned AMCs (for details see Dreyer, 2021). In Europe, the impact of the Global Financial Crisis and Sovereign Debt Crisis left the banking sector of several countries saddled with bad loans, leading to a series of initiatives to reduce the stock of legacy loans. Following a model used earlier in Ireland and Germany (see, e.g., Medina Cas and Peresa, 2016), The Spanish government created a bad bank (Sareb) devoted to acquire deteriorated real estate assets from distressed credit institutions in the context of their broader restructuring (). Italian and Greek governments instead facilitated the disposal of deteriorated loans with a publicly funded asset protection schemes (in Italy, the Garanzia Cartolarizzazione Sofferenze, GACS; and in Greece, the Hellenic Asset Protection Scheme, Hercules) aimed to limit the potential losses of the investors buying the loans. More recently, Acharya and Rajan (2020) have advocated for the creation of a bad bank in India to address the protracted high level of deteriorated loans.

rents by bank owners (which can render bank restructuring unacceptable to the senior creditors) when the former have information about the deteriorated loans that other investors do not have. Under a proper design, combining debt write-downs with asset sales allows for the restructuring of the more troublesome banks without inducing better banks to mimic them in order to benefit from similar concessions from their creditors. In a bank context in which the legacy creditors are insured depositors, we show that the concessions behind the restructuring plans that solve the debt overhang are then to be made by the deposit insurance fund (DIF), which by doing so will defend its own financial interests. We finally argue that these concessions can be implemented through an asset protection scheme provided for free by the DIF to the buyers of the loans banks are required to sell (e.g. offering partial guarantees on the loan repayments). Intuitively, under this implementation, the better price received for the bad loans thanks to the protection scheme compensates bank owners for some of the value gains that the DIF obtains from the new lending. Other equivalent implementations would include combining the unprotected sale of the loans with a transfer to the bank or to embed the necessary transfer in a subsidy to the purchase of distressed loans.

Thus, our analysis offers insights for the management of the restructuring phase of banking crises. It provides an explanation to the role of (bad) asset sales in bank restructuring and to the common involvement of authorities that represent the interest of the DIF in support of such sales. This explanation applies both in the context of the restructuring of a specific bank, where authorities can participate in the creation of a bad bank to which the bad assets get transferred, and to the sponsoring of industry-wide solutions such as a public asset management company (AMC) or asset protection schemes that insure third party buyers of bad assets against losses above a certain threshold. Our results highlight the importance, to deal with informational asymmetries, of the direct or state contingent support of legacy loan sales by the DIFs or eventually by the governments that provide DIFs with a fiscal backstop.[3] So our results help to shed light on the vivid debate over the past decade on the use of public funds to tackle with the bad loan legacy problem in Europe (see, e.g., Hellwig, 2017).

Further details on the model setup and results

[3] This role of the DIF in bank restructuring is akin to that often undertaken by the FDIC to support the wind down of failing banks under the least cost principle. The recent proposal by the European Commission (2023) for the review of banks' crisis management aframework in the European Union also envisages the use of national deposit insurance funds in resolution following the least cost principle.

We build on a model that restates the debt overhang problem of Myers (1977) in a banking context. We start considering an economy with two dates in which a continuum of banks initially have a portfolio of legacy loans and some outstanding senior debt, both maturing at the final date. The banks have also access to new lending opportunities with positive NPV that require raising fresh new funding, which we assume can only be provided by junior investors. Since their extension at some prior unmodeled date, a fraction of the legacy loans have deteriorated (bad loans), meaning that their payoffs in all future states of the economy will be (weakly) lower than those of the non-deteriorated loans (good loans). Banks only differ on their amount of bad loans, which is private information of the bank owners.

The presence of bad loans makes bank owners reluctant to finance the new lending. As in Myers (1977), they anticipate that part of the returns of such investments will be appropriated by the legacy creditors in the form of lower losses in case of failure (or a lower probability of failure). In the absence of concessions from the legacy creditors, this situation precludes new lending for banks with a sufficiently large amount of bad loans.

We formulate the analysis of solutions to the debt overhang by considering an authority that mediates between bank owners and the legacy creditors, which in the baseline version of the model hold uninsured debt and, hence, directly absorb the financial implications of any restructuring. The authority operates with no budget and is subject to the constraint that all the stakeholders (weakly) benefit from the proposed solution. It can make restructuring plans that require all participating banks to supply new lending and involve the restructuring of the banks' assets (legacy loan sales) and/or liabilities (write-downs of outstanding debt and/or debt-for-equity swaps). In order to address the informational asymmetry, the authority can propose a menu of restructuring plans that specifies a plan for each possibly reported fraction of bad loans by banks. Since bank owners possess private information about the quality of their legacy loans, the restructuring plan menu must deal with truth telling constraints, that is, prevent banks' from wanting to manipulate their reporting of bad loans to achieve a more advantageous restructuring plan.

We first consider plans that only involve the restructuring of liabilities, that is, reductions in the face value of the outstanding debt and/or its partial conversion into equity. Our first result is that, opposite to what happens in the classical debt overhang setup without informational asymmetries, an authority that exclusively considers menus of liability restructuring

plans cannot always solve the debt overhang. This is the result of combining the asymmetric information with the need to ensure that the owners of banks with a larger fraction of bad loans do not lose from the undertaking of the new lending. Specifically, the latter requires that the liability restructuring plan designed for banks with more deteriorated legacy loans must include larger concessions from the legacy creditors, who would otherwise appropriate more of the value of the new lending.

We find that, in order to prevent over-reporting of the true amount of bad loans, a pure liability-restructuring plan menu must necessarily leave some rents to the owners of banks exposed to debt overhang (except those with the maximum fraction of bad loans) as well as to the owners of banks close to being exposed to debt overhang (that might otherwise be tempted to falsely report that they suffer the problem). But then, for some distributions of the amount of bad loans across banks, the aggregate rents appropriated by bank owners exceed the aggregate NPV of the new lending, making it impossible to avoid harming the legacy creditors with the restructuring. Thus, liability restructuring plans are an insufficient tool to solve the debt overhang.

We then consider the case in which the authority can add a legacy loan sale requirement to the plans. We assume that the sold loans are purchased by some competitive uninformed outside investors that, given a restructuring plan menu, rationally anticipate the equilibrium average quality of the loans they acquire from each bank. Under a given restructuring plan, bank owners face the same per unit price for all the loans that they are requested to sell and satisfy the disposal requirement following a "pecking order": selling bad loans first and, thus, selling good loans only after running out of bad loans. The authority can take advantage of banks' strict preference for the sale of bad loans (or reluctance to sell good loans) and use the loan sale requirement as a latent punishment for any potentially over-reporting bank.

The incentive compatibility of the arrangement can, in fact, be achieved by requiring all banks exposed to debt overhang to sell as many loans as bad loans they have, and to write down their outstanding debt setting a haircut on the legacy debt that just ensures bank owners are not harmed by the funding of the new lending. Under such a restructuring plan menu, investors in the secondary loan market expect only bad loans to be sold, and the equilibrium price reflects that. In addition, since truth-telling banks sell all their bad loans,

a bank tempted to over-report would have to meet any over-reporting by selling good loans at the price of bad loans. So over-reporting is prevented because the underpricing losses would exceed the value of the additional concessions obtained in the restructuring of their outstanding debt. A menu of restructuring plans that combines this loan sale requirement with the write-down of legacy debt can thus solve the debt overhang problem for arbitrary distributions of bad loans across banks.

In the last part of the paper we extend our results to a more bank specific environment in which the legacy creditors of the banks are insured depositors whose claims cannot be renegotiated.[4] A new bank stakeholder enters into play, namely the DIF, whose contingent liability vis-à-vis the insured depositors gets reduced when banks undertake the new lending.[5] Pure liability restructuring plans can be reinterpreted as bank recapitalizations by the DIF, and our results imply that the pure recapitalization tool is not sufficient in the presence of asymmetric information, in the sense that bank owners might receive rents that exceed the NPV of the new lending and, hence, make the DIF worse off. The menu of concessions from legacy creditors and loan sale requirements that solves the debt overhang problem in the baseline model, can now be reinterpreted as a menu of subsidies from the DIF to the outside investors who purchase the legacy loans banks are required to sell, where the per unit subsidy is increasing in the required sales. Finally, the subsidy related to loan sales in this solution could be implemented by the DIF by offering an asset protection scheme to the buyers of the legacy loans (e.g., a suitably fixed partial guarantee on the loan repayment) which induces buyers to pay a higher price for the loans. Thus, our results rationalize the involvement of the DIF in bank restructuring and, specifically, in the form of financially supporting the sale of bad loans by distressed banks. This role would be complementary to the statutory responsibilities of the DIF in paying off insured deposits and liquidating banks once banks fail in its does not only help overcome banks' debt overhang but, through the positive effect of the new lending on subsequent bank performance, it also contributes to

[4] In this discussion we implicitly assume that capital regulation prevents the new lending to be fully financed by new insured deposits (that is, debt with the same seniority as the outstanding debt), in which case the debt overhang problem would not occur.

