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Abstract

When a bank is burdened with Non Performing Loans, an underinvestment problem may arise. Banking Authorities often take the initiative to segregate these Non Performing Loans into a Bad Bank (BB), so that the remaining part of the bank, the Good Bank, finds it profitable to make new loans. These BBs typically involve an injection of public funds.

We propose a different type of bank break up that does not require any government subsidy. The idea is to give to the bank's shareholders the option to create a BB on their own, and finance it ex-ante by requiring the bank to issue a bail-inable bond that is drawn down when the option is exercised. No tax payer money is involved. Such a restructuring differs from the bail-in regimes in the Bank Recovery and Resolution Directive in the EU and the Dodd-Frank Act in the USA in that it recognizes to the bank's shareholders the information rents that result from their private information on the bank's legacy loans.

JEL Classification: G00, G20, G21

Key words: Bad banks, Under-investment, Debt overhang, Bail-inable bond.

1 Introduction

Non Performing Loans (NPLs)[1] have recently become a serious and harmful issue for the European Banking Sector. The European Banking Authority (2019) estimates that in December 2018 the stock of gross NPLs in the European Union (EU) banks stood at €658 billion or 3.2% of total gross loans with uneven cross country distribution. Although the inflow of new NPLs has slowed down since the peak of the financial crisis and NPLs ratios have begun to decline, they remain high by historical standards, and about twice as much those in other jurisdictions like the USA and Japan (ESRB 2017). It is argued that NPLs reduce bank profitability, raise funding costs and ultimately tie up bank capital that could otherwise be devoted to increase lending in valuable projects (See e.g. IMF 2015).[2]

Policymakers have resorted to a number of solutions, involving banks recapitalizations, government's guarantees of bank liabilities, asset purchases programs, variously combined together (ECB 2017). Asset purchases programs involve the removal of NPLs from the bank balance sheet to house them in a Bad Bank (here after BB).

Despite the macroeconomic importance of the NPLs phenomenon and the widespread regulatory changes in the EU and in the USA, there are almost no specific models to study the economic rationale for setting up these BBs.

[1] Although the application of the NPL concept is currently not fully harmonised across countries and banks, a widely accepted definition is any exposure for which repayments are >90 days past due, or unlikely to be repaid without recourse to collateral (ESRB 2017).

[2] For example, Accornero et al. (2017) find that an *increase* of the level of NPL ratios may have a negative effect on bank lending in Italy, while a *high level* of the level of NPL ratios per se does not influence bank lending.

Two reasons for establishing a BB have been suggested in the literature.

The first one is to prevent Moral Hazard by poorly capitalized banks. For example, Kahn and Winton (2014) argue that when a combination of high leverage and asset opacity induces risk shifting, incentives can often be improved by creating a structure with two subsidiaries. One subsidiary is supposed to hold safer loans and the other one riskier loans. Each subsidiary's debt has recourse only to that subsidiary's assets.

The second reason is to avoid the Adverse Selection problem that the bank will face in raising funds if the market cannot distinguish assets' quality (See e.g. Thomson 2011). An indication that Adverse Selection in the NPLs market may be a first order problem is the wide gap between the book value of NPLs and their market value (ESRB 2017).

In this paper we show that Adverse Selection on the legacy asset generates informational rents for the banker and may cause under-investment. The status quo, that is passing profitable investment opportunities, is valuable to the bank's shareholders because it gives them the option to default on pre-existing debt. Any type of bank restructuring will encounter the resistance of the shareholders unless they receive at least the informational rent they would have obtained in the status quo.

To solve the under-investment problem we propose a new regulation whereby the bank restructuring occurs by breaking-up the original bank into a BB and a Good Bank (GB) and it can be financed ex-ante by requiring the bank to issue a bail-inable bond that is drawn down when the bank split occurs. This restructuring can be organized without any government funding, by giving to the bank's shareholders the option to split the bank, which is a way to extract the shareholders' rent and solve the under-investment problem.

We follow Myers (1977) observing that in a given moment a bank has both activities in place, like legacy loans and outstanding debts, and the opportunity to raise new funds to make new loans. If at an interim date the bank receives private information that the legacy loans are likely to perform poorly, and the perspective return of the new loans is not good enough to absorb the potential losses from legacy loans, then the bank may decide to forego the new loans even if they have positive expected net present value. This is more likely to happen in a downturn when the bank is so undercapitalized because of previous losses that the option to default on the outstanding debt is worth more than the expected net present value of the new loan.

In this paper we explore several alternatives to overcome the under-investment problem. We investigate first under which conditions the incumbent shareholders could make the new loan via a separate Special Purpose Vehicle (SPV). This is a viable solution when the net present value of the new loan is large w.r.t. the cost of equity to inject in the SPV. This solution is likely to be feasible only in the expansion phase of the business cycle when the growth opportunities are good, and the cost of equity and uncertainty are low. When this is not the case and the bank is undercapitalized a subsidy is needed to give the incumbent shareholders the incentive to make the new loan. The government could provide such a subsidy along with the break-up of the original bank into a BB and a GB. When the government does not or cannot provide the subsidy, it must come from other sources. One such a source is the bail-in of some class of creditors along with the bank split.

Regardless of the source of the subsidy, government or bondholders, the BB is the vehicle used to ring-fence the banker's rent.

This new regulation works like that: it would specify the amount of bail-inable debt that the bank must issue ex-ante and the threshold of NPLs for creating a BB, along with the amount of recapitalization of the GB. To bypass the Adverse Selection problem the parameters of the split should be such that revealing the true value of the NPLs is incentive compatible for the banker. The bail-in regimes envisioned by the Bank Recovery and Resolution Directive (BRRD) in the EU and by the Dodd-Frank Act (DFA) in the USA, are mainly designed to shield the taxpayer from costly bailouts, but would not solve the under-investment problem because they do not address its root cause: the Adverse Selection rent that must be recognized to the banker. In fact the solution that we propose differs from these bail-in solutions because in our mechanism the incumbent shareholders, not only is not wiped out, but must be given the rent that she could have obtained from not investing. This has some similarity with the result of Aghion et al. (1999) showing that bank recapitalizations must be designed to balance the incentive of the manager to hide poorly performing loans on the one hand, and to understate the performance of the bank to induce a bailout, on the other.

We stress that the aim of the new regulation that we propose is to solve the under-investment problem while maintaining the bank safe, and not to resolve of a bank failing or likely to fail. Of course when the bank split involves the recourse to public funds it may have a cost due to the distortionary nature of taxation. In those cases we show under which conditions the welfare cost from the bank split and the bail-in of a class of bond holders is lower than the welfare cost when the government buys the bad assets of a distressed bank.

The rest of this paper is organized as follow. In Section 2 we present some stylized facts about BBs and we discuss the related literature. In Section 3 we introduce the model and show that under-investment may arise in equilibrium. In Section 4 we show what it would cost the government to purchase the bad assets to eliminate the under-investment problem. In Section 5 we show that a bank split financed by the write down of a bond eliminates the under-investment without any government's subsidy. In Section 6 we analyze the welfare associated with two above solutions to under-investment. Section 7 concludes. In the appendix (Section 8) we have a proof and we conduct the calibrations of the limited liability option, of the bank's balance sheets, and of the welfare.

