Bank Restructuring without Government Intervention *

Marcella Lucchetta
University of Venice

Bruno M. Parigi
University of Padova, and CESifo

Jean-Charles Rochet
SFI@University of Geneva, and University of Zürich

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*E-mail: Lucchetta: lucchett@unive.it; Parigi: brunomaria.parigi@unipd.it; Rochet: jean-charles.rochet@bf.uzh.ch. We are grateful to Matthias Efing for providing the data for our calibrations. We also thank Rui Albuquerque, Elena Carletti, Pierre Collin-Dufresne, Jason Donaldson, Douglas Gale, Charlie Kahn, Bart Lambrecht, Robert Marquez, Erwan Morellec, Martin Oehmke, for helpful discussions and the audiences at the CESifo Applied Micro Conference, the Banque de France, the University of Sassari 2016 Summer Workshop in Alghero, the 2017 Safe/NYU/ETH Law&Banking/Finance Conference, the 4th Cambridge Corporate Finance Theory Symposium, the 2018 FIRS Conference, the Bank of Finland, and at the Universities of Venice, Padova, Lausanne Zurich, HEC, Toulouse for useful comments. Parigi is grateful to the Fondation Banque de France for its hospitality while some of this research was conducted. The usual disclaimer applies.

Abstract

This paper explores a new type of bank restructuring that solves the under-investment problem of banks burdened with non-performing loans (NPLs). If such a bank is allowed to segregate its NPLs and legacy debt in a Bad Bank, it may find it profitable to make new loans. Bad Banks are often created by Resolution Authorities and involve injection of public funds. We investigate a different type of Bad Bank initiated by the original shareholders with no injection of public funds. Such a restructuring is in the spirit of the bail-in regime required by the Bank Recovery and Resolution Directive in the EU and Dodd-Frank Act in the USA. We study the conditions under which a regulation that allows such restructuring is welfare improving.

JEL Classification: G00, G20, G21

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

1 Introduction

Non Performing Loans (NPLs)[1] have recently become a serious and harmful issue for the European Banking Sector. A study by the IMF (2016) estimates that gross NPLs in the Euro area banks were €900 billion at end-June 2015, or about 8% of the region Gross Domestic Product. Similarly the European Banking Authority (2018) estimates that in December 2017 the stock of gross NPLs in the EU banks stood at €813 billion or 4.0% of total gross loans with a very uneven cross country distribution (See Figure 1).

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 much higher than in other jurisdictions: in 2016 the NPL ratio was to 1.5% in the United States 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). Since the beginning of the crisis the growth of NPLs in the EU is associated with credit crunch in the form of a lower rate of growth of loans to non-financial firms (See Figure 2).

Policymakers have used a number of solutions, involving banks recapitalizations, government guarantees of bank liabilities, asset purchases programs, variously combined together. Recently the ECB has issued guidelines

[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).

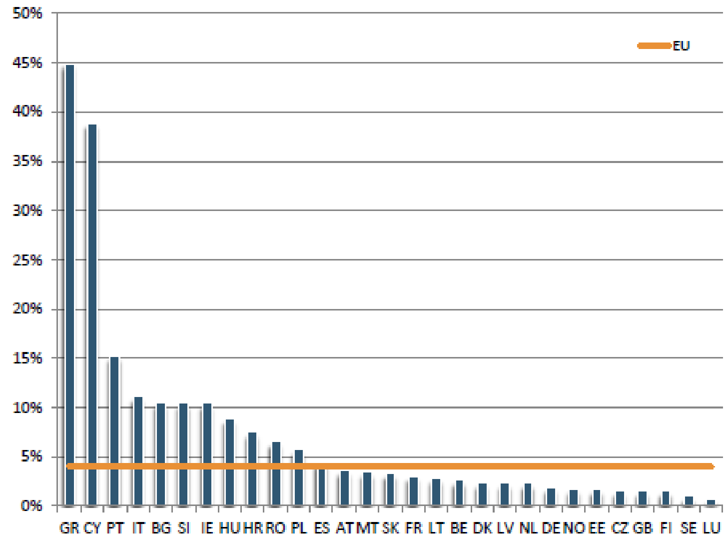

Figure 1: NPL ratios. Weighted averages by country. Source: EBA (2018) Risk Dashboard as of Q4 2017.

advocating a comprehensive approach to deal with NPLs (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), also called Asset Management Company (AMC).

Despite the macroeconomic importance of the NPLs phenomenon and the widespread regulatory changes in the European Union and in the USA, there are almost no specific models to study the economic rationale for setting up these AMCs. Two reasons for establishing a BB can be found 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 may induce risk shifting, incentives can often

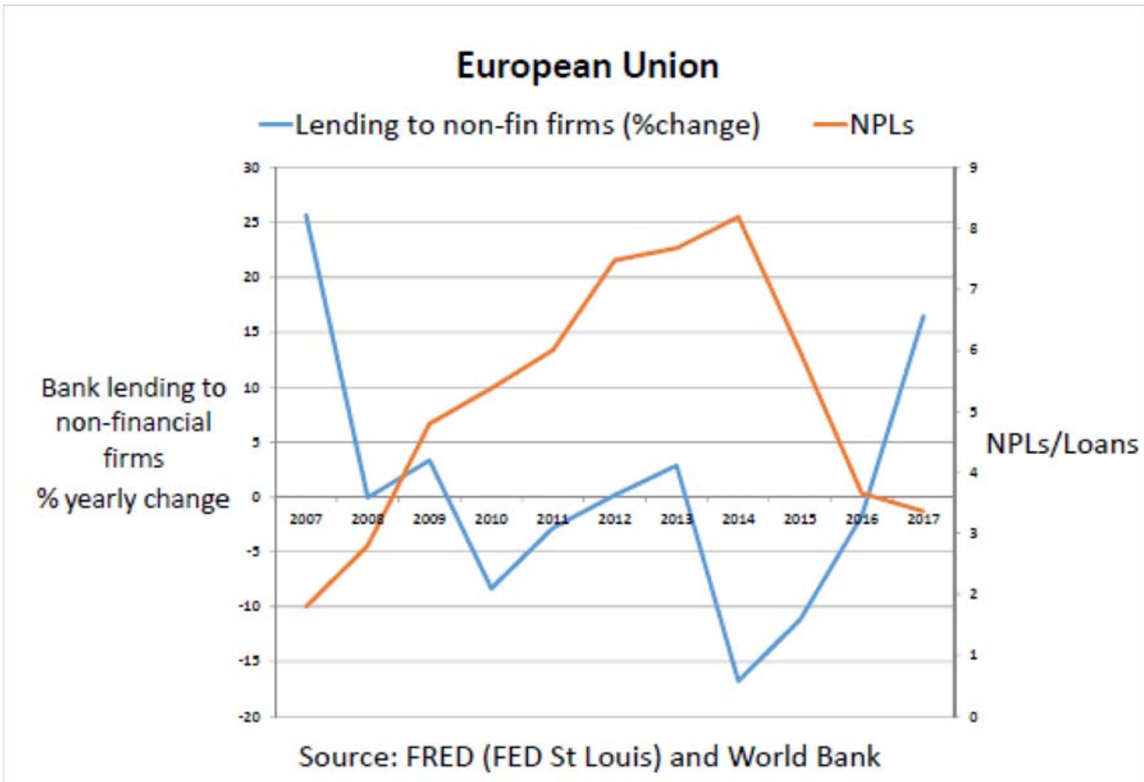

Figure 2: NPLs ratio and lending to non-financial firms in the European Union.