[5] Dewatripont and Tirole (1993) describe deposit insurance as a social contract under which dispersed and unsophisticated bank depositors delegate the monitoring of banks to bank regulators who, in exchange, take resposibility for paying off the deposits when banks fail. Extending this logic to the case of distressed but not failed banks, classical creditors' role in debt restructuring would also correspond to the deposit insurer.

reduce the overall cost of the contingent liabilities of the DIF.

Related literature Our paper is related to prior work analyzing optimal interventions on distressed banks. Many of the existing contributions consider setups with asymmetric information regarding the quality of existing assets (and specifically the presence of bad loans). An earlier literature (see, for example, Berglof and Roland, 1995; Aghion et al., 1999; and Mitchell, 2001) focused on how to address bank owners' incentives to gamble using evergreening strategies. In that spirit, Bruche and Llobet (2013) address the inefficient rolling-over of bad loans from a mechanism-design perspective and characterize interventions that induce the disposal of bad loans (via subsidized asset purchases) without leaving informational rents to bank owners; however, they do not discuss whether the restructuring of bank liabilities could achieve the same outcome. In Diamond and Rajan (2011) the rationale for policy intervention comes from the interaction between distressed banks (that hold illiquid assets for gambling reasons) and sound banks (that hoard liquidity in order to profit from fire sales by distressed banks), which produces suboptimal investment in good assets; they show that the mandatory disposal of the illiquid assets can help improve aggregate outcomes. Philippon and Schnabl (2013) consider a setup in which asymmetric information on banks' new investment opportunities gives rise to both underinvestment in profitable projects and opportunistic investment in unprofitable risky ones. They study the design of a one-size-fits-all intervention on the population of distressed banks, showing the optimality of providing cash injections (that limit the debt overhang) in exchange for preferred stock and warrants (that limit risk shifting temptations). Bhattacharya and Nyborg (2013) consider asset sales in a setup that differs from ours in that investment opportunities are linked to the assets in place (so selling a proportion of the latter implies selling the same proportion of the former) and find that intervention menus based on either equity injections or asset buyouts provide entirely equivalent solutions to the debt overhang. We instead find a unique role for loan sales in bank restructuring when the new lending opportunities are not attached to the legacy loans when the latter are sold.The assumption that investment opportunities are attached to the sold assets makes sense in divestitures involving the sale in block of a division or business line but seems less appropriate than ours when, in a banking context, the sales refer exclusively to some specific (bad) loans. Banks selling bad loans can retain their license, brand name, organizational capital, etc., although there could be value losses

linked to lending relationships disrupted by the loan sale. and preserve their lending opportunities in Our assumption that the new investment opportunities do not go with the sold loans makes special sense if the relevant lending opportunities appear in sectors different to those concentrating the bad loans (e.g. lending to the corporate sector after a real estate crisis).

In broader terms, our paper is also connected to the corporate finance literature that emphasizes conflicts of interest between shareholders and debtholders, including earlier references to shareholders' reluctance to adopt strategies that reduce the value of their default option (Black and Scholes, 1973; Merton, 1974), the seminal debt overhang paper of Myers (1977), and papers that have considered the dynamic implications of these conflicts of interest in the presence of contracting frictions. Papers considering financial restructuring in the face of informational frictions include Webb (1987), who explains costly bankruptcy as an implication of informational asymmetries, and Giammarino (1989), who considers the bargaining between the firms and its creditors under asymmetric information and a Chapter 11 type reorganization procedure. Hennessy (2004) considers the debt overhang in a dynamic capital structure setup. Admati et al. (2017) consider the dynamics of leverage in a setting in which firms are unable to commit to future funding choices. To the best of our knowledge, beyond the aforementioned bank-related papers, the distinct role of asset sales in financial restructuring has not been comprehensibly analyzed at a theoretical level in spite of the important role of asset divestitures in practical corporate restructuring.[6]

The discussion of the debt overhang problem in the context where bank depositors are protected by deposit insurance and the concessions implied by the optimal restructuring plans take the form of subsidies from the DIF makes our paper also connected to a broader literature on bank bailouts. Papers in such a literature, including Freixas (1999), Acharya and Yorulmazer (2007), Diamond and Rajan (2012), Farhi and Tirole (2012), Keister (2016),

[6]Eckbo and Thorburn (2013) report that publicly announced asset divestiture deals by US firms during the period 1971-2011 represented on average more than 30% of merger and acquisition volume (Figure 3.1). The empirical literature associates many of these deals with financial distress (e.g., Asquith et al., 1992; Ofek, 1993) but, outside the literature dealing with the debt overhang in a banking context, theoretical research establishing what makes asset restructuring especial is scant. Some dynamic capital structure models allow firm to react to negative shocks using both asset sales and debt buybacks (e.g. Reindl, 2013; Nishihara and Shibata, 2016). In a related discussion, Edmans and Mann (2019) consider a setup similar to Myers and Majluf (1984) and compare financing via asset sales with financing via the issuance of equity.

Colliard and Gromb (2018), and Walther and White (2020) emphasize ex post motivations for bank bailouts (preventing contagion, credit crunches and other externalities or social costs of bank failures) and the potential conflict with ex ante incentives (excessive risk taking and other forms of moral hazard). Importantly, the menus of restructuring plans that solve the debt overhang problem in our model do not leave rents to bank owners and, thus, to a first approximation, would not aggravate (relative to the non-restructuring benchmark) a potential ex ante moral hazard problem from external debt funding that we do not explicitly analyze.

The rest of the paper is organized as follows. Section 2 describes the the model setup. Section 3 identifies the existence of a debt overhang problem among banks holding a sufficiently large fraction of bad loans. Section 4 analyzes solutions to the debt overhang in the presence of asymmetric information regarding the fraction of bad legacy loans held by the bank. Section 5 reinterprets the discussed solutions in the context of a bank whose legacy debt is in the form of insured deposits. Section 6 concludes. The Appendix shows that our results are robust to a notion of debt overhang solution that is weaker than that used in the main text.

2 The model

Consider an economy with two dates, $t = 0, 1$, in which all agents are risk-neutral and have a zero discount rate. There is a continuum of measure one of banks owned and managed by their shareholders, who we call *bankers*. At $t = 0$, the banks have legacy loans of heterogeneous quality and outstanding senior debt held by *legacy creditors*. They also have the opportunity to supply some new loans. The legacy loans can be sold to *outside investors* and the new lending is assumed to be funded, for simplicity, by the bankers.[7] The quality of the legacy loans is private information of the corresponding bankers. Finally, there is an *authority* who, in order to solve potential debt overhang problems, mediates between the

[7]By adopting the simplifying assumption that the new lending is directly financed by the bank owners, we can abstract from the impact of asymmetric information on the raising of the new funding. An equivalent assumption would be that some new financiers can, through a due diligence process, learn the relevant information. In practice, the new lending of a regulated bank might be funded with a combination of uninformed debt (perhaps even new insured deposits) and owners' equity. What our assumption means in such a context is that the funding coming from owners' equity is sizable enough for them to be the residual bearers of any risk stemming from the potentially varying quality of the bank's legacy assets..

banks and their senior creditors but has no power to impose a restructuring deal between them.

The banks' initial balance sheet

Each bank's assets in place at $t = 0$ consist of a measure one of loans whose individual quality can be either good (G) or bad (B). Each loan's quality determines its performance across the two aggregate states at $t = 1$, high ($s = H$) and low ($s = L$), which happen with probabilities $q \in (0,1)$ and $1 - q$, respectively. Good loans pay $A > 0$ in both states, while bad loans pay $A > 0$ in the high state and zero in the low state. Banks differ in the share θ of bad loans in their legacy loan portfolio, which follows a distribution $F(\theta)$ with strictly positive density in all its support $[0,1]$. We refer to θ as the bank's type. Hence, the overall payoff of the legacy loan portfolio of a bank of type θ across aggregate states is:

$$A_s(\theta) = \begin{cases} A & if\ s = H \\ A(1-\theta) & if\ s = L \end{cases} \tag{1}$$

Legacy loans can be sold to outside investors at $t = 0$ at a competitive price that will reflect their expectation about the quality of the purchased loans. Each bank's outstanding debt at $t = 0$ promises to repay $B < A$ to the legacy creditors at $t = 1$. Bankers initially own 100% of the residual equity claims of the bank, are protected by limited liability, and are privately informed about the quality of their bank's legacy loans and, hence, the bank's type.

New bank lending

Each bank has access at $t = 0$ to a new lending opportunity which requires one unit of funding. We assume without loss of generality that the lending opportunity is not scalable, and denote with $l = 1$ when the bank undertakes it, and with $l = 0$ when it does not. The payoff of the new lending at $t = 1$ is y in the two states of the economy. As anticipated above, we assume that the new lending, if occurring, is funded with the bankers' own funds.

We make three assumptions on the return of new lending:

Assumption 1. $y > 1$.