2 Stylized facts and literature

2.1 What Bad Banks do

The BBs that have been set up in the past differ along several dimensions. Two stand out: the amount of risk transferred outside the balance sheet of the original bank, and the mix of public and private funds injected in the BB.[3] From the standpoint of risk transfers and complexity McKinsey (2009) distinguishes four basic organizational models for setting up BBs. The first one is the *On-balance-sheet guarantee* through which the bank protects its

[3] BBs differ also along the dimension of their aims. Some are mainly long term restructuring vehicles while others are mainly assets disposition vehicles (Klingebiel 2000).

portfolio against losses typically with a guarantee from the government. That was the case at Citigroup, where in 2008 the US government guaranteed up to $306 billion in problematic assets to ring-fence the risks on the balance sheet. The second one is the *Internal restructuring unit* or internal BB. This solution, like the previous one, lacks effective risk transfers but increases transparency. Citigroup in 2009 created a separate subsidiary, Citi Holdings, with more than $800 billion worth of assets at its peak. Deutsche Bank is said to be preparing the creation of an internal BB where to house or sell assets up to €50bn, comprising mainly of long-dated derivatives (Financial Times 2019). A third solution is the creation of a *Special-purpose entity* (SPE). In this off-balance-sheet solution, the bank offloads its unwanted assets into a SPE, usually government-sponsored. UBS has followed this approach transferring $60 billion of bad assets to an off-balance-sheet SPE funded by the Swiss National Bank. The fourth solution is the *Bad-bank spinoff*. In this solution the bank shifts the troubled assets off the balance sheet and into a legally separate banking entity, thus achieving maximum risk transfers and transparency, at the cost, however, of organizational complexity. The solution that we propose is closest to the latter mode.

Although most BBs involve injections of public funds, there is a growing number of examples of privately-funded BBs. The first one was the 1988 split of Mellon Bank in two units. Mellon wrote down about $1 billion of bad assets to 53% of their book value and moved them to Grant Street National Bank, a separately chartered and capitalized BB, financed partially by junk bonds, that did not take deposits and merely existed to liquidate the bad loans. The good assets remained in the original bank, which issued

$525 million of new equity to restore its capital base. Importantly the pre-existing shareholders of Mellon were not wiped out, but were simply diluted and shared the proceeds of the liquidation of bad loans moved to the BB (See New York Times 1988, and Thomson 2011). Another example, albeit extreme, of a BB without injection of public funds, occurred during the crisis of Cyprus Popular Bank (also known as Laiki) which had accumulated NPLs from the Greek crisis.[4]

In November 2015 the Italian banking authorities resolved four Italian regional banks.[5] Their €8.5 billion NPLs were written down to €1.5 billion and placed in a privately-funded BB. The BB was financed with €140 million, had no banking licence, and was tasked with managing and selling NPLs. The good assets and the original deposits were placed in four newly created GBs. No state aid was involved and the operation was entirely financed with the bail-in of shareholders and subordinated bondholders of the resolved banks, and new equity from the banking industry, in the spirit of the burden sharing imposed by the EU. As an illustration of the importance of Adverse Selection

[4]In March 2013 Laiki was resolved with the bail-in of the shareholders and bondholders of the bank and through the forced conversion of 47.5% of the uninsured deposits ($>$ €100,000) into equity. Bail-in of uninsured depositors was politically feasible as about 70% of deposits in the Cyprus Banking System belonged to non-EU residents. Laiki was split in two units. While uninsured deposits remained in the BB (Legacy Laiki), several assets and liabilities among which the insured deposits ($\leq$ €100,000) were transferred to the Bank of Cyprus. In exchange the BB received shares in the Bank of Cyprus. The uninsured depositors of Laiki also had claims on the liquidation of the assets of the BB (See Philippon and Salord 2017 for a detailed discussion).

[5]These banks are: Cassa Risparmio di Ferrara, Banca Marche, Banca Popolare dell'Etruria e del Lazio, Cassa Riparmio di Chieti.

in the NPLs market notice that the implicit value of the NPLs of the four banks was 17.6% of their book value i.e. €1.5 billion/€8.5 billion, thus representing a stiff haircut and setting a high benchmark for other banks that wanted to realize their losses. More generally the phasing in of the BRRD, has made majority-privately owned BBs more frequent in the EU (Gandrud and Hallerberg 2014).

2.2 Academic literature

Our paper is related to several strands of literature. The first comprises the pioneering study by Myers (1977): a firm facing pre-existing debt may pass valuable investment projects since the earnings generated by the new investments would be partially appropriated by existing creditors.

If debt contracts can be renegotiated easily the under-investment problem could be alleviated without any government involvement by a debt-for-equity swap. Bhattacharya and Faure-Grimaud (2001) show that debt write-down in an environment in which a single debt holder negotiates with the manager/shareholder and knows as much about the firm's prospects as the manager can alleviate the under-investment problem. However, they show that there is no debt reduction that would give the equity holder the incentive to make all new positive-net present value investments.

Landier and Ueda (2009) observe that such restructurings are hard to implement for various reasons among which the difficulty of coordinating among many stakeholders and the need for speed. Landier and Ueda argue that when debt renegotiation is not feasible some transfer from the tax payer is necessary.

Three recent papers study bank restructuring under debt overhang. Colliard and Gromb (2017) study how resolution rules affect the incentives to restructure a bank's debt to avoid an inefficient action due to debt overhang. Segura and Suarez (2019) show that, absent adverse selection on legacy loans, forcing banks to dispose of NPLs can restore incentives to lend. However, if the losses to absorb are large, bank owners may prefer that the bank is resolved. In that case combining NPLs disposal requirements with transfers solves the under-investment problem with the minimal cost to the deposit insurance scheme.

The paper most closely related to ours is Philippon and Schnabl (2013) (hereafter P-S). In their setting a negative aggregate shock to banks balance sheets causes debt overhang. A bank's decision to forgo profitable lending, reduces payments to households, which, in turn increases households defaults and worsens other banks' debt overhang. As a result, some banks do not lend because they expect other banks not to lend. P-S analyze interventions in which the government directly recapitalizes banks, which can decide whether to participate. Banks private information about their assets generates two problems: banks benefit from aggregate risk reduction when other banks participate, and thus may free ride; banks also exploit information advantage to participate opportunistically in the program. The solution is that the government makes all banks pivotal: either all participate, or no recapitalization will take place. This avoids Adverse Selection and corrects the externality. Unlike P-S in our model legacy debt is fairly-priced ex-ante in anticipation of future events. Furthermore we focus on the possibility of segregating the assets in place from the investment opportunity to avoid the debt overhang without any government intervention.

Tirole (2012) studies the problem of banks that must sell legacy assets to finance new projects. The Adverse Selection in the legacy assets market may prevent trade, and thus funding for the new projects is not available. Any attempt of the government to re-start the assets markets (e.g. TARP in the USA) must take into account that participation is voluntary, that is the asset owners will participate if and only if what they receive exceeds what they obtain in the marketplace. However, the market outcome itself depends on who participates in the government's program. Tirole argues that if the government's plan is successful to purge the market from its most toxic assets, the effect is to increase asset prices, thereby making asset owners more reluctant to sell. The solution is that the government buys the most toxic legacy assets, trading off the benefit of re-starting trade vs. the cost of the distortionary taxation to finance the assets purchases. Our model shares with this paper the notion that Adverse Selection on the legacy assets combined with the impossibility to commit to invest in new loans confer to the banker an information rent. However our focus is on private solutions that do not require any form of government intervention.

Finally, our paper is related to the strand of literature that investigates the conditions under which assets should be financed as a pool or separately. DeMarzo (2005) studies assets repackaging leading to pooling, tranching, and securitization. He considers both the ex-ante and the interim security design problems, and examines the question of whether to keep multiple assets in a single firm, and preserve the priority structure of the securities issued by the firm. Leland (2007) examines the pure financial benefit of separating or merging multiple activities as a function of correlation of cash flows, default costs, and tax rates. Our work is also related to Banal-Estañol, Ottaviani and Winton (2013) that study under which conditions two projects should be financed together or separately, trading off the insurance benefits of financing them together vs. the contamination cost if the failure of one project induces also the failure of the other.