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. (JC here I would like to cite the empirical work of Altavilla et al. that argue that banks with more NPLs increase lending to riskier borrowers, once we have that paper)

The second reason for creating a BB 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). Tirole (2012) studies the problem of a firm that must sell legacy assets of unknown value in order 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. The solution is that the government buys the legacy assets, trading off the benefit of restarting trade vs. the cost of the distortionary taxation to finance the assets purchases. 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 focus on another motive for the creation of BBs based on the impossibility to commit to invest in new assets due to private information on legacy assets. Our hypothesis is that BBs may be a way to address credit crunch or under-investment caused by the debt overhang that a bank may suffer when its loans portfolio deteriorates. Our contribution is to propose a new law to allow an individual bank to create a BB, that may increase ex ante social welfare. If the bank's incumbent shareholders break-up the bank by placing legacy NPLs and legacy debt in a separate structure, the BB, and create a new bank, the Good Bank (GB), this may make it profitable for the GB to raise funds to finance new loans and may solve the under-investment problem.

We follow Myers (1977) and Myers and Majluf (1984) 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 NPV. This happens when the option to default on the outstanding debt is worth more than the expected NPV of the new loan.

In this paper we explore the possibility of creating a BB without any government funding, which is in the spirit of the bail-in of some types of pre-existing debts required by the Bank Recovery and Resolution Directive (BRRD) in the EU and by the Dodd-Frank Act (DFA) in the USA. We show that if the current shareholders segregate the NPLs in a separate corporate structure, possibly writing down the pre-existing bonds and making them junior to the new debt that the BB may issue, then the GB funded with new equity and safe debt, has the incentive to make new loans that would be foregone otherwise. We stress that the aim of such segregation is to solve the under-investment problem arising from debt overhang, that is the aim is to restructure the bank as a going concern, and not the resolution of a bank failing or likely to fail.

If default is socially costly, and if the cash flows both from the legacy loans and from the new loans are less risky when they are pooled under the same corporate structure than when they are separated, then segregation sacrifices diversification opportunities and may reduce welfare ex ante even it eliminates under-investment. We study under which conditions splitting the bank in two is ex ante welfare improving.

The rest of this paper is organized as follow. In Section 2 we present some stylized facts about BBs. In Section 3 we discuss the related literature. In Section 4 we introduce the model and show that under-investment may arise in equilibrium. In Section 5 we illustrate how the creation of a BB eliminates under-investment and in Section 6 we establish the corresponding analytical results. In Section 7 we conduct the welfare analysis. Section 8 concludes. Some proofs are in appendix.

2 Stylized facts about Bad Banks

The BBs that have been set up in the past differ along several dimensions. Two dimensions 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. [2]

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

[2] 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 $800 billion worth of assets at its peak. Similarly in the wake of the crisis, Bank of America created its Legacy Assets and Servicing division to serve the same role as Citi Holdings. Dresdner Bank established an internal restructuring unit in 2003 with staff dedicated to the restructuring of a €35 billion portfolio. 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 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. 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.[3] 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).

Finally, the Italian banking authorities resolved four Italian regional banks[4] in November 2015. 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 fi-

[3] Bail-in of uninsured depositors was politically feasible as about 70% of deposits in the Cyprus Banking System belonged to non-EU residents.

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

nanced 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 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.

Gandrud and Hallerberg (2014) argue that the phasing in of the BRRD, has changed the framework for the creation of BBs and the mix of public and private funds. In a first phase (since Aug 2013) the BRRD only imposed some burden sharing of losses from NPLs among shareholders, and then (since July 2014) imposed a more stringent bail-in regime to shareholders and subordinated bondholders. Gandrud and Hallerberg document that at least 15 BBs were created by 12 EU countries in the period 2008-14 to assist at least 37 distressed banks. The authors argue that ownership matters as it alters the way BBs operate. Majority-privately owned BBs tend to acquire assets at higher haircuts, which forces them to realize losses sooner, avoiding the problem of "zombie banks", and making it more likely that the BB itself will be profitable. Gandrud and Hallerberg show that since the beginning of the crisis until mid-2009 the prevailing ownership model was mixed. Later on, increasingly stringent Eurostat rulings on whether these government participations count as public debt, have pushed member states to create BBs first with minimal private majority ownership and then with large private majority ownership.

3 Related literature

Our paper is related to several strands of literature. The first comprises the afore mentioned pioneering studies by Myers (1977) and Myers and Majluf (1984). Under-investment may arise because of debt overhang (Myers 1997): 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. Private information may also generate under-investment: Myers and Majluf (1984) show that if insiders have private information about the value of the assets in place and of the growth opportunities, new equity could be so severely underpriced that current shareholders may be better off passing valuable investment opportunities.

Two recent papers study bank restructuring under debt overhang. Philippon and Schnabl (2013) (hereafter P-S) and Colliard and Gromb (2017). The paper most closely related to ours is P-S. In their setting a negative aggregate shock to banks balance sheets causes debt overhang. In a general equilibrium model 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. If the economy suffers from such negative externalities, the social costs of debt overhang exceed private costs, and the resulting equilibrium is inefficient. P-S analyze interventions in which the government directly recapitalizes banks and banks 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 would like to stress that we focus on the possibility of segregating the assets in place from the investment opportunity to avoid the debt overhang without any government intervention.

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. In a continuous time model the bank manager, who is better informed about asset values, makes an offer to creditors. If the offer is refused, bargaining may break down and an inefficient action follows. By delaying his offer, the manager can extract a better deal from creditors, which he trades off against the risk that bargaining may break down. Since that cost varies with the assets' value, also the delay the manager is willing to accept varies with asset values. In a separating equilibrium the bank assets' quality is revealed to creditors but at the cost of potentially long negotiation delays. When the government (partially) bailouts the creditors, two effects arise which change the bargaining position of the parties, the length of the delay, and thus the potential for inefficiency. The first effect is that if the bailout is generous the parties have little incentive to negotiate at all, which delays the restructuring. The second effect, however, goes in the opposite direction: if the bailout is generous the value of the debt claim is not very sensitive to the value of the asset, hence the manager has little to gain by delaying making an offer.

There are many studies on the under-investment problem resulting from debt overhang. Bhattacharya (1977) argued that the under-investment problem could be reduced, if not eliminated entirely, by "collateralizing" the cash flows from the investment funded by the new junior creditors. Moyen (2007) estimates the importance of corporate debt overhang in a dynamic model with flexible investment and debt of different maturity. Jiménez et al. (2014) link debt overhang of non-financial corporations to weak banks balance sheet in an attempt to disentangle the bank and firm credit channels in Spain during the period 2002-2010. Andersen et al. (2016) illustrate the debt overhang problem of a binding regulatory liquidity ratio on the incentive of a bank to conduct a repo intermediation.

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. Besides the afore mentioned study by Kahn and Winton (2014), 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.

4 Under-investment in the base-line case

4.1 The model

We consider a bank that provides retail deposit services to households and lends to entrepreneurs. Deposits are insured by the government, while the bank and the entrepreneurs are protected by limited liability. The bank is owned and managed by a risk neutral agent, whom we call the banker. There are three dates 0,1,2. At date 0 the bank lends one unit of good to a first entrepreneur. At date 1 the banker has the possibility to lend to another entrepreneur. All projects pay-off at date 2: in case of success, they return $Y > 1$, the bank receives a repayment $R < Y$. In case of failure the bank and the entrepreneur both get 0. The probability of success q is random. The gross return on the loan is thus qR, while the contribution of the loan to social surplus is $qY > qR$. The banker discounts date 2 payments at rate $\rho > 0$, and has access to financial markets, which are populated by competitive risk neutral investors who are not impatient (zero discount rate).[5]

Thus at date 0 the banker provides a loan to the first entrepreneur (we call this loan the "legacy" asset). He also invests in risk free securities S whose net return we normalize to zero. The banker finances its assets with retail deposits d and equity E, which we both take as given, and by issuing a bond with market value $1 + S - d - E$ (the funding gap of the bank) and face value D_0 due at date 2. Deposits are guaranteed by the government as

[5] Assuming that the banker is more impatient than investors is a simple way to model the cost of equity: the banker requires a rate of return on equity of ρ, while investors only want to break even.

A	L	
1 investment	**d**	deposits
S securities	**1+S-d-E**	bond
	E	equity

Figure 3: Balance sheet at date 0

they must perform their function of payment instruments. See Figure 3 for the bank balance sheet at t=0.