This assumption implies new lending has a positive net present value (NPV).

Assumption 2. $y > B$.

This simplifying assumption implies that the return of new lending is sufficient to honor the repayment B of the legacy debt.

Assumption 3. $(1-q)B > y - 1$.

This assumption introduces a debt overhang problem for banks with a big enough share θ of bad loans, whose legacy creditors would appropriate an excessively large portion of the NPV of the new lending. The authority in this setup aims to design restructuring plans that solve the debt overhang problem and are acceptable to all the involved parties (bankers, legacy creditors and new outside investors), thus increasing welfare in a Pareto sense.

Plan for the analysis

In the following sections, we will first consider the outcome of banks' decisions on new lending in the absence of restructuring, showing the emergence of a debt overhang among banks with a sufficiently large share of bad loans. Then we will consider the design of restructuring plans that (weakly) improve welfare for all the agents relative to the no-restructuring equilibrium.

3 The debt overhang problem under no restructuring

The analysis in this section highlights that, in the absence of restructuring, banks with large fractions of bad loans are exposed to a debt overhang: their new lending opportunities have positive overall NPV but their bankers will not profit from undertaking them because too much of such value would be appropriated by legacy creditors.

Consider a bank of type θ (or, to put it shorter, bank θ) and its decision about supplying or not the new lending. Bankers own and manage the bank so the decision is made in order to maximize the value of bankers' equity stake in the bank net of the contribution of new funding that they will have to make if undertaking the new lending. From Assumption 1 we have that new lending has positive NPV, so whenever bankers appropriate this NPV in full, the new lending will be supplied. This definitely happens when the value of the legacy loans

is sufficient to repay the legacy debt is full in both aggregate states, that is, $A(1-\theta) \geq B$. Otherwise, limited liability implies that, without the new lending, the bank will default on its legacy debt in the L state, while if the new lending is undertaken the debt will be repaid in full also in such a state (Assumption 2). From bankers' perspective, when $A(1-\theta) < B$, the new lending is optimal if and only if:

$$A(1-\theta) + qA\theta + y - B - 1 \geq q(A-B), \tag{2}$$

where the left hand side (LHS) is bankers' equity value (expected equity payoffs at $t=1$) net of the funding cost of the new lending, while the right hand side (RHS) is the value of their equity without new lending. Clearly this condition holds if and only if the share of bad loans exceeds a threshold value defined as that for which (2) holds with equality (such threshold lays in $(0,1)$ from Assumption 3). This takes us to the following result.

Proposition 1. *There exists a threshold $\overline{\theta} \in (0,1)$ such that, in the equilibrium without restructuring, only banks with $\theta \leq \overline{\theta}$ supply new lending. The threshold $\overline{\theta}$ is defined by:*

$$y - 1 = (1-q)\left(B - A(1-\overline{\theta})\right). \tag{3}$$

The proposition states that banks with a sufficiently large share of bad loans suffer from a debt overhang and forgo their (positive NPV) lending opportunities. The critical share of bad loans $\overline{\theta}$ above which new lending is not undertaken is defined by (3). Its LHS accounts for the NPV of the new lending, while its RHS accounts for the increase in the value of the legacy debt induced by the new lending when the share of bad loans is $\overline{\theta}$. The debt value gain in the RHS is explained by the fact that, under the L state of the economy at $t=1$, which happens with probability $1-q$, the new lending allows the promised repayment B to be fully honored, while in the absence of new lending the bank would only pay $A(1-\overline{\theta}) < B$ to the legacy creditors. For the banks with bad loans exceeding $\overline{\theta}$, the value appropriated by the legacy debtholders would exceed the NPV of the new lending and bankers would prefer to forgo the new lending.

Using Proposition 1, we can write the following expressions for the value of bank equity to bankers, $\overline{E}(\theta)$, and the value of the outstanding debt to the legacy creditors, $\overline{D}(\theta)$, in the

equilibrium without restructuring as functions of the bank's type θ:

$$\overline{E}(\theta) = \begin{cases} A(1-\theta) + qA\theta - B + y - 1 - c, & \text{if } \theta \leq \overline{\theta}, \\ q(A-B), & \text{if } \theta > \overline{\theta}, \end{cases} \tag{4}$$

$$\overline{D}(\theta) = \begin{cases} B, & \text{if } \theta \leq \overline{\theta}, \\ qB + (1-q)A(1-\theta), & \text{if } \theta > \overline{\theta}. \end{cases} \tag{5}$$

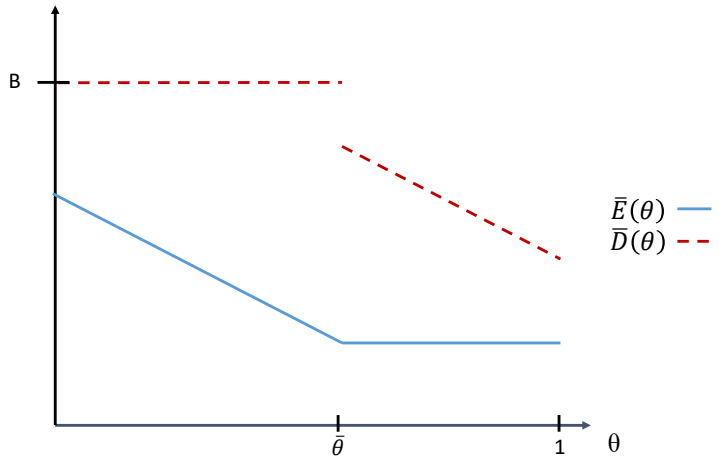
The dependence of these functions on a bank's type is depicted in Figure 1. In the region in which there is new lending ($\theta \leq \overline{\theta}$), increasing the share of bad loans of the bank leads to a reduction in the value of bank equity, while the outstanding debt is riskless and hence its value remains constant. In this case, equity value changes one-to-one with the value of the bank's legacy loans, while, for values of θ close to the threshold $\overline{\theta}$, the value of the outstanding debt is shielded from the increase in the share of bad loans thanks to the payoff of the new lending. In contrast, in the debt overhang region ($\theta > \overline{\theta}$), the impact of the share of bad loans on the value of the two claims gets inverted: equity value remains constant, while the value of outstanding debt falls with θ. This is because banks default in state L, and bankers only appropriate the residual value of the bank in state H, in which the two loan types pay the same and, hence, asset and equity payoffs are independent of θ. In this case, reductions in asset value due to rises in θ lead to one-to-one reductions of the value of the outstanding debt. This evidences that bankers take more advantage of the limited liability associated with their equity claims (in fact, only) when θ is above the debt overhang threshold $\overline{\theta}$.

Finally, notice that the value of equity is continuous at the the debt overhang threshold $\overline{\theta}$ while the value of the outstanding debt exhibits a discontinuity (equal to the NPV of the new lending) at that threshold. Indeed, we have from (3) that

$$\lim_{\theta \to \overline{\theta}^{+}} \overline{D}(\theta) = \overline{D}(\overline{\theta}) - (y-1), \tag{6}$$

which results from the fact that, at the debt overhang threshold, the legacy creditors appropriate all the NPV of the new lending, while, just at the right of the threshold such an NPV is just wasted since the new lending is not undertaken.

Figure 1: Value of bank equity and legacy debt without restructuring.



Note: The figure depicts the value of equity for bankers, $\overline{E}(\theta)$ (blue solid line), and the value of legacy debt, $\overline{D}(\theta)$ (red dashed line), without restructuring for each bank type θ.

4 Restructuring plans to solve the debt overhang

In this section we analyze the restructuring plans that an authority can propose at the initial date in order to solve the debt overhang of banks with a large share of bad loans. We consider an authority that mediates between the bankers and their legacy creditors but has no power to impose a restructuring deal. Hence, the restructuring plans must be acceptable to all parties. So we focus on restructuring plans that (weakly) increase welfare for all bankers and legacy creditors relative to the equilibrium without restructuring described in the previous section.

The analysis in this section is structured as follows. First we define a general class of restructuring plans which potentially involve the restructuring of both assets and liabilities and we establish conditions for those plans to solve the debt overhang and to do so in a distribution free manner (that is, which works for any possibly distribution of bank types $F(\theta)$ over the interval $[0, 1]$). Next we show that classical solutions to the debt overhang problem involving only (menus of) liability restructuring plans are not distribution free in our asymmetric information setup. Finally, we describe how adding a legacy loan sale requirement to the (menu of) liability restructuring plans allows to obtain distribution free solutions to the

debt overhang in this environment.

4.1 Restructuring plans and debt overhang solutions

In this section we introduce the general class of restructuring plans that authorities may propose to banks (or, indistinctively, bankers) and legacy creditors in our setup and define the notions of solution and distribution-free solution to the debt overhang problem.