3 Under-investment in the base-line case

3.1 The model

We consider a limited liability bank that provides deposit services to households and loans to firms. It is managed by a banker, who acts in the interest of the bank's shareholders. There are three dates 0,1,2. At date 0 the bank lends a total amount that we normalize to 1 and that we call the "legacy loan". At date 1 the bank has the possibility to provide a new loan of equal size 1. Financial markets are complete, and all investors value assets according to their risk adjusted net present value. However the bank's shareholders discounts date 2 payments at rate $\rho > 0$, while other investors are not impatient (zero discount rate).[6] We will use interchangeably the expressions loan, project, investment.

At date 0 the banker also invests S in risk free securities (or liquid reserves) that have a zero net return. The banker finances her assets with retail

[6] Assuming that the bank shareholder is more impatient than investors is a simple way to model the cost of equity: shareholders require a rate of return on equity of ρ, while investors only want to break even.

deposits d due at date 2 and equity E. Deposits are guaranteed by the government as they must perform their function of payment instruments. For this guarantee the banker pays ex ante a premium to the government. We take d, E, and the premium as given. At date 1 the banker privately observes a signal a_0 on the date 2-return of the legacy loan, which is $1 + \tilde{a}_0 - \tilde{\varepsilon}$. One can interpret $\tilde{a}_0$ as $r - \tilde{y}$, where $r > 0$ is the interest rate and $\tilde{y}$ is the fraction of NPLs, and $\tilde{\varepsilon}$ as a shock.[7] After observing a_0, the banker has the possibility to make another loan of equal size 1, which returns $1 + a_1 + \tilde{\varepsilon}$ at date 2. In the interest of simplicity we assume that this new loan is not affected by Adverse Selection: a_1 is publicly observable and deterministic. We assume that $\tilde{a}_0$ is supported by the interval $[\underline{a}_0, +\infty]$ with $\underline{a}_0 \leq 0$, and has a c.d.f. $F(.)$ with $\mathbb{E}(\tilde{a}_0) \geq 0$, while the shock $\tilde{\varepsilon}$ is symmetrically distributed in the interval $[-\varepsilon_M, \varepsilon_M]$, with c.d.f. $G(\cdot)$. A poor interim performance - low or negative realization of $\tilde{a}_0$ - weighs on the date-2 return of the loan which may become a NPL at date 2. In table 1 we represent the date-0 bank's balance sheet in the base-line case.

Legacy loan	1	d	Deposits
Securities	S	E	Equity

Table 1. Base-line case. Date 0

The simplifying assumption that the shocks on the two loans are exactly opposite implies that this risk is fully hedged when the two loans are under the same corporate structure. It is a simple way to capture the benefits of

[7]This is equivalent to assume that the bank has a whole portfolio of legacy loans, and that outsiders know which loans are NPLs but only the banker knows their value.

loans portfolio diversification, and gives the best chances for keeping the two investments under the same bank.[8]

In the spirit of Myers (1977), we assume that the banker cannot commit to make the new loan at date 1. One way to justify this is that nobody could verify whether, by contrast, the banker buys risk less securities at date 1. Here we just point out that the impossibility to commit to new loans is at the root of one of the unintended consequences of the Quantitative Easing exercises conducted by several central banks. In some instances banks that have been the beneficiary of this added liquidity have simply parked it in risk free securities, among which interest bearing excess reserves with their central bank.

Finally the banker could set up a SPV to finance the date-1 loan separately from her legacy assets and debt, and securitize the new loan. We thus start by evaluating the cost of setting up such a SPV.

3.2 Securitizing the new loan

The maximum amount that can be raised risk free against the cash flow of the date-1 loan is $1 + a_1 - \varepsilon_M$. We assume that $\varepsilon_M > a_1$ so that the banker needs to inject $\varepsilon_M - a_1$ out of its own wealth.[9] The date-2 expected payoff for the banker is

$$\mathbb{E}\left[1 + a_1 + \tilde{\varepsilon} - (1 + a_1 - \varepsilon_M)\right]_+ = \mathbb{E}\left[\varepsilon_M + \tilde{\varepsilon}\right]_+ = \varepsilon_M,$$

[8] We assume perfect negative correlation between the two shocks. Our results remain qualitatively similar as long as the correlation coefficient is less than 1.

[9] If $\varepsilon_M < a_1$ the loan can be financed by riskless debt, a case which makes the problem we are considering uninteresting.

which in present value is $\frac{\varepsilon_M}{1+\rho}$. Thus when $\frac{\varepsilon_M}{1+\rho} > \varepsilon_M - a_1$ or $a_1 > \frac{\rho\varepsilon_M}{1+\rho}$ the banker can finance the new loan on a stand-alone basis. The following proposition summarizes our result:

Proposition 1: When $a_1 > \frac{\rho\varepsilon_M}{1+\rho}$ the banker securitizes the new loan.

Proposition 1 is more likely to apply in the expansion phase of the business cycle when the growth opportunities a_1 are high, the cost of equity ρ is low, and the risk ε_M is low. In this case the date-1 investment can be made through a separate SPV, securitizing its cash flow. For the rest of the paper we focus instead on a situation where this is not possible. From now on, we make the following assumption:

$$\textbf{Assumption A1} \ a_1 < \frac{\rho\varepsilon_M}{1+\rho}.$$

We are thus focusing on a downturn where the cost of financing the new loan on a stand-alone basis exceeds its expected net present value, because the growth opportunities a_1 are low, the cost of equity ρ is high, and risk ε_M high.

3.3 The limited liability option

Assumption A1 implies that the banker will not create a SPV to finance the new loan. However, the incumbent bank can make this new loan, thanks to the diversification benefits with the legacy loan. The banker simply has to issue risk free debt in the amount 1, and she will receive a deterministic profit at date 2:

$$SV_M = 1 + a_0 + a_1 + S - d \equiv a_1 + x,$$

where the subscript M stands for Merged investment and $x \equiv 1 + a_0 + S - d$.

To guarantee that $SV_M > 0$ we assume that the value of the maximum losses on the legacy loan $|\underline{a}_0|$ is smaller than the value of the assets net of deposits $1 + a_1 + S - d$. This rules out the contamination effect (Banal-Estañol, Ottaviani and Winton, 2013), that is the possibility that the losses on the legacy loan can be so big to cause the default of the bank when it invests merged.

Since the banker cannot commit to invest at date 1, she will invest only if SV_M exceeds the expectation of her wealth when no new investment is made,

$$SV_\emptyset = \mathbb{E}\left[1 + a_0 + S - d - \tilde{\varepsilon}\right]_+ = \mathbb{E}\left[x - \tilde{\varepsilon}\right]_+ .$$

Thus the variable x, that will play an important role in the remainder of the paper, represents the loss-absorbing capacity of the bank (LAC). A full liability bank would only obtain $\mathbb{E}\left[x - \tilde{\varepsilon}\right] = x$ and would always invest in the new loan. However, this is not true of a limited liability bank. Indeed the value of the limited liability option, namely

$$O\left(x\right) \equiv \mathbb{E}\left[\tilde{\varepsilon} - x\right]_+ = \mathbb{E}\left[x - \tilde{\varepsilon}\right]_+ - x, \tag{1}$$

may exceed the expected present value of the new loan. It is easy to establish that $O(x)$ is decreasing in x, with $O(-\varepsilon_M) = \varepsilon_M$ and $O(\varepsilon_M) = 0$. Since $a_1 < \varepsilon_M$ then there is only one value of x, which we call x^*, such that $O\left(x^*\right) = a_1$. (See Figure 1 in Appendix). Therefore $x^* = O^{-1}\left(a_1\right)$ is the critical LAC below which the option to default is profitable and it is function of a_1. Since O is decreasing, x^* is a decreasing function of a_1. In Appendix we calibrate equation $x^* = O^{-1}\left(a_1\right)$ to assess the importance of the option to default.