At date 1 the banker privately observes a signal on the probability q of success of the legacy loan. We model this as follows: the net return on the loan $(qR-1)$ is decomposed into the difference between a random variable $\tilde{a}_0$ (which is observed by the banker at date 1) and a shock $\tilde{\varepsilon}$; that is the net return is $\tilde{a}_0 - \tilde{\varepsilon}$. After observing the realization a_0 of the signal, the bank has the possibility to invest one unit in another loan that returns $1+a_1+\tilde{\varepsilon}$ at date 2, where $a_1 > 0$ is publicly observable and deterministic. We assume that $\tilde{a}_0$ is defined on $\mathbb{R}^+$ and has a c.d.f. $F(.)$, while the shock $\tilde{\varepsilon}$ is symmetrically distributed in the interval $[-\varepsilon_M, \varepsilon_M]$, with c.d.f. $G(\cdot)$. The final pay off of the two loans are privately observed by the banker at date 2. Investors can only observe them by paying an audit cost γ. In this Costly State Verification set-up (Townsend 1979), the optimal financing mode is standard debt (when there is a single investor) or straight bonds when investors are many, like in our model. The audit will take place if the bank defaults on its debt.

The simplifying assumption that the shocks on the two loans are exactly opposite implies that this risk is fully hedged when the two investments are under the same corporate structure. It is a simple way to capture the benefits of loans portfolio diversification, and gives the best chances for keeping the two investments under the same bank.

In the spirit of Myers (1977), the banker cannot commit to make the new loan at date 1. This may come from the fact that investment opportunities appear randomly at date 1, and that the banker is the only one to observe whether an entrepreneur has applied or not. An explicit modelling of this feature would complicate the analysis without providing new insights. For the sake of simplicity, we just assume that commitment to providing the new loan is not possible for the banker. Finally the banker could envisage to set up a Special Purpose Vehicle (SPV) to finance the new loan separately from his legacy assets. We thus start by evaluating the cost of setting up such a SPV in our model.

4.2 The cost of financing the new project on a stand-alone basis

The date-1 investment generates a random return $1 + a_1 + \tilde{\varepsilon}$ at date 2. The banker can finance it by issuing a security to the investors and financing the rest by equity (his own funds). In our Costly State Verification set-up, the optimal security is a straight bond. The banker chooses the nominal value D_1 so as to maximize his discounted wealth:

$$V(a_1) \equiv Max_{D_1} \frac{\mathbb{E}[1 + a_1 + \tilde{\varepsilon} - D_1]_+}{1 + \rho} - [1 - MV(D_1)],$$

where $MV(D_1)$ is the market value of a bond of nominal D_1, and $[1 - MV(D_1)]$, is the equity injected by the banker. Adopting the convention that audit costs are paid by the investors, this market value is

$$MV(D_1) = \mathbb{E}[\min(D_1, 1 + a_1 + \tilde{\varepsilon})] - \gamma \Pr[1 + a_1 + \tilde{\varepsilon} < D_1]$$
$$= 1 + a_1 + \mathbb{E}[\min(D_1 - 1 - a_1, \tilde{\varepsilon})] - \gamma \Pr[\tilde{\varepsilon} < D_1 - 1 - a_1].$$

For convenience we will use $x_1 = D_1 - 1 - a_1$, the highest value of $\tilde{\varepsilon}$ that does not provoke bankruptcy (the bankruptcy threshold), as the decision variable of the banker:

$$V(a_1) \equiv \max_{x_1} \frac{\mathbb{E}[\tilde{\varepsilon} - x_1]_+}{1+\rho} - 1 + 1 + a_1 + \mathbb{E}[\min(x_1, \tilde{\varepsilon})] - \gamma G(x_1).$$

After rearranging terms and simplifying, the expression of the banker's wealth becomes:

$$V(a_1) = a_1 - C(\gamma, \rho)$$

where

$$C(\gamma, \rho) = \min_{x_1}[\gamma G(x_1) + \frac{\rho}{1+\rho}\mathbb{E}[\tilde{\varepsilon} - x_1]_+],$$

is the cost of financing the SPV. In the spirit of the trade off theory of corporate structure, this cost is the sum of the expected bankruptcy cost $\gamma G(x_1)$ and the cost of the equity injection needed to obtain a bankruptcy threshold x_1. When the cost of equity is not too high and the bankruptcy cost not too low, the program has a corner solution $x_1 = -\varepsilon_M$, which corresponds to issuing a risk free bond of nominal $1 + a_1 - \varepsilon_M$ and an equity injection ε_M. In that case the cost of financing is just $\frac{\rho \varepsilon_M}{1+\rho}$. The following proposition summarizes our results:

Proposition 1 *1) The project can be financed by a SPV whenever its expected net present value exceeds the cost of financing the SPV.*

2) In the case where the optimal financing is default free, this cost of financing equals $\frac{\rho\varepsilon_M}{1+\rho}$.

From now on, we make the following assumption:

Assumption A1 $a_1 < C(\gamma, \rho)$.

It means that the cost of financing the new loan on a stand-alone basis exceeds the $\mathbb{E}NPV$ of this loan. Note that it implies that $a_1 < \frac{\rho\varepsilon_M}{1+\rho}$, since $C(\gamma, \rho) \leq \frac{\rho\varepsilon_M}{1+\rho}$.

4.3 The limited liability option

Assumption A1 implies that the banker will not create a SPV for financing the new loan. However, this new loan can be financed by the incumbent bank, thanks to the diversification benefits with the legacy loan. The banker simply has to issue risk free debt, and he will receive a deterministic payment at date 2:

$$SV_M = 1 + a_0 + a_1 + S - d - D_0 \equiv a_1 + x,$$

where the subscript M stand for Merged investment and $x = 1+a_0+S-d-D_0$ represents the default threshold of the incumbent bank if there is no new loan. Since the banker cannot commit to invest at date 1 he will do so only if SV_M exceeds the expectation of his wealth when no new investment is made, namely

$$SV_\varnothing = \mathbb{E}\left[1 + a_0 + S - d - D_0 - \tilde{\varepsilon}\right]_+ = \mathbb{E}\left[x - \tilde{\varepsilon}\right]_+ .$$

A full liability bank would only get $\mathbb{E}\left[x - \tilde{\varepsilon}\right] = x$ and would always invest in the new loan. However, this is not true of a limited liability bank. Indeed

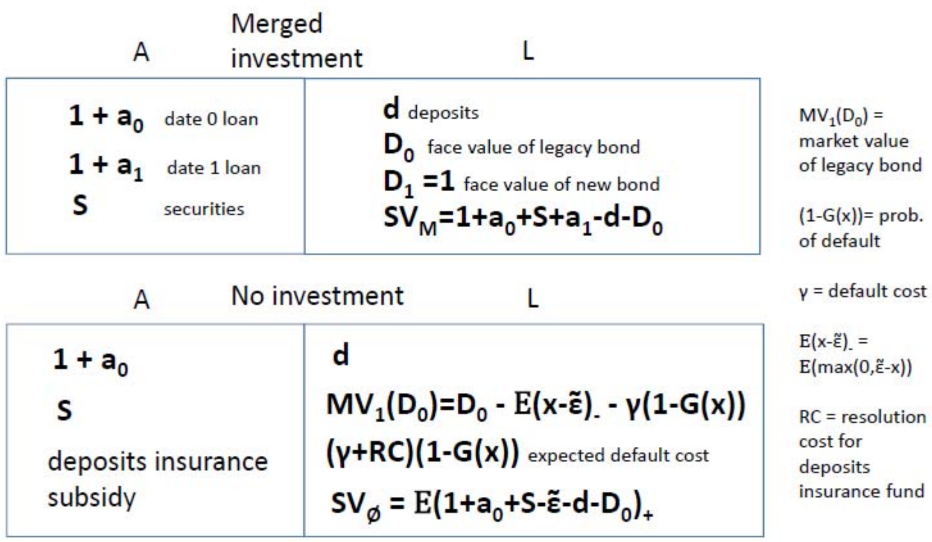

Figure 4: Base-line case: Balance sheets at date 1 when the bank invests merged and when it does not invest.