Restructuring plans. A *restructuring plan* set by the authority for a given bank is a tuple $R = (z, B', \alpha, p)$ prescribing the following actions at $t = 0$: (i) the sale of a measure $z \in [0, 1]$ of the bank's legacy loans to outside investors, (ii) the restructuring of the outstanding debt by reducing the promised repayment to legacy creditors to $B' \leq B$ and by granting them a share $\alpha \in [0, 1]$ of the bank's equity, and (iii) the supply of new lending by the bank (financed with bankers' own funds). For notational convenience, we include in the description of the restructuring plan the per loan price p at which the competitive outside investors buy the legacy loans from the bank if $z \in (0, 1]$ and we set $p = 0$ if $z = 0$.

Since the quality of each loan is unobservable, the bank has discretion regarding which loans to sell to satisfy a loan disposal requirement z. We denote by $x \leq \min\{\theta, z\}$ the measure of bad loans the bank sells to comply with the disposal requirement, so that the remaining measure of sold loans, $z - x$, are good loans. We refer to x as the bank's loan disposal compliance decision. Notice that outside investors are unable to distinguish good and bad loans and, hence, assuming that they buy all loans at the common per loan price p (which will reflect their rational expectation about the choice of x by the bank) implies no loss of generality.

Before proceeding, we introduce some additional notation. The post-restructuring overall asset value for each state $s = H, L$ at $t = 1$ of a bank of type θ that complies with a requirement to sell z units of legacy loans at a price p by disposing of $x \leq \min\{\theta, z\}$ units of bad loans is:

$$A_s(x, R, \theta) = \begin{cases} zp + A(1 - z) + y, & s = H, \\ zp + A(1 - \theta - (z - x)) + y, & s = L. \end{cases} \tag{7}$$

Asset value in each state includes the proceeds zp from the loan disposal (assumed to be kept in a safe account between $t = 0$ and $t = 1$), the payoff from the retained legacy loans

(which in state $s = H$ is A of each of the $1 - z$ units of retained loans and in state $s = L$ is A only for the $1 - \theta - (z - x)$ units of retained good loans), and the payoff y of the new lending undertaken upon the restructuring.

Given a restructuring plan $R = (z, B', \alpha, p)$, the value of the bank of type θ to its bankers for a loan disposal compliance decision x is:

$$E(x, R, \theta) = (1 - \alpha)\mathbb{E}\left[\left(A_s(x, R, \theta) - B'\right)^+\right] - 1, \tag{8}$$

which accounts for the fact that the bankers keep a fraction $1 - \alpha$ of the residual equity payoffs of the bank under the restructured debt repayment B', and contribute the funding for the new lending. Using Assumption 2, $B' \leq B$, and (7), we have that the value of the restructured legacy debt is:

$$D(x, R, \theta) = \mathbb{E}\left[\min\left\{A_s(x, R, \theta), B'\right\}\right] = B', \tag{9}$$

which simply depends on B' and, hence, does not directly depend on the bank type θ, the loan disposal requirement z, the loan disposal price p, or the loan disposal compliance decision x. The equality simply states that the restructured legacy debt is safe, and this is because the new lending return y suffices to entirely repay it.

In order to address the asymmetric information problem we assume that the authority sets a restructuring plan *menu* defined as a set of type-specific restructuring plans

$$\mathcal{R} = \left(R(\theta) = \left(z(\theta), B'(\theta), \alpha(\theta), p(\theta)\right)\right)_{\theta \in [0,1]}.$$

Given the restructuring plan menu $\mathcal{R}$, each bank θ optimally decides which type $\hat{\theta}(\theta)$ to report and the bank is then subject to the restructuring plan $R(\hat{\theta}(\theta))$. By the Revelation Principle, we will focus on truth reporting restructuring plans, that is, menus inducing $\hat{\theta}(\theta) = \theta$ for all θ.

Debt overhang solutions. As already stated, we are interested in restructuring plans that induce new lending by all banks and make bankers and legacy creditors no worse off than without restructuring. These restructuring plans, if they exist, increase overall welfare in a

Pareto sense, that is, without negative redistributional implications for any agent, so they would be acceptable to bankers, legacy creditors and outside investors of all banks.

Formally, we say that a restructuring plan menu $\mathcal{R}$ is a *solution to the debt overhang* for the bank type distribution $F(\theta)$ if there exists a set of bank-type-contingent disposal compliance decisions $x(\theta) \leq \min\{\theta, z(\theta)\}$ satisfying:

- *Banks' truth-reporting constraint*s: Each bank θ finds it optimal to choose the restructuring plan $R(\theta) = (z(\theta), B'(\theta), \alpha(\theta), p(\theta))$ and the disposal compliance decision $x(\theta)$ given the restructuring plan menu $\mathcal{R}$:

$$E(x(\theta), R(\theta), \theta) = \max_{\theta' \in [0,1], x \leq \min\{\theta, z(\theta')\}} E(x, R(\theta'), \theta). \tag{10}$$

- *Bankers' participation constraint*s: The value of each bank θ to its bankers under the restructuring plan menu is no lower than in the equilibrium without restructuring:

$$E(x(\theta), R(\theta), \theta) \geq \overline{E}(\theta), \tag{11}$$

  where the no-restructuring bankers' value $\overline{E}(\theta)$ was defined in (4).

- *Legacy creditors' participation constraint*: The expected value of the restructured debt and equity obtained by banks' legacy creditors under the restructuring plan menu $\mathcal{R}$ is no lower than in the equilibrium without restructuring:

$$\begin{aligned} &\int B'(\theta) dF(\theta) + \\ &+ \int \alpha(\theta) \left(\mathbb{E}\left[A_s(x(\theta), R(\theta), \theta) \right] - B'(\theta) \right) dF(\theta) \quad \geq \quad \int \overline{D}(\theta) dF(\theta). \end{aligned} \tag{12}$$

  Since legacy creditors are initially uninformed about each bank's type, their participation constraint says that the expected value across all bank types of the claims received by legacy creditors after the restructuring must be no lower then the expected value across all bank types of the debt without restructuring. At both sides of the inequality, expectations are computed using the ex ante distribution of bank types $F(\theta)$. The first term in the LHS uses the fact that the restructured debt is always safe, as previously ex-

plained (see (9)); the second term is the expected value of the fraction $\alpha(\theta)$ of the equity of the restructured bank granted to the legacy creditors in the restructuring.[8] The value of outstanding debt in the equilibrium without restructuring, $\overline{D}(\theta)$, was introduced in (5).

- *Outside investors' competitive pricing of legacy loans*: For each bank type θ, the price $p(\theta)$ paid by the outside investors for each of the legacy loans disposed under the requirement $z(\theta)$ stipulated in the restructuring plan menu $\mathcal{R}$ allows them to break even, that is, equals the expected value of the payoffs of the combination of bad and good loans offered for sale by bank θ given the truthful revelation of its type revelation and the banks' disposal compliance decision $x(\theta)$:

$$p(\theta) \quad = \quad \frac{x(\theta)qA + (z(\theta) - x(\theta))A}{z(\theta)} \text{ if } z(\theta) > 0. \tag{13}$$

  In other words, the outside investors who buy the disposed legacy loans have rational expectations and correctly anticipate banks' self-selection under the restructuring plan menu and their optimal disposal compliance decisions. In particular, (13) accounts for the fact that bank θ sells $x(\theta)$ units of bad loans with expected return qA,and $z(\theta) - x(\theta)$ units of good loans with expected return A.

Distribution-free solutions. We say that a restructuring plan menu $\mathcal{R}$ is a *distribution-free solution to the debt overhang* if $\mathcal{R}$ is a solution to the debt overhang for any bank type distribution $F(\theta)$ with support in the interval $[0, 1]$. We will focus for the rest of the paper in this stronger notion of debt overhang solution, to which we will most of the time refer simply as a debt overhang solution.[9]

[8] The expression for the value of restructured equity uses the fact that, since the restructured debt is safe, we can write:

$$\mathbb{E}\left[\left(A_s(x(\theta), R(\theta), \theta) - B'(\theta)\right)^+\right] = \mathbb{E}\left[A_s(x(\theta), R(\theta), \theta)\right] - B'(\theta)$$

[9] The formal exposition becomes simpler and more intuitive when we focus on the concept of distribution-free debt overhang solution but our main results regarding the insufficiency of pure liability restructuring plans and the sufficiency of solutions involving asset sales hold under the weaker notion of debt overhang solution given a bank type distribution. See the Appendix for details.

4.2 Some properties of restructuring plans and debt overhang solutions

We start our analysis with some properties of restructuring plans and debt overhang solutions that will be frequently used later.

Suppose that bank type θ is subject to the restructuring plan $R = (z, B', \alpha, p)$ and has to decide how to comply with the loan disposal requirement z. For two compliance choices $x, x' \leq \min\{\theta, z\}$ satisfying $x < x'$, we have from (7) that

$$A_H(x, R, \theta) = A_H(x', R, \theta) \text{ and } A_L(x, R, \theta) < A_L(x', R, \theta). \tag{14}$$

The more bad loans the bank sells to comply with the loan disposal requirement the higher the overall return of its assets in the L state, while that in the H state remains invariant. This is because the outside investors buy the two loan types at the same price because loan quality is not observable, but good loans have a strictly higher return in the L state than bad loans (and the same return in the H state). Using Assumption 2 we have from (14) that

$$E(x, R, \theta) < E(x', R, \theta),$$

and the next lemma characterizing how banks comply with loan disposal requirements follows.