We illustrate the date-1 choice of the banker between investing merged (Table 2) and no-investment (Table 3) by presenting the corresponding date-2 balance sheets.

Legacy loan	$1 + a_0 - \tilde{\varepsilon}$	d	Deposits
New Loan	$1 + a_1 + \tilde{\varepsilon}$	1	Nominal of new bond
Securities	S	SV_M	To shareholders

Table 2. Base-line case. Merged investment. Date 2

Legacy loan	$1 + a_0 - \tilde{\varepsilon}$	$min\,(d, 1 + a_0 + S - d - \tilde{\varepsilon})$	Deposits
Securities	S	$max\,(1 + a_0 + S - d - \tilde{\varepsilon})$	To shareholders

Table 3. Base-line case. No investment. Date 2

If $d > 1 + a_0 + S - d - \tilde{\varepsilon}$ the deposit insurance fund pays the difference to depositors. At date 1 the banker decides to forgo the investment opportunity or to invest merged depending on the difference $SV_{\emptyset} - SV_M = O\,(x) - a_1$. Under-investment occurs when this difference is positive. This in turn depends on the interim value a_0 of the legacy loan. The following proposition summarizes when this occurs.

Proposition 2: For under-investment to occur it is needed that $E < x^* - \underline{a}_0$. Under-investment occurs if the realization of $\tilde{a}_0$ is below some threshold value $\hat{a}_0$, namely

$$a_0 < \hat{a}_0 = x^* - (1 - d + S) = x^* - E. \tag{2}$$

This proposition establishes that when the interim information indicates that the return of the legacy loan is sufficiently low, $a_0 < \hat{a}_0$, namely that the fraction $\tilde{y}$ of NPLs is sufficiently high, the banker's option to default on the pre-existing debt (deposits) exceeds the expected net present value of the new investment opportunity.

Observe that under-investment plays a role conceptually similar to risk shifting or asset-substitution since the merged investment is not risky and has higher return, while not investing is riskier and has lower return (See for example Diamond 1991). Under-investment becomes profitable when the sum of the return of the legacy loan and equity $a_0 + E$ falls short of the buffer x^* that makes the default option profitable. From now on we make the following assumption:

Assumption A2 $E < x^* - \underline{a}_0$.

Assumption A2 means that the bank is undercapitalized as equity is lower than the sum of x^* plus the maximum possible loss on the legacy loan $-\underline{a}_0 > 0$. This is consistent with a situation where the bank's equity has been reduced by previous losses. A2, likewise A1, is more likely to be satisfied in a downturn, when, therefore, under-investment is more likely to arise.

When under-investment occurs the risk $\tilde{\varepsilon}$ is not fully hedged so that the deposit insurance fund is potentially exposed to reimburse depositors.

In the next two sections we explore how segregating the troubled legacy loan may overcome the under-investment problem. We stress that the mechanisms that we explore below are designed to eliminate under-investment in a bank which is not failing or likely to fail.

4 The Bad Bank and Adverse Selection

To solve the under-investment problem, governments typically buy the troubled assets of the banks and put them into an asset management company. The crucial question is the transfer price T at which the purchase takes place. If T is low, too few banks accept the deal and under-investment will go on. If T is large the cost for the public finances will be too high. The optimal T is the minimum value that eliminates under-investment. To find such a T in our model consider an incumbent bank that sells its troubled assets to the government and thus becomes the GB. The GB receives the transfer T, assumes the deposit liabilities net of the securities of the original bank, finances itself by issuing new debt with market value D_{GB} and it is owned by the incumbent shareholders. T can then be computed easily by writing down the balance sheet of the GB at date 2 (See Table 4).

New loan	$1 + a_1 + \tilde{\varepsilon}$	d	Deposits
Securities	$S + T$	D_{GB}	New debt
		$SV_{GB} + \tilde{\varepsilon}$	To shareholders

Table 4. GB balance sheet when government buys NPLs. Date 2

If the GB is safe the shareholders' value when the split is undertaken is SV_{GB}. By the balance sheet equation it is equal to

$$SV_{GB} = 1 + a_1 + S + T - d - D_{GB},$$

where $D_{GB} = 1$ since the GB is safe. The optimal T is such that

$$SV_{GB} = SV_M\left(\hat{a}_0\right) = 1 + \hat{a}_0 + a_1 + S - d.$$

Thus

$$T = 1 + \hat{a}_0 + a_1 + S - d - (a_1 + S - d) = 1 + \hat{a}_0.$$

The counterpart of this transfer is that the government will own the legacy loan, whose value is

$$\mathbb{E}\left[1 + \tilde{a}_0 | a_0 \leq \hat{a}_0\right].$$

The expected subsidy paid by the government to the shareholders is thus

$$\mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+ = \int_{\underline{a}_0}^{\hat{a}_0} \left(\hat{a}_0 - \tilde{a}_0\right) dF\left(\tilde{a}_0\right),$$

which is the expected information rent left to the banker. We are going to show that this subsidy can be eliminated by organizing the split in a different way:

- extracting the informational rent of the banker by leaving her the ownership of the BB in exchange of a recapitalization of the GB;
- provisioning the cost of the split by requiring that the bank issues a bail-inable bond at date 0.

5 The bail-in solution

This section shows that under-investment can be eliminated without any government's subsidy. This can be done if the regulator forces the bank to issue at date 0 a bail-inable bond of nominal D can be drawn down to $D - H$ if the BB is created, where H represents the haircut. The bail-inable bond could be, for example, a type of CoCo bond called Principal Write Down. As Avdjiev et al. (2013) argue CoCo Bonds can absorb losses either by converting into common equity (common equity CoCo Bonds) or by suffering a principal writedown (full or partial). Although both types of Coco Bonds boost equity, a Principal Write Down bond does so by incurring a write-down. This avoids the dilution of the existing shareholders and thus a Principal Write Down bond dominates a common equity bond to solve the under-investment problem. The trigger, that is the point at which the loss absorption mechanism is activated, is known ex ante: it occurs when the volume of NPLs exceeds some threshold. Our innovation is that it is the banker rather than the supervisor who has the option to split the bank because the banker has private information.

At date-0 the bank invests the proceed B from issuing the bail-inable bond in risk less securities. If the bank is split, the BB receives the legacy loan and assumes the liability of the written down bond. The GB assumes the deposit liability and receives the risk less securities S and B. The GB finances the new investment with a new bond $1 - E_{GB}$ and a forced recapitalization E_{GB}. The value E_{GB} is chosen in a such a way to make the GB default free, and extract maximal surplus from the banker. In Appendix we calibrate the bank's balance sheet. In Table 5 we show the date-0 balance sheet of the original bank:

Legacy loan	1	d	Deposits
Securities	$S + B$	B	Bail-inable bond
		E	Equity

Table 5. Bail-in case. Date 0

The market value of the bail-inable bond at date 0 is

$$B = \mathbb{E}\left[MV^{BI}\left(D\right)|a_0 < \hat{a}_0^{BI}\right] + D\left[1 - F\left(\hat{a}_0^{BI}\right)\right], \tag{3}$$

where $MV^{BI}\left(D\right)$ is the date 1 market value of the bail-inable bond conditional on the split, i.e.

$$MV^{BI}\left(D\right) = \mathbb{E}\left[min\left(D - H, 1 + \tilde{a}_0 - \tilde{\varepsilon}\right)|a_0 < \hat{a}_0^{BI}\right], \tag{4}$$

and $\hat{a}_0^{BI}$, which is determined below, is the threshold value of a_0 below which the BB is created. The superscript "BI" refers to the bail-in solution. The intuition for (3) is that if the split occurs the bondholders receive at most the written-down bond $D-H$, or the value of the assets $1+a_0-\tilde{\varepsilon}$ if it falls short of $D-H$. If there is no split, which happens with probability $\left[1 - F\left(\hat{a}_0^{BI}\right)\right]$, bondholders receive the promised repayment D.