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 $\mathbb{E}NPV$ of the new loan. It is easy to establish that $O(x)$ is decreasing in x, with $O(-\varepsilon_M)=\varepsilon_M$ and $O(\varepsilon_M)=0$. Thus Assumption A1 implies that there is only one value of x, which we call x^*, such that $O\left(x^*\right)=a_1$. See Lemma 1 in Appendix.

In Figure 4 we report the date 1 balance sheets of the bank when it invests merged and when it does not invest. The following proposition establishes when under-investment occurs.

Proposition 2 *For given values of* a_1 *and* D_0, S, d, *under-investment occurs* *in the base-line case if the realization of* $\tilde{a}_0$ *is below some threshold value, namely*

$$a_0^P = D_0 - 1 + d - S + x^*.$$

Proof. See Appendix.

Under-investment occurs when the interim information on the return of the legacy asset turns out sufficiently low, $a_0 \leq a_0^P$, e.g. when the legacy loan is non-performing. It would always be socially optimal to invest in the new loan at date 1 as its $\mathbb{E}NPV$ is positive, but it may not be in the interest of the current shareholders to do so.

(JC this is the new piece about debt renegotiation) Debt renegotiation could in principle alleviate the debt overhang but it runs against adverse selection problems and lack of commitment to invest. Bhattacharya and Faure-Grimaud (2001) investigate 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. They ask whether the under-investment problem could be eliminated if the existing creditors could be persuaded to renegotiate their claims to limit the wealth transfer from the junior creditors that results from the new investment. They show that if the manager/shareholder cannot commit to invest, there is no debt reduction that would give the equity holder the incentive to make all new positive-NPV investments.

In our model, where in addition to the non-contractible investment, the banker is privately informed about a_0, a debt write down would not help as it would always be adopted by the banker. Since this will be anticipated ex ante by the investors, ultimately it would not affect the decision. By contrast, if the write down could be conditioned on investment, then there would be a trade-off: there would be more investment for a given interest rate but interest rates would increase, and the net effect is ambiguous.

4.4 Under-investment and equilibrium interest rates

The possibility of under-investment feedbacks into the promised repayment D_0 that investors demand at date 0 to finance the gap $1 + S - d - E$. To compute D_0 observe that when the bank does not invest at date 1 the shock $\tilde{\varepsilon}$ is not hedged. Then default at date 2 happens when the realization of the shock exceeds the default threshold $1 + S - d + a_0 - D_0 = x$. Using

$$a_0^P = D_0 - 1 + d - S + x^*, \tag{2}$$

the default threshold can be written as

$$x = a_0 - a_0^P + x^*.$$

The probability of default conditional on a_0 is therefore

$$[PD \mid a_0] = 1 - G\left(a_0 - a_0^P + x^*\right) = G\left(a_0^P - a_0 - x^*\right).$$

Thus the unconditional probability of default is

$$PD = \int_0^{a_0^P} G\left(a_0^P - a_0 - x^*\right) dF\left(a_0\right) \equiv \Lambda\left(a_0^P\right). \tag{3}$$

For convenience we focus on a_0^P as the main variable of interest. D_0 can then be determined by (2). Since by convention creditors bear the bankruptcy costs, the market value of debt is

$$MVD(a_0^P) = D_0 - \int_0^{a_0^P} \{\mathbb{E}\left[\tilde{\varepsilon} - a_0 + a_0^P - x^*\right]_+ + \gamma G\left(-a_0 + a_0^P - x^*\right)\} dF\left(a_0\right) \tag{4}$$

$$= a_0^P + 1 - d + S - x^* - \int_0^{a_0^P} \mathbb{E}\left[\tilde{\varepsilon} - a_0 + a_0^P - x^*\right]_+ dF\left(a_0\right) - \gamma\Lambda\left(a_0^P\right),$$

where the term between brackets is the expected shortfall upon liquidation of the bank assets and the last term is the expected liquidation cost.

Competitive pricing of debt at t=0 implies that the funding gap equals the expected repayment to bondholders. Thus a_0^P is a solution of the pricing equation of the bond:

$$MVD(a_0^P) = 1 + S - d - E. \tag{5}$$

Using (2) and (5), we can rewrite equation (4) as

$$x^* = E + \underbrace{a_0^P - \int_0^{a_0^P} \mathbb{E}\left[\tilde{\varepsilon} - a_0 + a_0^P - x^*\right]_+ dF\left(a_0\right) - \gamma\Lambda\left(a_0^P\right)}_{\Phi\left(a_0^P\right)}. \tag{6}$$

Since x^* is the default threshold below which the value of the limited liability option exceeds the $\mathbb{E}NPV$ from the new investment, given the bank equity, then $x^* - \Phi\left(a_0^P\right)$ in (6) could be interpreted as the average loss absorbing capacity (LAC) that the bank needs to have in order to sustain the under-investment threshold a_0^P. Then we can rewrite (6) as

$$x^* - \Phi\left(a_0^P\right) = E. \tag{7}$$

This condition equalizes equity financing with the average LAC needed to sustain the under-investment threshold a_0^P. Since $\Phi(0) = 0$, under-investment will only occur if

$$x^* > E. \tag{8}$$

Indeed if the bank equity is higher than the critical threshold below which the default option is more valuable than the new investment, under-investment will not occur at equilibrium ($a_0^P = 0$). From now on we assume

Assumption A2 $x^* > E$.

In that case, the following proposition determines the threshold a_0^P and the face value of the bond as a function of the funding gap and of a_1.

Proposition 3 *Under assumptions A1 and A2, under-investment occurs at equilibrium. For given values of* a_1 *and of the funding gap,* a_0^P *is the smallest solution of* (7) , *and the equilibrium face value of the bond,* D_0^P, *follows from* (2) .

This proposition establishes that, in the base-line case, under-investment arises if the return of the legacy loan is below the threshold a_0^P. When the interim information on the return of the legacy asset is sufficiently low, $a_0 \leq a_0^P$, the banker's option to default on the pre-existing debt exceeds the $\mathbb{E}NPV$ of the new investment opportunity. The equilibrium interest rate that incorporates the premium that bondholders demand at t=0 is $\frac{D_0^P}{1+S-d-E} - 1$.[6]

In the next section we explore how splitting the bank may overcome the under-investment problem. We stress that the mechanism that we explore

[6]Observe that we do no need that a_0 takes on negative values to have under-investment. In fact lack of commitment to invest causes investors to demand a premium over the funding gap (as $D_0 > 1 + S - d - E$) which may be enough to cause the debt overhang.

below is designed to eliminate under-investment while treating the bank as a going concern, and not to resolve a bank which is failing or likely to fail.

5 Bad Bank, Good Bank, and Haircut

5.1 The main idea behind the split

The previous section has identified the two main reasons behind the under-investment problem:

- The cost of financing the new loan on a stand-alone basis is too high (Assumption 1)
- The banker wants to benefit from the option to default, which exceeds the $\mathbb{E}NPV$ of the new loan (Assumption 2)

The split of the bank into a Good Bank (GB) and a Bad Bank (BB) can address these two issues, provided two conditions are met:

- The GB receives a subsidy that makes the stand-alone financing of the new asset profitable.
- The BB provides the same option value to the shareholders of the incumbent bank.

In practice, as we have seen, it has often been the case that the subsidy to the GB was paid by the government. However a purely private solution is feasible, provided that the legacy debt-holders incur a haircut that allows financing this subsidy by a new bond issue, while keeping total nominal debt constant. We now describe in more detail how this mechanism can work.