Lemma 1. *Let z be the loan disposal requirement in a restructuring plan bank θ is subject to. Independently of the loan disposal price p, the bank only sells good loans after exhausting of its bad loans, that is, its optimal loan disposal compliance decision is:*

$$x = \min\{\theta, z\}. \tag{15}$$

The lemma states that the bank follows a "pecking order" in complying with the loan disposal requirement: it sells bad loans first, and only if all of them are sold (which requires the disposal requirement z to exceed the bank's measure of bad loans θ), it sells good loans to meet the remaining sale requirement.

Suppose now that bank type $\theta' > \theta$ is also subject to the restructuring plan R. Using Lemma 1, we have that the measure of good loans held by bank θ following the restructuring

plan amounts to:

$$1-\theta-(z-\min\{\theta,z\})=1-\max\{\theta,z\},$$

and analogously for bank θ'. Since $\theta'>\theta$, we have that

$$\underbrace{1-\max\{\theta',z\}}_{G \text{ loans bank } \theta' \text{ under } R} \leq \underbrace{1-\max\{\theta,z\}}_{G \text{ loans bank } \theta \text{ under } R}, \tag{16}$$

that is, bank θ keeps on holding a (weakly) larger amount of good loans than bank θ' following the restructuring plan. Since legacy good loans have a state-contingent higher payoff than bad loans, we have that

$$A_s(\min\{\theta,z\},R,\theta)\geq A_s(\min\{\theta',z\},R,\theta') \text{ for } s=H,L,$$

and the next intuitive monotonicity result on the value of the restructured bank to bankers under a given restructuring plan follows.

Lemma 2. *Let $R=(z,B',\alpha,p)$ be a restructuring plan. The value of a bank to bankers under any given restructuring plan $R=(z,B',\alpha,p)$ is weakly decreasing in the bank's type, that is, if $\theta'>\theta$ then*

$$\max_{x\leq\min\{\theta',z\}} E(x,R,\theta')\leq \max_{x\leq\min\{\theta,z\}} E(x,R,\theta). \tag{17}$$

The lemma states that the value of a bank to its bankers under a given restructuring plan is weakly decreasing in its share of bad loans. This is because the state-contingent payoffs of the legacy loan portfolio of a bank are weakly increasing in the share of good loans, and banks with more good loans prior to adopting any given restructuring plan still have a (weakly) larger amount of good loans following the restructuring (while being equal along any other dimension relevant to determine their value to bankers).

A solution to the debt overhang problem increases aggregate net surplus by inducing new lending with positive NPV. Conditions (11) and (12) impose that both bankers and their legacy creditors must weakly benefit from the solution to the problem. We next show that the distribution-free requirement on our debt overhang solution concept implies that bankers cannot obtain positive rents from their banks' restructuring.

Clearly, the overall rents bankers obtain under a solution to the debt overhang given a

type distribution $F(\theta)$ cannot exceed the increase in aggregate surplus coming from the new lending, that is, we must have:

$$\int \underbrace{\left(E(x(\theta), R(\theta), \theta) - \overline{E}(\theta)\right)}_{\text{Rents}(\geq 0)} dF(\theta) \leq \Pr[\theta \geq \overline{\theta}](y-1). \tag{18}$$

Consider first bank types $\theta \leq \overline{\theta}$, which do not suffer from debt overhang in the equilibrium without restructuring. If bankers were to obtain positive rents from any of these banks, a type distribution $F(\theta)$ with sufficiently large mass on those banks and low mass above the threshold $\overline{\theta}$ would not satisfy inequality (18). So a distribution-free solution to the debt overhang requires that bankers do not obtain any rents from banks with $\theta \leq \overline{\theta}$.

Consider now a bank of type $\theta > \overline{\theta}$ and suppose its bankers were to obtain rents. We next show that deterring a bank with type $\overline{\theta}$ from (falsely) reporting type θ would lead its bankers to also obtain rents, which we argued above cannot happen. To see this, notice that combining the truth-reporting condition in (10) with the monotonicity condition in (17) implies:

$$E(x(\overline{\theta}), R(\overline{\theta}), \overline{\theta}) \geq E(\min\left\{\overline{\theta}, z\right\}, R(\theta), \theta) \geq E(x(\theta), R(\theta), \theta). \tag{19}$$

In addition, we have from (4) that, without restructuring, bankers obtain the same value from banks of types $\overline{\theta}$ and θ:

$$\overline{E}(\overline{\theta}) = \overline{E}(\theta) = q(A - B). \tag{20}$$

Finally, combining (19) and (20) we obtain that

$$E(x(\overline{\theta}), R(\overline{\theta}), \overline{\theta}) - \overline{E}(\overline{\theta}) \geq E(x(\theta), R(\theta), \theta) - \overline{E}(\theta) > 0,$$

which cannot be.

We have thus proved the following result.

Lemma 3. *Under a distribution free solution to the debt overhang bankers obtain no rents, that is, their participation constraints, (11), are binding for all bank types θ.*

4.3 The insufficiency of liability restructuring plans

After introducing a general class of restructuring plans in our setup and presenting some initial properties of solutions to the debt overhang, we consider a restricted subclass of restructuring plans that only include the restructuring of liabilities. Liability restructuring is regarded the classical solution to debt overhang problems. Yet, we will show that it does not generally work in our setup due to the presence of asymmetric information. This highlights the crucial role of loan sales in the general solutions that we will subsequently analyze.

Liability restructuring plans are restructuring plans $R = (z, B', \alpha, p)$ that do not include loan sale requirements, that is, with $z = p = 0$. Suppose that there exists a liability restructuring menu $\mathcal{R}$ that solves the debt overhang. Since we trivially have that $x(\theta) = 0$ and that $p(\theta)$ is irrelevant for all bank types, we can drop the arguments $z(\theta), x(\theta)$, and $p(\theta)$ from all the objects defined in previous subsections.

Consider a bank θ which suffers from debt overhang without restructuring, that is, with $\theta > \overline{\theta}$ (Proposition 1). The participation constraint (11) of its bankers under the liability restructuring plan $R(\theta) = (B'(\theta), \alpha(\theta))$ designed for its type can be written as:

$$\underbrace{(1-\alpha(\theta))\left(A(1-\theta)+qA\theta+y-B'(\theta)\right)-1}_{=E(B'(\theta),\alpha(\theta),\theta)} \geq \underbrace{q\,(A-B)}_{=\overline{E}(\theta)}, \tag{21}$$

where in the LHS we use that the fact that the restructured debt becomes riskless (since the payoffs of the new lending are enough to repay $B'(\theta)$ in all states by Assumption 2). Using the expression of the debt overhang threshold $\overline{\theta}$ in (22) and that $1-\alpha(\theta) \leq 1$, we can easily prove that the inequality above has a solution pair $(B'(\theta), \alpha(\theta))$ if and only if

$$B'(\theta) \leq B - (1-q)A(\theta - \overline{\theta}). \tag{22}$$

The inequality states that it is possible to induce bank θ to supply new lending by means of sufficiently reducing the promised repayment of the outstanding debt (which would have to be accompanied with a sufficiently large equity retention $1-\alpha(\theta)$ by its bankers).[10] This

[10] Intuitively, we have from (21) that the minimum $1-\alpha(\theta)$ compatible with bankers' participation is increasing in the promised repayment $B'(\theta)$ on the restructured debt, and that when $B'(\theta)$ is at the upper limit given by (22) bankers must retain $1-\alpha(\theta) = 1$, that is, all the equity of the bank.

is the well known result that debt-for-equity swaps solve underinvestment problems in a perfect information environment in which there are no information asymmetries among the relevant stakeholders. But, in our setup bank types are unobservable to the legacy creditors and outside investors so that inducing the shareholder value maximizing banks to truthfully report their types puts additional constraints on the liability restructuring plans that can be offered to each bank.

We next prove that the information frictions regarding the quality of legacy loans present in our setup necessarily create rents for the owners of some bank types if liability restructuring plans are used to solve their debt overhang. From Lemma 3 this will imply that there is no liability restructuring solution to the debt overhang.