At date 1 the shareholders value in case of a merged investment becomes $SV_M = a_0+a_1+E-(D-B)$. The banker could mimic the merged investment and invest in risk free securities which is equivalent to doing nothing, i.e.:

$$SV_\emptyset = \mathbb{E}\left[a_0 + E - (D - B) - \tilde{\varepsilon}\right]_+ \tag{5}$$

This is bigger than SV_M whenever

$$a_0 < x^* - E + (D - B) \equiv \hat{a}_0^{BI}. \tag{6}$$

From (2) and (6) it follows that the threshold $\hat{a}_0^{BI}$ is bigger than $\hat{a}_0$ in the base-line case because $D > B$. Thus with the bail-inable bond the banker splits the bank also in cases in which the investment would occur merged in the base-line case.

However, under-investment is avoided by splitting the bank which provides the banker with the same payoff as doing nothing, i.e.

$$\underbrace{\mathbb{E}\left(1+a_0-\tilde{\varepsilon}-(D-H)\right)_+}_{SV_{BB}}+\underbrace{\mathbb{E}\left(\tilde{\varepsilon}+\varepsilon_M\right)}_{SV_{GB}}-(1+\rho)\,E_{GB}=\underbrace{\mathbb{E}\left[a_0+E-(D-B)-\tilde{\varepsilon}\right]_+}_{SV_{\emptyset}}$$

whenever the parameters of the split are well chosen:

$$D-H=(D-B)+(d-S)\,, \tag{7}$$
$$E_{GB}=\frac{\varepsilon_M}{1+\rho},\qquad B=(d-S)+\frac{\rho\varepsilon_M}{1+\rho}-a_1.$$

Notice that the BB has the same net debt, LHS of (7), of the incumbent bank, RHS of (7). The purpose of the BB is to "ring fence" the Adverse Selection on the NPLs, so that the GB can finance the new loan without any Adverse Selection (or default) premium. The forced recapitalization E_{GB} has two objectives: making the GB default free, and extracting the surplus SV_{GB} from the banker. We summarize our results in the following proposition:

Proposition 3: Under-investment can be eliminated if the bank is required to issue at date 0 a bail-inable bond of market value B and nominal value D. If the BB is created, the nominal value is reduced to $D-H$, where the haircut H is equal to $\frac{\rho\varepsilon_M}{1+\rho}-a_1$, and the shareholders inject equity $E_{GB}=\frac{\varepsilon_M}{1+\rho}$ in the GB which issues a risk less bond for the difference $1-E_{GB}$.

Notice that the rationale for the split is not to avoid the contamination effect of the bad legacy loan on the new loan (Banal-Estañol, Ottaviani and Winton, 2013), since we have assumed that even with the lowest possible return on the legacy loan the merged bank would remain risk free and thus its funding cost would not be affected. In table 6 we show the date 2 balance sheets of the BB and GB.

BB

Legacy loan	$1 + a_0 - \tilde{\varepsilon}$	$min\,(D - H, 1 + a_0 - \tilde{\varepsilon})$	Risky debt
		$max\,(1 + a_0 - \tilde{\varepsilon} - (D - H)\,, 0)$	To shareholders

GB

New loan	$1 + a_1 + \tilde{\varepsilon}$	d	Deposits
Securities	$S + B$	$1 - E_{GB}$	Risk free debt
		$\tilde{\varepsilon} + \varepsilon_M$	To shareholders

Table 6. Bail-in. Balance sheets of the BB and GB. Date 2

In the next subsection we discuss the bail-in solution, we place it the context of the current regulatory framework, and consider an alternative solution to the under-investment problem.

6 Discussion and extension

Several observations are in order. First, the fact that deposits are in the GB and that the GB is safe is consistent with the notion that the incumbent bank is treated as a bank which is not failing or likely to fail.

Second, for the split to work we need debt write-down, segregation, and recapitalization. One may then ask whether we could achieve the same result without segregation. Without segregation the Adverse Selection would not be "ring-fenced" and debt write-down alone would not solve the under-investment problem. In fact, given her information advantage, the banker would abuse the write-down option and write the bond down all the times. To prevent this abuse there is a cost for the banker that invokes the write down clause, namely she has to recapitalize the GB to make it risk free. With segregation alone without the debt write-down, the banker would not find it profitable to invest in a SPV given assumption A1. Furthermore, issuing bonds that would convert into equity would not work either because it would dilute the existing shareholders.

Third, to place this mechanism in the context of the current regulatory framework, notice, first, that it requires no public funds. This is consistent with the no-bailout constraint imposed by the DFA and the BRRD. Furthermore, the possibility of setting up a BB is consistent with the DFA and with the BRRD, and it is specifically advocated in some cases by the recent ECB guidelines on NPLs (ECB 2017) when the goal is to restructure a distressed bank, and not its resolution. Bankruptcy restructurings are seldom used for distressed banks as they take a long time, while speed of resolution is essential (White and Yorulmazer 2014). Finally, the GB is the continuation of the original bank which is in line with the evidence that, usually, the GB keeps the licence of the original bank, while the BB has no licence and it is often entrusted only with the task of managing and selling the NPLs (Klingebiel 2000).

In the plans envisioned by the BRRD and the DFA, typically the authority initiates the procedure and the shareholders of the distressed bank are wiped out before subordinated bondholders are bailed in. In our mechanism the banker plays an indispensable role because only she has received the information on the legacy loan which confers to her the right not make the investment. This generates a rent for the banker which, at the interim stage is paid by the bail-inable bondholders, and it is priced ex ante.

We stress that the mechanism that we propose differs from the recent debt write-downs imposed retroactively on some classes of bank's creditors in Cyprus and in Italy. We argue instead that bail-inable bonds should be issued in anticipation of future crises and that the implicit write-down risk should be fairly priced ex ante, as opposed to be imposed unexpectedly in a crisis.

Furthermore, it may be useful to discuss how splitting the bank in a BB and GB differs from other types of ring-fencing of assets and liabilities, and solutions to the debt overhang problem. In *project finance* a company incorporates a project as a bankruptcy-remote subsidiary, resolving potential debt overhang problems. The subsidiary's residual income (after new creditors are repaid), then, flows back to the company, so, ultimately, the company's existing creditors may benefit, too. This is not the case in our model where current creditors lose when the bank is split as the haircut on preexisting debt is positive. Similarly, with *covered bonds*, new creditors' debt would be secured by new assets (and/or existing ones), limiting the transfer of wealth to existing creditors. This, then, facilitates new investment, and existing creditors may benefit, too, unlike our model. *Securitization* may help dispose of NPLs but runs against Adverse Selection problems. Furthermore securitization refers only to the asset side while with the bail-in solution existing debt is written down.

We conclude this section by analyzing how the government could avoid under-investment by subsidizing directly the securitization of the stand-alone project, without splitting the bank. Recall that we have established in Section 3.2 that under assumption A1 the new loan cannot be made as a stand-alone project. If the government provides a direct subsidy $\frac{\rho\varepsilon_M}{1+\rho} - a_1$ to the banker she could raise a risk free amount $1 + a_1 - \varepsilon_M$ and inject $\varepsilon_M - a_1$ into a SPV. In expectation the shareholders breaks even and under-investment disappears, since from the SPV she receives

$$\mathbb{E}\left[1 + a_1 + \tilde{\varepsilon} + \left(\frac{\rho\varepsilon_M}{1+\rho} - a_1\right) - (1 + a_1 - \varepsilon_M)\right]_+ = \frac{\rho\varepsilon_M}{1+\rho} - a_1 + \varepsilon_M,$$

equal to the equity injection. Remark that the incumbent bank which keeps the deposits is risky so there is a positive probability that the depositors will have to be reimbursed by the government. Therefore this solution is dominated by the bail-inable bond.