5.2 The bad bank: a description

The mechanism, which is depicted in Figure 5, works as follows:

- At date 0, like in the base-line case, the bank finances its funding gap $1+S-d-E$ by issuing a bond of face value D_0^A due at date 2, where the superscript A refers to the fact that bank split is allowed, and anticipated by investors.

- At date 1, the banker has the option to create a BB that ring-fences the legacy loan and bond away from the balance sheet of the incumbent bank, which becomes the GB. The banker commits to recapitalize the GB to make it default free. (JC, we have to quantify recapitalization; furthermore, below we seem to be saying different things: $E_{GB}(\hat{a}_0) = \varepsilon_M - a_1$ and, implicitly, $E_{GB} = \frac{\varepsilon_M}{1+\rho}$ when we introduce $U(a_0, \bar{a}_0)$) In exchange, the GB receives a transfer P from the BB (financed by issuing senior risk free debt) and the BB is allowed to reduce the nominal value of its legacy debt by a haircut H. Since the GB becomes default free (and refinancing costs are bygone) the new investment will always be made when the BB is created.

After observing a_0, the banker compares the shareholder values associated with three possibilities:

- doing nothing: $SV_\varnothing = \mathbb{E}\left[1 + a_0 + S - d - D_0^A - \tilde{\varepsilon}\right]_+$

- merged investment: $SV_M = 1 + a_0 + a_1 + S - d - D_0$

- creating a BB: $SV_{BB} = \underbrace{\mathbb{E}\left[1 + a_0 - D_0^A - P + H - \tilde{\varepsilon}\right]_+}_{\text{Bad Bank}} + \underbrace{a_1 + P + S - d - \frac{\rho\varepsilon_M}{1+\rho}}_{\text{Good Bank}}.$

Under-investment is eliminated if doing nothing is never the preferred option: $Max(SV_M, SV_{BB}) \geq SV_\varnothing$ and the GB is profitable for the banker: $a_1 + P + S - d - \frac{\rho\varepsilon_M}{1+\rho} \geq 0$.

The splitting of the bank into the BB and the GB is costly, because it implies issuing new equity for the GB. The threshold below which the banker chooses the split is denoted a_0^A. It is defined by the value of a_0 that satisfies the equality $SV_M = SV_{BB}$. The socially optimal scheme (see below for a full analysis) is the one that minimizes the probability of the split, $F(a_0^A)$, under the constraint that under-investment disappears $Max(SV_M, SV_{BB}) \geq SV_\varnothing$. We show below that the optimal scheme is such that $SV_{BB} \equiv SV_\varnothing$, which is equivalent to two conditions:

$$P = d - S + \frac{\rho\varepsilon_M}{1+\rho} - a_1, \text{ and } H = P + S - d = \frac{\rho\varepsilon_M}{1+\rho} - a_1. \qquad (9)$$

Note that assumption A1 implies that $H > 0$. The next section provides a full contract theoretic analysis and shows that the characteristics of the BB described above corresponds to an optimal revelation mechanism for solving the under-investment problem under adverse selection.

5.3 The bad bank as an optimal revelation mechanism

There are essentially two frictions[7] in our model:

[7] A third friction is the deposit insurance subsidy, which implies that the banker will tend to use too little equity financing. This aspect is outside the scope of the model.

- adverse selection: the banker has private information on borrowers. i.e. the signal a_0 on the legacy asset, and
- costly state verification: date 2 cash flows are private information of the banker, unless the investors perform a costly audit .

The second assumption is very natural, as it implies that debt financing is optimal for the bank, and is a simple way to introduce the cost of failures. Note that this cost is higher for a deposit taking institution, since the Deposit Insurance Fund has to incur, in addition to the audit cost γ, the cost RC of repaying depositors.

(JC I think we need to add that there is a third friction, non-contractible investment, and then we can explain below that these two frictions together prevent debt renegotiation) The first assumption is crucial for establishing the optimality of the BB/GB mechanism. If a_0 was public information, the banker could renegotiate a reduction of the nominal debt with the bondholders in such a way that both parties gain.

With adverse selection, and because the banker cannot commit to invest at date 1 in all circumstances, the only instrument available to solve the under-investment problem is the split of the bank between the GB and the BB. In full generality we can envisage a revelation mechanism where the banker reports a message $\hat{a}_0$, possibly different from the truth. The mechanism can be described as follows:

- at date 0 investors inject $1 + S - d - E$ into the bank, in exchange for a promised repayment at date 2 (specified below).

- at date 1 the banker observes a_0 and reports $\hat{a}_0$.

- if the message $\hat{a}_0$ belongs to the set $\mathbb{B}$ (to be determined) the bank is split in two entities. The banker injects new equity $E_{GB}(\hat{a}_0)$ into the GB to make it default free. New investors inject $(1 - E_{GB}(\hat{a}_0))$ into the GB, and at date 2 they receive $P(\hat{a}_0)$ from the BB and $(1 - E_{GB}(\hat{a}_0) - P(\hat{a}_0))$ from the GB, so that they exactly break even. The banker receives $[1 + a_0 - P(\hat{a}_0) - D(\hat{a}_0) + H(\hat{a}_0) - \tilde{\varepsilon}]_+$ from the BB and $1 + a_1 + S - d + \tilde{\varepsilon} - (1 - E_{GB}(\hat{a}_0) - P(\hat{a}_0))$ from the GB, where $D(\hat{a}_0)$ is the debt repayment promised to investors, $E_{GB}(\hat{a}_0)$ is the equity injected by the GB and $D_{GB}(\hat{a}_0) = (1 - E_{GB}(\hat{a}_0) - P(\hat{a}_0))$ is the debt. Subtracting the cost of equity, we compute the banker's the total net expected utility: (JC. I think there is a problem of notation because above we denoted with SV_{BB} the payoff from both the BB and GB, and we never introduced SV_{GB})

$$U(a_0, \hat{a}_0) \equiv SV_{BB} + SV_{GB} - (1+\rho) E_{GB}(\hat{a}_0) \equiv$$
$$\mathbb{E}[1 + a_0 - P(\hat{a}_0) - D(\hat{a}_0) + H(\hat{a}_0) - \tilde{\varepsilon}]_+ + a_1 + S - d + P(\hat{a}_0)) - \rho E_{GB}(\hat{a}_0).$$

- if the message $\hat{a}_0$ does not belong to the set $\mathbb{B}$ the banker is not allowed to make the split and chooses, like in the base-line case, between doing nothing and a merged investment. The net expected utility of the banker is:

$$U(a_0, \hat{a}_0) \equiv Max\left(\mathbb{E}\left[1 + a_0 + S - d - D(\hat{a}_0) - \tilde{\varepsilon}\right]_+, 1 + a_1 + S - d + a_0 - D(\hat{a}_0)\right).$$

We restrict attention to Incentive Compatible Mechanisms. For such mechanisms, where truthful revelation is the optimal strategy of the banker, we denote his utility by

$$U(a_0) = U(a_0, a_0) = Max_{\hat{a}_0} U(a_0, \hat{a}_0).$$

(JC in the proposition below we say $E_{GB}(\hat{a}_0) = \varepsilon_M - a_1$, while we say implicitly, $E_{GB} = \frac{\varepsilon_M}{1+\rho}$ when we introduce $U(a_0, \bar{a}_0)$)

Proposition 4 *The following mechanism is incentive compatible and replicates the banker's status-quo payoff:*

$$\begin{aligned} \forall \hat{a}_0 &\notin \mathbb{B} \qquad D(\hat{a}_0) \equiv D \\ \forall \hat{a}_0 &\in \mathbb{B} \qquad P(\hat{a}_0) = d - S + \rho\varepsilon_M - a_1(1+\rho) \\ H(\hat{a}_0) &= \rho\varepsilon_M - a_1(1+\rho); \quad E_{GB}(\hat{a}_0) = \varepsilon_M - a_1 \\ \mathbb{B} &= \left[0, a_0^A\right], \quad \textit{where } a_0^A = D - 1 + x^*. \end{aligned}$$