To see this, consider two banks exposed to a debt overhang in the absence of restructuring, that is, two types θ and θ' with $\theta > \theta' > \overline{\theta}$. If the bank with less bad loans (bank θ') pretends to be the bank with more bad loans (bank θ) and is subject to the liability restructuring designed for the latter, its bankers' value would amount to

$$\underbrace{(1-\alpha(\theta))\left(A(1-\theta')+qA\theta'+y-B'(\theta)\right)-1}_{=E(B'(\theta),\alpha(\theta),\theta')} = \underbrace{(1-\alpha(\theta))\left(A(1-\theta)+qA\theta+y-B'(\theta)\right)-1}_{=E(B'(\theta),\alpha(\theta),\theta)}+ \\ +(1-\alpha(\theta))(1-q)A(\theta-\theta'), \tag{23}$$

where bankers' value expressions use the fact that the restructured debts with promised repayment $B'(\theta) \leq B$ of the two banks become riskless when the new lending is undertaken. Notice that the RHS in (23) is just an algebraic manipulation of the LHS in which the first term equals bankers' value of bank θ under the restructuring plan designed for it, and the second equals the additional value to its bankers that bank θ' can obtain by reporting type $\theta > \theta'$. Notice that since the new lending makes the restructured debt of the two banks safe under the restructuring plan designed for bank θ, thus removing limited liability distortions, the differences in the value of their equity (of which the fraction $1-\alpha(\theta) > 0$ makes the second term in the RHS of (23)) equals the difference in the expected value of the legacy loans of the two banks.

Now, from bankers' participation constraints, any two banks suffering from debt overhang in the absence of restructuring, must provide at least the same value to their bankers as

without restructuring, where this value is identical for all banks suffering the debt overhang and is given by:

$$\overline{E}(\theta') = \overline{E}(\theta) = q(A - B). \tag{24}$$

Now, combining (23) with the optimality condition in (10) for bank θ' and the participation constraint (11) of the bankers of bank θ, we obtain:

$$E(B'(\theta), \alpha(\theta), \theta') \geq \overline{E}(\theta) + \underbrace{(1 - \alpha(\theta))(1 - q)A(\theta - \theta')}_{\text{Rents}>0}, \tag{25}$$

which implies that bank θ' can provide positive rents to its bankers by mimicking bank θ. More generally, this means that under any liability restructuring solution of the debt overhang problem, all banker types exposed to a debt overhang without restructuring (except banks with the worst type $\theta = 1$) will necessarily obtain strictly positive informational rents. The rents arise because these bankers can over-report their type and be subject to a restructuring plan that solves the debt overhang of a bank with less valuable legacy loans and grants its bankers the common no-restructuring value provided by all banks subject to an unsolved debt overhang. Preventing over-reporting thus creates rents.

The following proposition states formally the result we have just proven.

Proposition 2. *A distribution free solution to the debt overhang involving only a menu of liability restructuring plans does not exist.*

The result highlights that informational asymmetries regarding the quality of the legacy assets make liability restructuring plans not a universal solution to the debt overhang because of the rents these restructuring plans necessarily leave on some banker types.[11]

4.4 Debt overhang solutions with loan sales

We show in this section that the additional restructuring tool provided by loan sale requirements is sufficient to solve the debt overhang in the presence of asymmetric information. We will in fact specify a restructuring plan menu consisting of minimal loan sale

[11] As anticipated in footnote 9, our results do not hinge in the use of the notion distribution free solution to the debt overhang. In fact, we show in the Appendix a stronger version of Proposition 2 that states that there exist bank type distributions $F(\theta)$ such that no menu of liability restructuring plans is a solution to the debt overhang given the distribution $F(\theta)$.

requirements and legacy debt principal reductions that solves the problem. But before presenting that example, we provide some results that help understand more generally the role of loan sales in solving the debt overhang under asymmetric information.

The role of loan sale requirements. Recall that, while the value bankers obtain from their banks under a given restructuring plan is generally weakly decreasing on their bank's type (Lemma 2), it is strictly decreasing when the restructuring plan relies exclusively on liability restructuring (expression (23)). Such a property was the key driver for our finding in the previous section that liability restructuring menus fail to provide solutions to the debt overhang problem.

The next lemma describes how loan disposal requirements affect how the value of banks to bankers changes with their type under a given restructuring plan.

Lemma 4. *Consider two bank types θ and θ' with $\theta' < \theta$ and a restructuring plan $R = (z, B', \alpha, p)$, then*

$$\max_{x \leq \min\{\theta', z\}} E(x, R, \theta') = \max_{x \leq \min\{\theta, z\}} E(x, R, \theta) \text{ iff } z \geq \theta. \tag{26}$$

The logic behind this result can be best grasped through its proof. If two bank typesθ and θ' with $\theta > \theta'$ are subject to a restructuring plan $R = (z, B', \alpha, p)$, Lemma 1 implies the following retained portfolio of legacy loans for bank θ after the restructuring:

$$\begin{aligned} B \text{ loans} &: \theta - \min\{z, \theta\} = \max\{0, \theta - z\}, \\ G \text{ loans} &: 1 - \theta - (z - \min\{z, \theta\}) = 1 - \max\{z, \theta\}, \end{aligned}$$

since it complies with the loan sale requirement z by selling $\min\{z, \theta\}$ bad loans and $z - \min\{z, \theta\}$ good loans. Analogous expressions can be obtained for bank θ', and the difference between the amounts of good loans retained by banks θ' and θ after the restructuring foreseen in R is:

$$1 - \max\{z, \theta'\} - (1 - \max\{z, \theta\}) = \Delta(\theta, \theta' | z) \equiv \begin{cases} 0 & \text{if } z \geq \theta \\ \theta - z & \text{if } \theta' \leq z < \theta, \\ \theta - \theta' & \text{if } z < \theta' \end{cases}$$

which is weakly positive and strictly so if and only if $z < \theta$. In words, the bank with a higher quality legacy portfolio to start with retains a higher quality loan portfolio under the common loan sale requirement z if $z < \theta$, while the two banks retain a portfolio of the same quality (made of just good loans) if $z \geq \theta$.[12]

Extending equation (23) to the case in which restructuring plans include a loan disposal requirement $z > 0$, we can write:

$$E(\min\{z, \theta'\}, R, \theta') = E(\min\{z, \theta\}, R, \theta) + (1 - \alpha)(1 - q)A\Delta(\theta, \theta'|z),$$

which says that the value of bank θ' to its bankers under the restructuring plan intended for a worse bank θ would exceed that of bank θ to its bankers by an amount that is proportional to the difference in post-restructuring retained good loans under such a plan, $\Delta(\theta, \theta'|z) \geq 0$. Therefore, only if $z \geq \theta$ both banks will have the same value to their bankers, as stated in the lemma that we wanted to prove (Lemma 4). Intuitively, if the two banks are subject to a sufficiently large loan disposal requirement, their asset heterogeneity vanishes after the restructuring and their values to bankers get equalized. Conversely, if asset heterogeneity is not removed because the loan disposal requirement is too small, a fraction $1 - \alpha$ of the difference in the post-restructuring value of assets across banks is appropriated by the corresponding bankers (because the restructuring induces new lending and makes banks' debt riskless, thus mapping asset value differences directly into equity value differences).

Combining Lemma 3 and 4 and taking into account that all banks subject to a debt overhang provide the same value to their bankers in the absence of restructuring, we immediately obtain the following corollary.

Corollary 1. *The loan disposal requirement for each bank exposed to a debt overhang in a distribution free solution to the problem is no lower than its amount of bad loans, that is,*

$$z(\theta) \geq \theta \text{ for all } \theta > \overline{\theta}. \tag{27}$$

The corollary states that a solution to the debt overhang must consist of a restructuring

[12] Notice that $\Delta(\theta, \theta'|z)$ also captures the difference between the amounts of bad loans retained by banks θ and θ' (in this order).

plan menu in which each bank is required to sell an amount of loans that is at least equal to its amount of bad loans. Since bankers comply with any loan disposal requirement by selling first bad loans and only if exhausted also good loans (condition (15) in Lemma 1), the corollary a fortiori implies that in the presence of asymmetric information on loan quality solving the debt overhang problem requires removing all bad loans from the balance sheet of the affected banks.

A distribution free solution to the debt overhang with minimum loan sales. We next present a specific solution to the debt overhang problem. We consider the restructuring plan menu $\mathcal{R} = (R(\theta))_{\theta\in[0,1]}$ described by:

$$R(\theta) = \left(z(\theta) = \mathbf{1}_{\theta>\overline{\theta}}\theta, B'(\theta) = B - (1-q)A(\theta-\overline{\theta})^+, \alpha(\theta) = 0, p(\theta) = qA\right). \tag{28}$$

Notice the following four features of the restructuring plan. First, from Corollary 1 we have that it exhibits the minimum loan sale requirements necessary to solve the debt overhang. Second, legacy creditors are only offered a restructured debt and no bank equity. Third, banks that do not suffer from underinvestment in the absence of restructuring are offered the "empty restructuring" $R_\emptyset(\theta) = (z(\theta) = 0, B'(\theta) = B, \alpha(\theta) = 0, p(\theta) = qA)$, that is, they are de facto not restructured. Fourth, the price set for the loans sold by banks subject to a minimum loan sale requirement is the break even price that outside investors are willing to pay according to (13) under the rational expectation that the selling banks will only sell bad loans since, by Lemma 1, we have $x(\theta) = z(\theta)$.

On this basis, we can establish the following sequence of partial properties for the restructuring plan menu $\mathcal{R}$:

I- If $\mathcal{R}$ induces truth-reporting by banks, then legacy creditors appropriate all the surplus created by the restructuring.