7 Welfare Analysis

To understand which of the two bank-split solutions to under-investment - government's purchase of troubled assets vs. bail-inable bond - adds more value, we need to specify the objective of the government. We assume that this objective is to find the least costly way to eliminate under-investment, while making the bank safe. We assume that there is a welfare cost λ, $0 < \lambda < 1$, for the use of public funds, e.g. because of . distortionary taxation. This cost is likely to be high when the government has small fiscal capacity, bailouts are politically costly, or supranational regulators constrain the ability of the government to conduct publicly-funded bailouts to rescue domestic banks. Equity entails a welfare cost ρ.

We first compute welfare conditional on the realization of a_0 for the case of government buying the troubled assets (W_1) and in the bail-inable bond case (W_2). We also compute the bank values, that is the shareholders value net of the equity cost in the two cases, that we denote V_1 and V_2, respectively. Then we take the expectation w.r.t. $\tilde{a}_0$ of the subsidy to the shareholders, that is the expectations of the differences $V_1 - W_1$, and $V_2 - W_2$, and finally we compute the expected difference $\mathbb{E}(W_2 - W_1)$.

For values $a_0 < \hat{a}_0$, the government buys the troubled assets at the price $T = 1 + \hat{a}_0$. Welfare is therefore

$$W_1 = a_0 + a_1 - \rho E - \lambda \mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+$$

where ρE is the cost of injecting equity E at date 0 and $\lambda \mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+$ is cost of the government's subsidy to the shareholders. Bank value is $V_1 = \hat{a}_0 + a_1 - \rho E$, which does not depend on interim information a_0.

For values $a_0 > \hat{a}_0$, the government does not buy the troubled assets and investment takes place with no government expenditure so that

$$W_1 = V_1 = a_0 + a_1 - \rho E.$$

Therefore for $a_0 < \hat{a}_0$ the banker receives a subsidy

$$\begin{aligned} V_1 - W_1 &= \hat{a}_0 + a_1 - \rho E - \left[a_0 + a_1 - \rho E - \lambda \mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+\right] \\ &= \hat{a}_0 - a_0 + \lambda \mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+, \end{aligned}$$

and $V_1 - W_1 = 0$ otherwise. Thus in expectation the banker receives a positive subsidy, namely

$$\mathbb{E}\left[V_1 - W_1\right] = (1 + \lambda)\, \mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+ > 0.$$

See Figure 2 in Appendix for an illustration.

With the bail-inable bond for $a_0 < \hat{a}_0^{BI}$, bank split occurs without any government's expenditure so that

$$W_2 = a_0 - \rho E - H,$$

and

$$
\begin{aligned}
V_2 &= \mathbb{E}\left[(a_0 + E - D + B - \tilde{\varepsilon})_+\right] - (1+\rho) E \\
&= O\left(a_0 + E - D + B\right) + a_0 - D + B - \rho E.
\end{aligned}
$$

For $a_0 > \hat{a}_0^{BI}$, investment is merged:

$$
\begin{aligned}
W_2 &= a_0 + a_1 - \rho E, \\
V_2 &= a_0 + a_1 - \rho E - D + B.
\end{aligned}
$$

Therefore the subsidy to the banker for $a_0 < \hat{a}_0^{BI}$ is

$$
\begin{aligned}
V_2 - W_2 &= O\left(a_0 + E - D + B\right) + a_0 - D + B - \rho E - \left(a_0 - \rho E - H\right) \\
&= O\left(a_0 + E - D + B\right) + B - D + H,
\end{aligned}
$$

and for values $a_0 > \hat{a}_0^{BI}$ is

$$
\begin{aligned}
V_2 - W_2 &= a_0 + a_1 - \rho E - D + B - \left(a_0 + a_1 - \rho E\right) \\
&= B - D < 0.
\end{aligned}
$$

In expectation the subsidy is $\mathbb{E}\left[V_2 - W_2\right] = 0$. See the Appendix for the proof and for the illustration in Figure 3. Finally we want to check whether $\mathbb{E}\left(W_2 - W_1\right) \lesseqgtr 0$. Observe that

$$
\begin{aligned}
\mathbb{E}\left(W_2\right) &= \mathbb{E}\left(\tilde{a}_0\right) - \rho E - HF\left(\hat{a}_0^{BI}\right) + a_1\left(1 - F\left(\hat{a}_0^{BI}\right)\right) \\
&= \mathbb{E}\left(\tilde{a}_0\right) + a_1 - \rho E - F\left(\hat{a}_0^{BI}\right)\frac{\rho \varepsilon_M}{1+\rho}, \qquad (8)
\end{aligned}
$$

and

$$
\mathbb{E}\left(W_1\right) = \mathbb{E}\left(\tilde{a}_0\right) + a_1 - \rho E - \lambda \mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+
$$

so that

$$\mathbb{E}\left(W_2 - W_1\right) > 0 \Leftrightarrow \lambda\mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+ - F\left(\hat{a}_0^{BI}\right)\frac{\rho\varepsilon_M}{1+\rho} > 0. \tag{9}$$

This expected welfare difference has two components. The first one is the additional cost of public funds when the government buys troubled assets. The second one refers to the fact that also the bail-in is not cost-less since it entails a costly recapitalization. The expected welfare difference is positive if the cost of government's funds is high, which is likely to be in a downturn, and if the expected recapitalization cost is not too large. In Appendix we calibrate our welfare analysis.

8 Conclusion

In this paper we have proposed a new mechanism to resolve the under-investment problem arising from Adverse Selection on a bank's non-performing loans. This mechanism does not require any government's funding, nor the resolution of the bank. Breaking up the bank by placing legacy NPLs and the legacy bond in a BB and writing down the legacy bond, makes it profitable for the GB to finance the new loan. The key to our mechanism is that private information generates an Adverse Selection rent for the shareholders. The implications of our mechanism differ from those of the bail-in regimes envisioned in the BRRD and in DFA because in our mechanism the shareholders, not only are not wiped out, but must be given their rent. This rent is paid by the bail-inable bond at the interim stage, and ex ante by the shareholders.

Although the bail-in is not the only solution to solve the under-investment problem, when the cost of use of public funds is large it provides a higher ex ante welfare than a solution in which the government buys the bank's NPLs.

These results are important in light both of the sheer size of the stock of NPLs remaining in the European Banking industry years after the beginning of the financial crisis, and of the new regulatory environment for bank crises resolution.

9 Appendix

9.1 Model calibrations

To calibrate the model we proceed in steps: first we calibrate the option value, then we calibrate the balance sheets, and finally we calibrate the welfare analysis.

Calibrations of the option value $O(x)$

From (1) it follows that $x^* = O^{-1}(a_1)$ (See Figure 1). Thus the critical LAC x^* depends on the value of the growth opportunity a_1. Observe first that $\frac{dx^*(a_1)}{da_1} < 0$. That is, the value of LAC where the option to default becomes valuable increases when the net present value of the new loan declines, as for example in a downturn. We can then determine the sensitivity of the critical LAC x^* to changes in a_1 for different values of ε_M. In particular we assume that the gross return of the two loans can be subject to shocks of $\pm 40\%, \pm 60\%, \pm 80\%$, i.e. $\varepsilon_M = 40\%, 60\%, 80\%$. To calibrate the shock $\tilde{\varepsilon}$, that is symmetric around zero, we assume that $\tilde{\varepsilon}$ is distributed as $\tilde{\varepsilon} \sim Beta(1.1, 1.1)$. To illustrate, when $-0.6 \leq \tilde{\varepsilon} \leq 0.6$, the c.d.f. of $\tilde{\varepsilon}$ is

$$G(v) = \int_{-0.6}^{v} \frac{(\varepsilon + 0.6)^{0.1} (0.6 - \varepsilon)^{0.1}}{1.0223} d\varepsilon. \tag{10}$$

We then proceed to compute x^* given a_1. For instance, when $-0.6 \leq \tilde{\varepsilon} \leq 0.6$, using (10) equation (1), becomes

$$\int_{-0.6}^{x^*} (x^* - \varepsilon) \frac{(\varepsilon + 0.6)^{0.1} (0.6 - \varepsilon)^{0.1}}{1.0223} d\varepsilon - x^* = a_1.$$

Table 7 shows the value of the critical LAC x^* for given values of a_1 and ε_M.