Proof. Consider first the case $\forall \hat{a}_0 \notin \mathbb{B}$. Then by construction

$$U(a_0, \hat{a}_0) \equiv Max\left(\mathbb{E}\left[1 + a_0 + S - d - D(\hat{a}_0) - \tilde{\varepsilon}\right]_+, 1 + a_1 + S - d + a_0 - D(\hat{a}_0)\right)$$

which is status-quo payoff of the banker. Note that $U(a_0, \hat{a}_0)$ does not depend on $\hat{a}_0$. However, the banker could choose a message $\bar{a}_0 \in \mathbb{B}$ in which case

$$U(a_0, \bar{a}_0) \equiv \mathbb{E}\left[1 + a_0 + S - d - D + P - H - \tilde{\varepsilon}\right]_+ + a_1 + S - d + P - \rho E_{GB}.$$

Replacing P, H and E_{GB} by their values we obtain

$$U(a_0, \bar{a}_0) \equiv \mathbb{E}\left[1 + a_0 + S - d - D - \tilde{\varepsilon}\right]_+$$

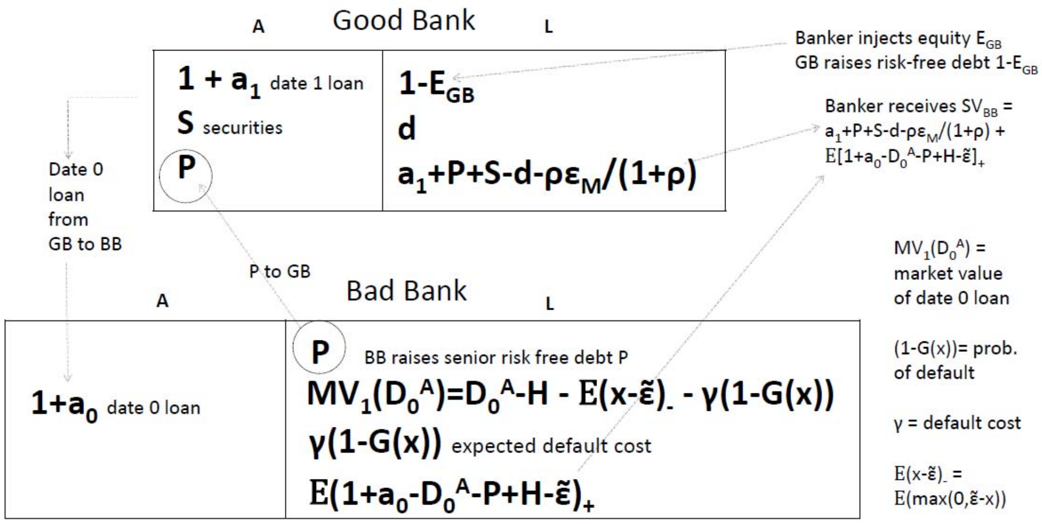

Figure 5: Bank split allowed: date 1 balance sheets of the Good Bank and of the Bad Bank.

which is (weakly) smaller than $U(a_0, \hat{a}_0)$, and equal when $\hat{a}_0 \in \mathbb{B} = \left[0, a_0^A\right]$.
■

The mechanism described in proposition 4 is the optimal mechanism we were looking for because it is incentive compatible and exactly replicates the banker's status quo utility. (JC, status quo utility is not immediately clear; I suggest we say participation constraint and add $SV_{\varnothing}$) Figure 5 shows the date 1 balance sheets of the GB and the BB.

To place the mechanism that we propose in the context of the current regulatory framework, several observations are in order. First, this mechanism requires no public funds: this is consistent with the no-bailout constraint imposed by the DFA and the BRRD. Second, the possibility of setting up a BB is consistent with the DFA (White and Yorulmazer 2014) 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. Third, bankruptcy restructuring are seldom used for distressed banks as they take a long time, while speed of resolution is essential (White and Yorulmazer 2014). Fourth, our scheme differs from Coco bonds that are activated by a verifiable event, which is at odd with the notion that the incumbent shareholders can discretionally invest on the basis of private info. Furthermore, unlike with Coco bonds, in our mechanism incumbent shareholders and creditors retain no right to the GB. 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).

However, unlike the recovery and resolution plans envisioned by the BRRD and DFA, where typically the resolution authority initiates the procedure and the shareholders of the distressed bank are wiped out before subordinated bondholders are bailed-in, in this mechanism the incumbent shareholders play an indispensable role because only they have the right to make the investment, and only they have received the information a_0. Hence this mechanism takes into account their participation constraint.

We conclude this section by discussing 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 H 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. In any case these two solutions would never be chosen voluntarily by the banker in our model since they are dominated by merged investment. Indeed project finance or covered bonds would give the banker a shareholder value $\mathbb{E}[1 + a_0 + a_1 + S - d - D_0 - \tilde{\varepsilon}]_+$ which is less than $SV_M = 1 + a_0 + a_1 + S - d - D_0$ since the option to default cannot have a negative value. *Securitization* may help dispose of NPLs but runs against adverse selection problems. Furthermore securitization refers only to the asset side while with the bank split existing debt is written down, the BB loses securities S and the right to make the new loan, it is relieved of the obligation to pay deposits d, and the GB receives a transfer P for the transaction. Finally, also the cash flow from the new investment could be *securitized*, but like in the cases of project finance and covered bonds the economies of scope between deposits and lending would be lost. (JC, I think that the previous sentence is not correct. In light of A1 it is not optimal to set up a SPV to securitize the cash flow from the new investment)

6 Solving the under-investment problem

In the previous section we have described the optimal mechanism to create the BB and the GB. We are now able to establish the threshold value of the legacy loans that triggers the bank split and the resulting risk premium that bondholders demand at date 0. Next result shows that when a_0 is sufficiently low, i.e. when the legacy loans are non-performing, the incumbent shareholders set up the BB, and the GB invests at date 1.

Proposition 5 *When the bank split at date 1 is allowed we obtain that:*

1. *under-investment disappears since either the GB makes the investment separately or the original bank makes the investment merged with legacy loans;*
2. *the split takes place if and only if* a_0 *is below or equal to a threshold* a_0^A*, which is the smallest solution of the equation* $x^* - \Psi\left(a_0^A\right) = E$*, where* $x - \Psi\left(a_0^A\right)$ *is the average loss absorbing capacity needed by the incumbent bank.*

Proof. See Appendix.

Observe that when the bank split is allowed, the minimum loss absorbing capacity that the bank needs is different from the one in the base-line case. In fact it is increased by the expected haircut $HF\left(a_0^A\right)$. Thus we can compare the profitability thresholds to invest merged when the bank split is allowed and in the base-line case. From (18) $\Psi\left(a_0^A\right)$ can be expressed as follows:

$$\Psi\left(a_0^A\right) = \Phi\left(a_0^A\right) - HF\left(a_0^A\right).$$

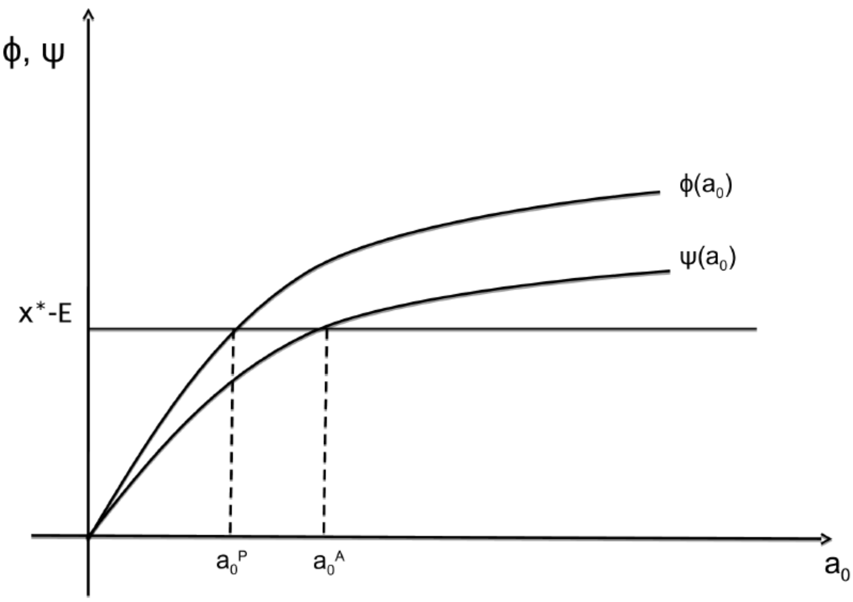

Figure 6: In the interval $\left[a_0^P, a_0^A\right]$ the BB is created too often ex post.