In fact, we have from the definition of the debt overhang threshold $\overline{\theta}$ in (3), the expression $\overline{D}(\theta)$ for the value of the outstanding debt in the absence of restructuring in (5), and the definition of the restructured debt repayment $B'(\theta)$ in (28), that

$$B'(\theta) - \overline{D}(\theta) = \mathbf{1}_{\theta>\overline{\theta}}(y-1). \tag{29}$$

If the restructuring plan menu induces truth-reporting, then from Assumption 2 the restructured debt becomes riskless for all bank types, and the equality above implies that the increase in the value of outstanding debt of each bank type induced by the restructuring is exactly equal to (that is, neither higher nor lower than) the NPV of the new lending. Legacy investors appropriate all the surplus created by the restructuring plan, so bankers obtain no rents. Notice this is achieved by setting a restructured promised repayment $B'(\theta)$ that, for $\theta > \overline{\theta}$, decreases at a pace that is equal to that at which the value of the outstanding debt would decrease under no-restructuring.

II- $\mathcal{R}$ induces banks not to over-report their types.

Truth-reporting leads each bank θ to offer to its bankers the same value $\overline{E}(\theta)$ as in the absence of restructuring. From (4) this value is strictly decreasing for $\theta \leq \overline{\theta}$, and constant otherwise. Consider a bank θ that reports to be bank $\theta' > \theta$. Taking into account that there is an "empty" restructuring $R_{\emptyset}$ under the menu $\mathcal{R}$ for bank that report $\theta' \leq \overline{\theta}$, it suffices to consider the incentives to report $\theta' > \overline{\theta}$. Using that the loan disposal requirement for these types satisfies $z(\theta') = \theta'$, and that $p(\theta') = qA$, we obtain from the condition in (26) that:[13]

$$\max_{x \leq \min\{\theta, z(\theta')=\theta'\}} E(x, R(\theta'), \theta) = \max_{x \leq \{\theta', z(\theta')=\theta'\}} E(x, R(\theta'), \theta') = \overline{E}(\theta') \leq \overline{E}(\theta). \tag{30}$$

Over-reporting thus (weakly) reduces expected utility and is not a strictly profitable deviation. This is despite the fact that by over-reporting the bank would get a larger legacy debt reduction (since $B(\theta') < B(\theta)$). Yet, such debt reduction benefit is always dominated by the losses stemming from the additional loan sales the over-reporting bank has to accommodate with sales of good loans at the bad loan price since loan sale requirements are precisely set to exhaust bad loan availability under truth-reporting (so $z(\theta') > z(\theta) = \theta$) banks.

III- $\mathcal{R}$ induces banks not to under-report their types.

Under-reporting instead leads a bank to obtain a lower legacy debt reduction at no gain. In fact, suppose that bank θ reports to be bank $\theta' < \theta$, and sells $x = \min\{\theta, \theta'\} = \theta'$ of its bad loans at the price $p(\theta') = qA$ then, since Assumption 1 implies that banks supply new

[13] Since we consider $\theta' > \theta$, the roles of θ and θ' in (30) are inverted relative to those in (26).

lending and become riskless, the value of the under-reporting bank to its bankers would be:

$$\begin{aligned} E(x=\theta', R(\theta'), \theta) &= A(1-\theta) + qA(\theta-\theta') + \theta' p(\theta') + y - B'(\theta') - 1 \\ &= A(1-\theta) + qA\theta + y - B'(\theta') - 1 \\ &= E(x=\theta, R(\theta), \theta) - \underbrace{\left(B'(\theta') - B(\theta)\right)}_{\geq 0}. \end{aligned}$$

Taking into account that if bank θ truthfully reports its type, its disposed loans will also have a price $p(\theta) = qA$, the chain of equalities above states that if the bank under-reports its type, its bankers' value will be reduced by exactly the reduction $B'(\theta') - B(\theta) \geq 0$ in the haircut applied to the promised repayment of its outstanding debt under the restructuring plan for the better imitated bank.[14] Banks thus have no incentives to under-report their types.

Combining our partial results *I* - *III* we obtain the following proposition, which constitutes the main result of the paper.

Proposition 3. *There exist restructuring plan menus exhibiting loan sale requirements to banks exposed to a debt overhang problem that provide a distribution-free solution to the problem. In particular, the restructuring plan menu* $\mathcal{R} = (R(\theta))_{\theta\in[0,1]}$ *defined in (28) solves the debt overhang.*

5 Implementation under deposit insurance

We consider in this section a bank whose legacy debt B consists of deposits insured by a deposit insurance fund (DIF), and reinterpret all the results of the previous sections in such an environment. The key specificity we assume for a bank with insured deposits is that their face value cannot be renegotiated and/or partially converted into bank equity as a concession to make bankers willing to undertake the new lending. The underlying reasons for deposit insurance or the unfeasibility of concessions from depositors fall beyond the scope of our model. In the case of demand deposits, the provision of deposit insurance may be the means to prevent runs triggered by the fear that some restructuring would prevent their full repayment. Demand deposits may in turn be justified as a way to insure risk averse investors against idiosyncratic liquidity risk (Diamond and Dybvig, 1983) or it can be that attaining the special value of deposits as a cash-like asset requires preserving them as safe or

[14] Notice from (28) that $B'(\theta') - B(\theta) > 0$ provided $\theta > \bar{\theta}$.

information insensitive at all times (Dang et al., 2017). In the presence of deposit insurance, there is an additional bank stakeholder whose utility is potentially affected by the issuance of new lending, the DIF.

If insured deposits cannot be restructured and their entire promised repayment B will be always repaid at the final date (possibly with some contribution from the DIF in state L), the role of legacy creditors in making concessions in banks' restructuring plans will be played by the DIF. The general restructuring plans introduced in Section 4 can be adapted to this set-up by considering tuples of the form $R' = (z, T, \alpha, p)$ where z keeps on being the loan disposal requirement, $T \geq 0$ is a lump-sum transfer the DIF makes at $t = 0$ to the bank whose role is akin to that of reducing the repayment of the outstanding debt to $B'(\theta) \leq B$ in the baseline model, and α is the share of the bank's equity after the restructuring granted to the DIF (in contrast to the baseline model in which it is granted to the legacy creditors). Notice that the pair (T, α), which replaces the pair (B', α) captures the liability side of the restructuring plan and can be naturally interpreted as a recapitalization of the bank by the DIF.

The definition and analysis of restructuring plan menus that solve the debt overhang problem with insured deposits is analogous to that in Section 4 with two adaptations. First, from the perspective of each bank, a recapitalization pair (T, α) is equivalent to a liability restructuring pair (B', α) with $B' = B - T$ in the baseline version of the model, that is, with the injected funds T playing the role of the debt write down $B - B'$. Second, the following participation constraint for the DIF:

$$\begin{aligned} \int T(\theta) dF(\theta) - \\ - \int \alpha(\theta) \left(\mathbb{E}\left[A_s(x(\theta), R(\theta), \theta) \right] + T(\theta) - B \right) dF(\theta) \quad &\leq \quad \int \left(B - \overline{D}(\theta) \right) dF(\theta), \end{aligned} \tag{31}$$

replaces the participation constraint of legacy creditors in (12). The LHS in the inequality above captures the net expected disbursements faced by the DIF under the restructuring plan menu. The first term accounts for the funds injected int he banks at $t = 0$ and the second term subtracts the expected payoff at $t = 1$ of the equity stakes that the DIF receives from the banks. The RHS in (31) captures the overall expected deposit insurance costs in case of no-restructuring, which are fully avoided by the restructuring since, under Assumption 2, when

banks undertake their new lending they are able to repay their outstanding deposits in full. Notice that to express the value of the guarantees provided by the DIF to depositors under no restructuring, we use the difference between the face value of the deposits B and the value $\overline{D}(\theta)$ that uninsured outstanding debt with the same promised repayment has under no-restructuring in the baseline model.. It is a matter of simple algebraic manipulation to check that if (31) is satisfied then (12) is also satisfied for $B'(\theta) = B - T(\theta)$ for all θ. And the converse also holds given a set $B'(\theta)$ if one defines $T(\theta) = B - B'(\theta)$ for all θ.

The next result immediately follows.

Lemma 5. *A restructuring plan menu $\mathcal{R}' = ((z(\theta), T(\theta), \alpha(\theta), p(\theta))_{\theta\in[0,1]}$ solves the debt overhang problem for banks with insured deposits if and only if the restructuring plan menu $\mathcal{R} = ((z(\theta), B'(\theta), \alpha(\theta), p(\theta))_{\theta\in[0,1]}$, where $B'(\theta) = B - T(\theta)$, solves the debt overhang problem for the banks in the baseline model.*

The lemma implies that all the results in Section 4 hold in the model with insured deposits if one reinterprets the debt haircut $B - B'(\theta)$ designed for bank type θ under a restructuring plan menu $\mathcal{R}$ in the baseline model as an injection of funds the DIF makes to that bank at $t = 0$ under $\mathcal{R}'$.