Table 7. Calibrations of the critical LAC x^*			
x^*	a_1		
30%	7.2%	3.4%	0.5%
20%	10.5%	6.2%	2.2%
10%	12.5%	7.9%	3.6%
ε_M	0.8	0.6	0.4
$x^* = O^{-1}(a_1)$			

For example, the entry 10.5% indicates that even when the net return of the new loan is large the banker prefers to risk default when the shock ε_M is large (80%) if the value of LAC is less than 20%, that is if assets minus debt is less than 20% of the investment.

As observed above, for a given ε_M as the value of the net return of the new loan declines, the critical LAC increases; $\frac{dx^*(a_1)}{da_1} < 0$. The magnitude of this change is sizeable: for example when $\varepsilon_M = 80\%$ as the value of the net return of the new loan declines by 2% points (from 12.5% to 10.5%) the critical LAC increases by 5% points (from 15% to 20%).

Furthermore, as ε_M increases, the value of the net return of the new loan that triggers the profitability of default for a given critical LAC, increases. That is as ε_M increases, the profitability required to the new loan to avoid the under-investment problem increases. Also the magnitude of this change is sizeable: when the critical LAC is 30% and ε_M increases from 40% to 80% the value of the profitability required to avoid under-investment increases from 0.50% to 7.2%.

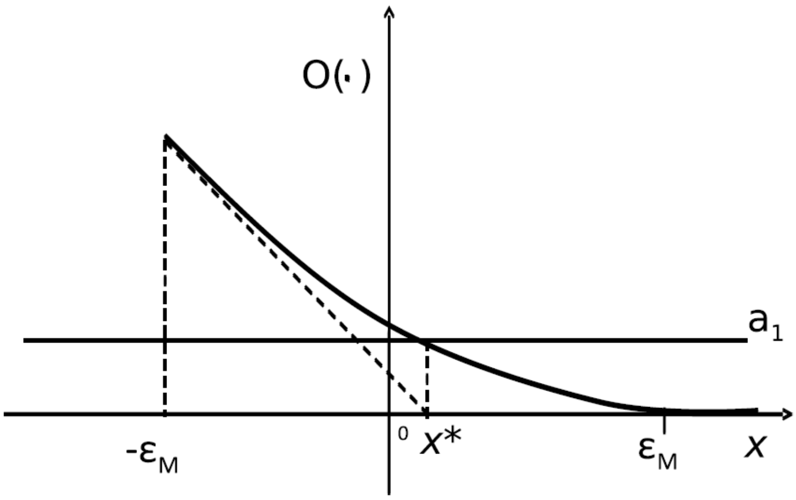

Figure 1: Limited liability option

Calibrations of the balance sheet

We use data on the balance sheets of 108 large banks in the period 1995-2010 from Brei et al. (2013), Table 2. Banks in the sample cover at least 80% of the size of the domestic banking systems in the G10 plus Austria, Australia and Spain. The consolidated balance sheet is represented in Table 8.

Loans	55.8	46.13	Deposits
Liquidity	20.58	47.9	Market funding
Securities	22.89	5.65	Equity

Table 8. All variables in % of total assets.
Source Brei et al. (2013).

In Table 9 we have reclassified the items from Table 8 lumping together Deposits and Market funding, and Liquidity and Securities.

Loans	55.8	94.03	Deposits+Market funding
Liquidity+Securities	43.47	5.65	Equity

Table 9. All variables in % of total assets.

We assume that 10 out of 55.8 loans are risky (approximately 18%) while rest is safe. The resulting balance sheet after approximations is in Table 10.

Risky loans	10	94.4	Deposits+Market funding
Liquidity+Securities+Safe loans	90	5.6	Equity

Table 10. All variables in % of total assets.

In Table 11 we normalize the figures from Table 10 with respect to the size of the date 0 risky loans, which is 1 in the model.

Legacy (risky) loans	1	9.44	Deposits+Market funding
Safe loans+Liquidity+Securities	9	0.56	Equity

Table 11. Base-line case. Date 0

We assume that Table 11 is the numerical representation of Table 1, the date 0 balance sheet of the bank in the base-line case, that is $1 + S = d + E$, where d represents Deposits and Market funding, and S represents Safe loans, Liquidity and Securities.

If we take $a_1 = 3.4\%, \varepsilon_M = 0.6$, and $\rho = 0.1$ it follows that $H = \frac{0.6(0.1)}{1.1} - 0.034 = 2\%$. Thus the bail-inable bond is

$$B = d - S + H = 0.44 + 0.02 = 0.46,$$

so that the date 0 balance sheet with bail-inable bond in Table 12, is the numerical representation of Table 5;

Legacy loan	1	0.44	Deposits - Securities
Securities	0.46	0.46	Bail-inable bond
		0.56	Equity

Table 12. Bail-in case. Date 0

Recall that the pricing equation of the bail-inable bond is (3) where $MV^{BI}(D)$ is from equation (4). To compute the nominal D of the bail-inable bond we use the following approximation. We assume that the distribution $F(\tilde{a}_0)$ is such that the bank split happens with probability 10%, that is $F\left(\hat{a}_0^{BI}\right) = 0.1$, where below we show that $\hat{a}_0^{BI} = -0.224$,. In case of split bondholders recover the smallest between $D - H$ and the value of the legacy loan $1 + \tilde{a}_0 - \tilde{\varepsilon}$. To simplify we assume that in case of split the bail-inable bondholders recover 30% of the written down bond $D - H$. So that the pricing equation of the bail-inable bond (3) becomes

$$\begin{aligned} B &= (0.1)(D - H)(0.3) + (0.9) D \\ 0.46 &= (0.1)(D - 0.02)(0.3) + (0.9) D \end{aligned}$$

which yields $D = 0.49527$. From the calibration of the option value in Table 7, when $a_1 = 3.4\%$ and $\varepsilon_M = 0.6$, we have $x^* = 0.3$. Then the threshold split $\hat{a}_0^{BI}$ is

$$x^* - 1 + D - H = 0.3 - 1 + 0.49527 - 0.02 = \hat{a}_0^{BI} = -0.224.$$

Suppose that at date 1 the legacy loan suffers a loss of 23% that is $a_0 = -0.23 < \hat{a}_0^{BI} = -0.224$. Then the bank is split in BB and GB. From Table 6 the resulting date-2 balance sheets are:

BB

Legacy loan	$1 - 0.23 - \tilde{\varepsilon}$	$min\,(0.47, 0.77 - \tilde{\varepsilon})$	Risky debt
		$max\,(0.77 - \tilde{\varepsilon} - 0.47, 0)$	To shareholders

GB

New loan	$1 + 0.03 + \tilde{\varepsilon}$	$d - S = 0.44$	Deposits-original secur.
Securities	$B = 0.46$	$1 - E_{GB} = 1 - \frac{0.6}{1+0.1}$	Risk free debt
		$\tilde{\varepsilon} + \varepsilon_M = \tilde{\varepsilon} + 0.6$	To shareholders

Table 13. Bail-in. Balance sheets of the BB and GB. Date 2

If we take $\tilde{\varepsilon} = 0$ then we have

BB

Legacy loan	0.77	0.47	Risky debt
		$0.77 - 0.47$	To shareholders

GB

New loan	1.034	0.44	Deposits-original secur.
Securities	0.46	0.45	Risk free debt
		0.6	To shareholders

Table 14. Bail-in. Balance sheets of the BB and GB. Date 2

Thus far we have shown that the bank will avoid under-investment by issuing a bail-inable bond B at date 0 equal to 0.46 of the legacy loan, with nominal $D = 0.49527$, and haircut $H = 0.02$, while keeping the proceeds in risk-less securities. In this way the bank will always make a new loan with net return 3.4%; 10% of the times the investment will be made by the GB, 90% of the times it will be merged.