This allows us to establish the following result.

Proposition 6 *Since* $\frac{\rho \varepsilon_M}{1+\rho} > a_1$ *the haircut* H *is positive, and* $a_0^A > a_0^P$.

Proof. See Figure 6.

Proposition 6 clarifies the trade-off associated with the authorization of BBs. On the one hand, it eliminates the under-investment problem. On the other hand, the possibility for the banker to reduce his nominal debt by the haircut H implies that the banker will create a BB too often ($a_0^A > a_0^P$). The bank split is established more often than socially optimal, since segregation takes place for realizations of a_0 in which the investment would be made merged with the legacy loan if the bank split would not have been allowed.

Bondholders anticipate this and demand a higher premium ex ante; from (15) and (14) it follows that $a_0^A > a_0^P \Longrightarrow D_0^A > D_0^P$.

7 Welfare analysis

7.1 The components of social welfare

The main motivation to allow privately-funded BB is to stimulate investment, which increases social surplus by a factor $\mathbb{E}[q] Y \equiv V$ which exceeds the bank's return on assets $1 + a_1 = \mathbb{E}[q] R$.

A second impact of our bank split would be to reduce dramatically the burden on deposit insurance, given that the GB, who manages deposits is default free in our model. According to Bennett and Unal (2015) who have analyzed more than 1200 bank failures in the US over the period 1986-2007, the average resolution cost RC for a failing bank is 15% of the book value of assets, on top of the direct liquidation costs (our γ), which they estimate on average to 1.5%

With these two elements at hand, social welfare can be computed as follows in our model:

$$W^P = V + V[1 - F(a_0^P)] - (\gamma + RC)\Lambda(a_0^P), \tag{10}$$

in the base-line case (the first V corresponds to the legacy loan, the second to the new loans, only financed when $a_0 > a_0^P$) and

$$W^A = 2V - \gamma\Lambda(a_0^A) - \frac{\rho\varepsilon_M}{1+\rho}F(a_0^P), \tag{11}$$

when the bank split is allowed, where the last term is the expected cost of the equity injected by the banker in the GB.

7.2 Analysis

We now investigate whether allowing the bank to split increases welfare ex ante with respect to the base-line case. We have established in Proposition 3 that when the bank split is allowed under-investment is eliminated. However, when $\frac{\rho\varepsilon_M}{1+\rho} > a_1$ bank split occurs more often than socially optimal ex post. This matters because since the shock $\tilde{\varepsilon}$ is not hedged the BB is risky and default is socially costly. Using (10) and (11) we can compute the incremental welfare generated by the possibility to create the bad bank

$$\Delta W = W^A - W^P = [V - \frac{\rho\varepsilon_M}{1+\rho}]F\left(a_0^P\right) - \gamma[\Lambda\left(a_0^A\right) - \Lambda(a_0^P)] + RCF\left(a_0^P\right), \tag{12}$$

whose sign is ambiguous when $a_0^A > a_0^P$. The first term on the RHS of (12) is the net benefit of segregation, which is given by the probability that the BB is established times the surplus generated by the new investment net of the cost of the equity injected in the GB. The second term is the cost of establishing the BB too often, which is given by the bankruptcy cost γ times the increase of the probability of default when the BB is allowed vs. the base-line case. The last term is the decrease in the deadweight loss of the Deposit Insurance Fund, given that, when the BB is created, deposits are managed by the GB, which is default free.

(JC, the section on Welfare is too short and ends abruptly. On the other hand the section Bad Bank, Good Bank, and Haircut is too long. I wonder if we should unify the subsection on Solving the under-investment problem and the Welfare section)

8 Conclusion

In this paper we have proposed a new mechanism to resolve the under-investment problem coming from the debt overhang situation of a bank. This mechanism does not require any government funding, nor the resolution of the bank. Breaking up the bank by placing legacy NPLs and legacy bonds in a BB, makes it profitable for the GB to finance new loans. We find that allowing segregation, recapitalizing the GB, and writing down existing bonds, may eliminate the under-investment problem. However, if default is socially costly and if combining the cash flows from legacy loan and the new loan makes them less risky than when they are separate, then segregation sacrifices diversification opportunities and may lower welfare ex ante even if it eliminates under-investment.

These results are important in light both of the sheer size of the stock of NPLs remaining in the European Banking Sector years after the beginning of the financial crisis, and of the new regulatory environment for bank crises resolution. We stress that the creation of this type of Bad Bank entails no Government funding in the spirit of the possibility of the bail-in of the pre-existing debt required by the BRRD and FDA.

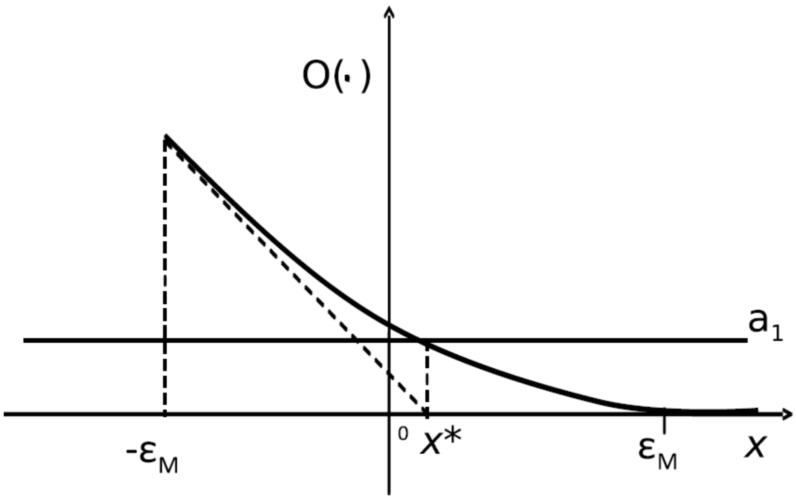

Figure 7: Limited liability option

9 Appendix

Lemma. Under the assumption that $a_1 < \mathbb{E}\left[\tilde{\varepsilon}\right]_+$, there exists a unique value $x^* > 0$ such that $x \leq x^* <=> O\left(x\right) \geq a_1$.

Proof of Lemma. Since the function $O\left(x\right)$ has the following properties:

$$O\left(x\right) = -x \text{ for } x \leq -\varepsilon_M; \quad O\left(x\right) = 0 \text{ for } x \geq \varepsilon_M; \quad O'\left(x\right) = G\left(x\right) - 1 < 0,$$

then there exists a unique value of x that we label x^*, such that the limited liability option is equal to the NPV of the new investment, i.e.

$$O\left(x^*\right) = a_1. \tag{13}$$

See Figure 7. This establishes that since the limited liability option value decreases with the net resources available at t=1, and given that $a_1 < \mathbb{E}\left[\tilde{\varepsilon}\right]_+$, then there is a positive threshold value of the net resources x^* below which the NPV of the new investment a_1 falls short of the limited liability option.

Proof of Proposition 2. We determine the threshold value of a_0 below which, for a given a_1, D_0, d, S, this limited liability option causes under-investment. Thus

$$\Delta(a_0) \geq 0 <=> O(x) \equiv \mathbb{E}[x - \tilde{\varepsilon}]_+ - x \geq a_1.$$

For given values of a_1, D_0, d, S, the threshold value of a_0 below which under-investment occurs is thus

$$a_0^P = D_0 - 1 + d - S + x^*, \tag{14}$$

where x^* is determined in (13). ■

Proof of Proposition 7.