Recall that Proposition 2 sates that restructuring plans with no loan sales cannot constitute a solution to the debt overhang problem. In this alternative set-up, the proposition implies that a menu of pure bank recapitalizations conducted by the DIF cannot solve the debt overhang problem, that is, provide an incentive-compatible distribution-free solution in which both the DIF and bankers are weakly better off than under no restructuring. Instead, Proposition 3 can be reinterpreted in this alternative set-up as stating that (suitable chosen) bank recapitalizations by the DIF combined with loan sale requirements are able to solve the debt overhang problem.

Recall also that the particular solution described in (28) features $\alpha(\theta) = 0$. In the reinterpretation for the case with insured deposits, this implies that the solution of the debt overhang problem does not require the DIF to take equity stakes on the restructured banks. Finally notice that, since we have maintained the assumption that the legacy loans sold following the requirement contained in the restructuring plans are fairly price by the uninformed outside investors, it is possible to interpret the injection of funds $T(\theta)$ that the DIF

makes in each bank under the postulated solution as a subsidy to the sale of bad loans.

In fact, using (28), we can write the per unit subsidy on sold loans of the bank of type θ as follows:

$$\tau(\theta) \equiv \frac{T(\theta)}{\theta} = \frac{B - B'(\theta)}{\theta} = (1-q)A\left(1 - \frac{\overline{\theta}}{\theta}\right)^{+}, \tag{32}$$

which is increasing in θ. So, under this interpretation, banks that truthfully report and sell more bad loans benefit from a larger subsidy on each of them. Notwithstanding, the menu of subsidized loan sales deters banks from over-reporting because that would require them to sell some good loans at terms that, even after taking the subsidy into account, would imply making losses at the margin.

The implementation of the restructuring plan menu under this last interpretation would only require the DIF to specify the per unit loan subsidy curve $\tau(\theta)$ as in (32). Notice that, even though we have assumed throughout the paper that new lending is contractible and the restructuring plan menus specify that new lending must be issued, such a requirement would not be necessary under the specific debt overhang solution we are now discussing. The intuition is that banks exposed to the debt overhang would find it optimal to sell all their bad loans under the proposed scheme and, after doing so, they would become safe and thus free from the limited liability distortions that engendered the debt overhang problem to start with.

In the implementation described above the subsidy to bad loan sales involves a transfer from the DIF to the banks at the time of selling. An alternative implementation which avoids those direct transfers to the banks but its otherwise entirely equivalent would consist in supporting the secondary market for bad loans through the provision by the DIF of an asset protection scheme to the buyers of the disposed loans. The scheme would work as follows: for a bank that sells θ units of loans, the DIF would guarantee a minimum payoff of $\sigma(\theta) \leq A$ on each of the loans, where:

$$\sigma(\theta) = A\left(1 - \frac{\overline{\theta}}{\theta}\right)^{+}. \tag{33}$$

Taking into account that the DIF will have to satisfy the guarantee only in the L state and

for bad loans whose payoff is zero in that state, we have that if investors expect only bad loans to be sold, then the value of the guarantee $\sigma(\theta)$ on each loan sold by a bank that sells θ loans would equal as specified $\tau(\theta)$ in (32). Since investors are competitive, the price at which they would be willing to buy those bad loans would exceed the value of the loans by exactly the value of the guarantee and, hence, in equilibrium each bank would get the right subsidy. Building on this it can be checked that a DIF-sponsored asset protection scheme with the guarantees described in (33) allows to solve the debt overhang problem.

6 Conclusion

We consider restructuring solutions to the debt overhang problem faced by banks with a deteriorated loan portfolio in the presence of asymmetric information on loan quality. We show that legacy loan sales are necessary to avoid an excessive appropriation of rents by bank owners when they have private information about the deteriorated loans.

In the classical presentation of Myers (1977), the debt overhang problem can always be solved, in the benefit both of creditors and shareholders, if the senior creditors make concessions in the form of debt write-downs or debt-for-equity swaps, so loan sales are not necessarily part of the solution. We find that this conclusion changes in the presence of asymmetric information about the quality of the legacy loans. Restructuring plan menus that combine (bad) loan sales with debt write-downs allow for the restructuring of the more troublesome banks without inducing better banks to try to benefit from similar concessions from their creditors. Separation builds on the intuitive idea that loan prices that are attractive for weak banks to sell their bad loans are not attractive for better banks to sell their good loans, which helps keeping the latter away from the plans intended for wekaer banks.

After characterizing solutions to the debt overhang problem cum asymmetric information in a setup in which banks' legacy senior creditors are uninsured, we consider the case in which all outstanding debt are insured deposits and the concessions behind the restructuring plans are consequently made by the deposit insurance fund (DIF) rather than the depositors. Adapting our results to this situation, our analysis implies that the DIF will find beneficial to its own financial interests to participate in bank restructuring arrangements based on menus of restructuring plans that combine concessions to the trouble banks with bad loan sales. We characterize a specific solution involving subsidized (bad) loan sales in which the

concessions appear implicit in the corresponding subsidies. We show that the concessions could be alternatively implemented through an asset protection scheme (partially insuring against potential credit losses) provided for free by the DIF to the buyers of the loans.

From a general corporate finance perspective, our paper contributes to explain the common resort to asset carve-outs in workout agreements. As for banks, our analysis offers insights for the management of the restructuring phase of banking crises. It explains the role of (bad) asset sales and, in the presence of insured senior liabilities, the rationale to involve the DIF (or some authority representing its interests) in the restructuring process. We discuss why and how the solution to the debt overhang problem (and the defense of the interests of the DIF) may involve financially sponsoring the creation of a bad bank, a public AMC or an asset protection scheme for third party buyers of bad assets. Our results contribute to open policy debates about the role of the DIFs and the involvement of public funds in the management of banking crises.

Appendix

The following proposition proves that the main results of the paper generalize to the weaker notion of debt overhang solution given a bank type distribution.

Proposition 4. *There exist bank type distributions $F(\theta)$ such that i) there exist no liability restructuring plan menu that provides a solution to the debt overhang given the distribution $F(\theta)$; and ii) there exists a restructuring plan menu exhibiting loan sale requirements that provides a solution to the debt overhang given the distribution $F(\theta)$.*

Proof. We prove sequentially the two claims in the proposition. Claim i): Consider the worst bank type $\theta = 1$ and a liability restructuring plan $R = (B', \alpha)$ that satisfies the participation constraint (11) of its bankers, which takes the form in (21). Taking into account that $B' \geq 0$, we have from (21) that there exists $C > 0$ such that $1 - \alpha \geq C$.

Consider now a small $\epsilon > 0$ and a distribution $F_\epsilon(\theta)$ with mass $1 - \epsilon$ in the interval of bank types $(\overline{\theta} - \epsilon, \overline{\theta})$. Suppose that a pure liability restructuring menu $\mathcal{R}$ solves the debt overhang given $F_\epsilon(\theta)$. Reproducing the arguments preceding Proposition 2, we have for $\theta' \in (\overline{\theta} - \epsilon, \overline{\theta})$ and $\theta = 1$ that:

$$E(B'(\theta), \alpha(\theta), \theta') - \overline{E}(\theta') \geq (1 - \alpha(1))(1 - q)A(1 - \theta') - \left(\overline{E}(\theta') - \overline{E}(1)\right).$$

Using this inequality and (18) we necessarily have that:

$$\int_{\overline{\theta}-\epsilon}^{\overline{\theta}} \left[(1 - \alpha(1))(1 - q)A(1 - \theta') - \left(\overline{E}(\theta') - \overline{E}(1)\right)\right] dF_\epsilon(\theta') \leq \epsilon(y - 1).$$

In addition, we have that $1 - \alpha(1) \geq C$ and from (4) that $\overline{E}(\theta') - \overline{E}(1) = (1 - q)\left(\overline{\theta} - \theta'\right)$,so that the inequality implies that:

$$\int_{\overline{\theta}-\epsilon}^{\overline{\theta}} \left[C(1 - q)A(1 - \theta') - \left(\overline{E}(\theta') - \overline{E}(1)\right)\right] dF_\epsilon(\theta') \leq \epsilon(y - 1).$$

As $\epsilon \to 0$ the LHS in the inequality above tends to $C(1 - q)A(1 - \overline{\theta}) > 0$, while its RHS tends to zero, which is a contradiction. Therefore there exists $\epsilon > 0$ sufficiently small such that no pure liability restructuring plane menu solves the debt overhang given $F_\epsilon(\theta)$

Claim ii): Let $F_\epsilon(\theta)$ be the distribution constructed in the proof of claim *i)* and $\mathcal{R} = (R(\theta))_{\theta \in [0,1]}$ the restructuring plan menu with loan sale requirements defined in (28). Then Proposition 3 states that $\mathcal{R}$ is a solution to the debt overhang given the distribution $F_\epsilon(\theta)$. □

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