Observe that the parameter restrictions are all satisfied. In fact A1 is satisfied as

$$H = \frac{\rho \varepsilon_M}{1+\rho} - a_1 = \frac{(0.1)(0.6)}{1.1} - 0.034 = 0.02;$$

and $a_1 = 0.034 < \varepsilon_M = 0.6$. If we take $\underline{a}_0 = -.4$ then A2 is satisfied as $E < x^* - \underline{a}_0$ since $0.56 < 0.3 - (-0.4)$. Furthermore, the value of the assets of the bank when investment is merged is positive even when the legacy loan takes the maximum loss:

$$1 + \underline{a}_0 + a_1 + S - d = 1 - .4 + 3.4\% - .44 > 0.$$

Finally, the value of the stand alone legacy loan is non-negative in the worst possible case, $1 + \underline{a}_0 - \varepsilon_M \geq 0$ as $1 - 0.4 - 0.6 = 0$.

Welfare calibration

We begin with the expected welfare from bank split and bail-inable bond, $\mathbb{E}(W_2)$, from equation (8). From our previous steps it follows that $F\left(\hat{a}_0^{BI}\right)\frac{\rho\varepsilon_M}{1+\rho} = (0.1)\frac{(.6)(0.1)}{1.1} = 0.0054$. If we take $\mathbb{E}(\tilde{a}_0) = a_1 = 3.4\%$ then

$$\mathbb{E}(W_2) = 0.034 + 0.034 - (0.1)(0.56) - 0.0054 = 0.0066 > 0.$$

That is the expected welfare $\mathbb{E}(W_2)$ is in order of 66 bps.

The final step is to compute the expected welfare difference from equation (9). To estimate $\mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+$ we take the following route. Recall first that $\hat{a}_0 = x^* - E = 0.3 - 0.56 = -0.26$. Since $\underline{a}_0 = -0.4$ then the maximum loss that the government bears occurs when it buys at $T = 1 + \hat{a}_0 = 1 - 0.26 = 0.74$ a legacy loan which is worth just $1 - 0.4 = 0.6$; hence at a loss of 0.14. The minimum loss is 0. The average between the maximum and the minimum loss is $\frac{0.14}{2} = 7\%$. This loss occurs in case of split with government bailout, with probability $F\left(\hat{a}_0\right) \simeq F\left(\hat{a}_0^{BI}\right)$, that is with probability 10%. Thus we take $(7\%)\,(10\%) = 0.007$ as our estimate of $\mathbb{E}\left[\hat{a}_0 - \tilde{a}_0\right]_+$. Recall that $F\left(\hat{a}_0^{BI}\right)\frac{\rho\varepsilon_M}{1+\rho} = 0.0054$. Thus the distortion associated with public funding λ that equates the expected welfare in the two solutions is found solving the equation $\lambda 0.007 - 0.0054 = 0$. For $\lambda > 0.771$ the bank split with bail-inable bond solution yields higher expected welfare than the bank split with government bailout.

In sum, our calibrations show that, although the bail-in solution always avoids underinvestment and increases welfare, it is preferable from a welfare standpoint when the distortion in the use of public funds is large.

9.2 Proof that $E\left[V_2 - W_2\right] = 0$.

Observe that

$$\mathbb{E}\left[V_2 - W_2\right] = B - D + \mathbb{E}\left[\left[O\left(\tilde{a}_0 + E - D + B\right) + H\right] | a_0 < \hat{a}_0^{BI}\right].$$

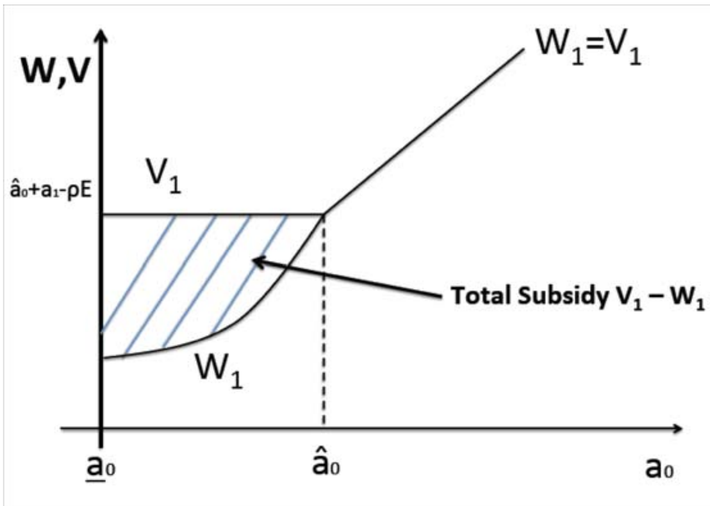

Figure 2: Bank value and welfare when Government buys bad assets.

Recall that B is determined in (3) and $MV^{BI}(D)$ in (4). It is easy to show that

$$\mathbb{E}\left[MV^{BI}(D)\,|a_0 < \hat{a}_0^{BI}\right] = \mathbb{E}\left[\mathbb{E}\left[min\left(D-H, 1+\tilde{a}_0-\tilde{\varepsilon}\right)\right]|a_0 < \hat{a}_0^{BI}\right]$$

$$= \quad (D-H)\,F\left(\hat{a}_0^{BI}\right) - \mathbb{E}\left[O\left(\tilde{a}_0+E-D+B\right)|a_0 < \hat{a}_0^{BI}\right].$$

Thus (3) becomes

$$B = (D-H)\,F\left(\hat{a}_0^{BI}\right) - \mathbb{E}\left[O\left[\left(\tilde{a}_0+E-D+B\right)|a_0 < \hat{a}_0^{BI}\right]\right] + D\left[1-F\left(\hat{a}_0^{BI}\right)\right]$$

from which $\mathbb{E}\left[V_2 - W_2\right] = 0$.

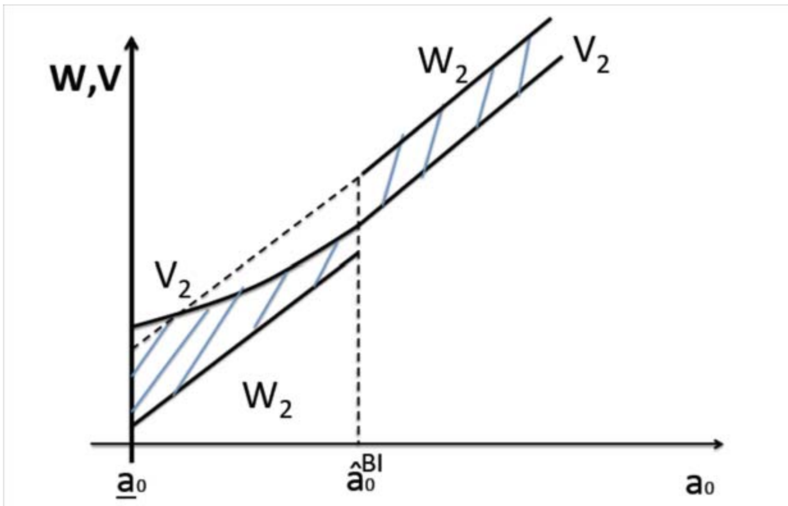

Figure 3: Welfare and bank value with bail-inable bond.

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