1) When the bank split is allowed, as long as $SV_{BB} \geq SV_{\varnothing}$ that is as long as constraint (16) is satisfied, under-investment is eliminated. For $a_0 < a_0^A$ the BB is created and the GB invests; for $a_0 \geq a_0^A$ the original bank invests merged.

2) Given the funding gap $1 + S - d - E$, the relationship between a_0^A and D_0^A is:

$$a_0^A = D_0^A - 1 + d - S + x^*, \tag{15}$$

where x^* is determined in (13). To price D_0^A, observe first that when $a_0 \leq a_0^A$ this bond repays the amount

$$D(a_0) = \mathbb{E}[\min(D_{BB}, 1 + a_0 - \tilde{\varepsilon} - P)] - \gamma G(D_{BB} + P - 1 - a_0), \tag{16}$$

where the first term on the RHS of (16) is the expected value of the smallest between the written down pre-existing bond D_{BB}, and the cash flow of the legacy loan net of the repayment of the new senior debt P. Notice that

$$\min\left(D_{BB}, 1+a_0-\tilde{\varepsilon}-P\right) = D_{BB} - \max\left(0, D_{BB}+P-1-a_0+\tilde{\varepsilon}\right),$$

and that from (9) and (15) it follows that

$$\begin{aligned}\min\left(D_{BB}, 1+a_0-\tilde{\varepsilon}-P\right) &= D_{BB} - \left(D_0^A+d-S-1-a_0+\tilde{\varepsilon}\right)_+ \\ &= D_{BB} - \left(a_0^A-a_0-x^*+\tilde{\varepsilon}\right)_+ .\end{aligned}$$

Competitive pricing of the bond implies that D_0^A is such that

$$1+S-d-E = D_0^A\left[1-F\left(a_0^A\right)\right] + \int_0^{a_0^A} D\left(a_0\right) dF\left(a_0\right). \tag{17}$$

From (9) we can easily see that the haircut is $H = D_0^A - D_{BB} = S-d+P$. Equation (17) can therefore be written as

$$\begin{aligned}&1+S-d-E = D_0^A \\ &-\int_0^{a_0^A}\left\{\underbrace{S-d+P}_{H} + \mathbb{E}\left(a_0^A-a_0-x^*+\tilde{\varepsilon}\right)_+ + \gamma G\left(-a_0+a_0^A-x^*\right)\right\} dF\left(a_0\right) \\ &= D_0^A - \int_0^{a_0^A}\left\{H + \mathbb{E}\left(a_0^A-a_0-x^*+\tilde{\varepsilon}\right)_+ + \gamma G\left(-a_0+a_0^A-x^*\right)\right\} dF\left(a_0\right).\end{aligned}$$

Finally, after using (15), we obtain,

$$x^* = E + \underbrace{a_0^A - \int_0^{a_0^A}\left\{H + \mathbb{E}\left(a_0^A-a_0-x^*+\tilde{\varepsilon}\right)_+ + \gamma G\left(-a_0+a_0^A-x^*\right)\right\} dF\left(a_0\right)}_{\Psi\left(a_0^A\right)}, \tag{18}$$

where, like in (6), $x^* - \Psi\left(a_0^A\right)$ is the loss absorbing capacity of the bank when bank split is allowed. a_0^A is the smallest solution of (18). The resulting equilibrium interest rate is $\frac{D_0^A}{1+S-d-E} - 1$ where D_0^A follows from (15) and is the fairly-priced value of the bond. ■

10 References

Allen, F., S. Bhattacharya, R. Rajan, and A. Schoar (2008) "The Contributions of Stewart Myers to the Theory and Practice of Corporate Finance" *Journal of Applied Corporate Finance* 20, 1-13.

Allen, F., E. Carletti, and R. Marquez (2011) "Credit market Competition and Capital Regulation" *Review of Financial Studies* 24, 983-1018.

Bhattacharya, S. (1977) "The Role of Collateral in Resolving Problems of Incentives and Adverse Selection," Working Paper, Sloan School, Massachusetts Institute of Technology.

Bhattacharya, S. and A. Faure-Grimaud (2001), "The Debt Hangover: Renegotiation with Non-contractible Investment" *Economics Letters* 70, 413-419.

Banal-Estañol, A., M. Ottaviani and A. Winton (2013) "The Flip Side of Financial Synergies: Coinsurance Versus Risk Contamination" *Review of Financial Studies* 26, 3142-3181.

Colliard, J.-E. and D. Gromb (2017) "Financial Restructuring and Resolution of Banks" HEC mimeo, May.

DeMarzo, P. (2005) "The Pooling and Tranching of Securities: A Model of Informed Intermediation" *Review of Financial Studies* 18, 1-35.

EBA (2018) "Risk Dashboard Data Q4 2017"; https://www.eba.europa.eu/documents
.

ECB (2017) "Guidance to banks on non-performing loans" Banking Supervision, March; Frankfurt.

ESRB (2017) "Resolving non-performing loans in Europe" European System of Financial Supervision, July 2017 Report.

Gandrud, C., and M. Hallerberg (2014) "The Bad Banks in the EU: The Impact of Eurostat Rules" Bruegel Working Paper n.15, December.

IMF (2015) "A Strategy for Resolving Europe's Problem Loans", Staff Discussion Note 15/19.

IMF (2016) "Global Financial Stability Report", April.

Jiménez, G., S. Ongena, J.-L. Peydró, J. Saurina (2014) "Credit Demand Forever? On the Strengths of Bank and Firm Balance-Sheet Channels in Good and Crisis Times" mimeo November, http://ssrn.com/abstract=1980139.

Kahn, C. and A. Winton "Moral Hazard and Optimal Subsidiary Structure for Financial Institutions" *Journal of Finance*, 69, 2531-2576.

Leland, H.E. (2007) "Financial Synergies and the Optimal Scope of the Firm: Implications for Mergers, Spinoffs, and Structured Finance" *Journal of Finance* 62, 765-807.

Klingebiel, D. (2000) "The Use of Asset Management Companies in the Resolution of Banking Crises. Cross-Country Experience" The World Bank, Policy Research Working Paper 2284.

McKinsey (2009) "Understanding the bad bank" by G. Brenna, T. Poppensieker, and S. Schneider, McKinsey, Zurich and Munich Offices, December.

Moyen, N. (2007) "How big is the debt overhang?" *Journal of Economic Dynamics and Control* 31, 433-472.

Myers, S. (1977) "Determinants of Corporate Borrowing" *Journal of Financial Economics* 5, 147–175.

Myers, S. and N.S. Majluf (1984) "Corporate Financing and Investment Decisions When Firms Have Information That Investors do not Have" *Journal of Financial Economics* 13, 187-221.

New York Times (1988) "Mellon Set to Shift Bad Loans" July 26.

Philippon, T. and A. Salord (2017) "Bail-Ins and Bank Resolution in Europe: A Progress Report" Geneva Report on the World Economy, Special Report 4, Geneva.

Philippon, T. and P. Schnabl (2013) "Efficient Recapitalization" *Journal of Finance* 68, 1-42.

Thomson, J.B. (2011) "How to build a bad bank - for the greater good" *Forefront,* Federal Reserve Bank of Cleveland Winter, 2, 1, 12-16.

Tirole, J. (2012) "Overcoming Adverse Selection: How Public Intervention Can Restore Market Functioning" *American Economic Review* 102, 29–59.

Townsend, R.M. (1979) "Optimal Contracts and Competitive Markets with Costly State Verification" *Journal of Economic Theory,* 21, 265-293.

White, P. and T. Yorulmazer (2014) "Bank Resolution Concepts, Tradeoffs, and Changes in Practices" *Economic Policy Review*, Federal Reserve Bank of New York, 20, 2, 153-173.