Bail-in Vs Bail-out: Bank Resolution and Liability Structure

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Abstract

With a dynamic continuous-time model, I shed light on the optimal liability structure of a bank for a given set of distinct resolution frameworks and capital requirements. In doing so, I introduced an extension of the "Modigliani Miller I theorem for banks", a kind of "3D version". Indeed, I determined the optimal bank's liabilities combination, among different financing instruments, which allows shareholders to reach the desired optimal level of leverage. The model's results highlight that a macro-prudential policies' rethinking, in banking, is needed. With a credible resolution regulation, the "too-big-to-fail" incentive declines and, consequently, the "ex-ante" capital requirements become less necessary and could be relaxed, with a sizeable impact in terms of complexity and costs' reduction in regulating the banking system.

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Introduction

After the banking industry crisis (2007/2009), the issue of bank liability structure has drawn significant attention from regulators. The crisis triggered important unexpected economic, political and social consequences, and the 535 billion impairment losses realized by failed European banks (Conlon & Cotter, 2014) highlighted the necessity to change the previous banking regulatory framework, Basel II. This framework did not consider the going concern loss-absorbing capacity of the required capital instruments and has been also considered unable to properly model banks' investment risks. Moreover, this regulatory scheme discouraged banks from holding liquid assets because it did not consider liquidity as a source of risk, therefore, it raised incentives to frequently run balance sheet duration mismatches which, eventually, triggered widespread Bail-outs.

Previously, any systemic bank fallout was dealt by the regulator re-capitalizing and nationalizing the domestic financial institutions (Dübel, 2013) using public funds, avoiding the general panic in the system and the negative knock-on effect on the real economy. Indeed, in case of Bail-out the policymakers usually face the dilemma of whether to let a financial institution fail (with a potential risk to financial stability) or to bail it out at taxpayers cost (with serious moral hazard consequences). The government-assisted mergers and acquisitions of last years have resulted in further consolidation of financial institutions in the United States and across Europe. Consequently, the top financial institutions of today have become larger and both the European and U.S. financial sectors have become even more concentrated than before, aggravating so the too-big-to-fail problem (IMF Staff Discussion Note, 2012).

Thanks to the new regulatory framework, Basel III, policymakers seek to strengthen the "ex-ante" banking regulation from different fronts: higher equity and loss-absorbing capital instruments requirements, lower level of leverage, more liquid assets requirements and better duration matching between assets and liabilities. Moreover, in the Eurozone both the European Stability Mechanism (ESM) statute and the new European Resolution regime (based on the European Bank Recovery and Resolution Directive (BRRD)) requires the prior participation of bank creditors in meeting the costs of bank resolution. This means that either the bank remains a going concern and the bail-in process is triggered to effect bank recapitalization to restore it to health ("open bank" bail-in process) or, in conjunction with the exercise of resolution powers, treating the bank as gone concern ("closed bank" bail-in process).

However, the goals of the bail-in process are not the same in every jurisdiction. For example, in the United States the Orderly Liquidation provision of the Dodd-Frank Act, provides a process to quickly and efficiently liquidate a large and complex financial company that is close to failing. In this case the bail-in process (and subsequent conversion of creditor claims) that takes place for the systemically important financial institutions (SIFIs) is imbedded in the mechanics and architecture of Title II of the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010. This means that triggering the bail-in process aims at providing with sufficient capital the new entities that will emerge from the liquidation of the resolved parent institution. This is in contrast with European's approach to SIFIs resolution given that in the DFA only the "second approach" is used. According to Goodhart and Avgouleas (2014), this bifurcation is likely to prove problematic because, although both the US and the European authorities are moving simultaneously towards reliance on bail-in mechanisms, little attention appears to be paid in each detail of what the other is doing[1].

While there are numerous quantitative studies focused on the "subsidy", provided by the governments, to the larger banks (Morgan and Stiroh, 2005; Ueda and Weder-Di Mauro, 2011; Li et al., 2013; Santos, 2014) and there is sufficient evidence that shows that too-big-to-fail banks are prone to take much riskier assets than other banks (Gadanecz et al., 2008, Gropp et al., 2011; Brandao et al., 2013; Afonso et al., 2014), there is lack in the literature concerning the effects of the bail-in resolution framework on bank's capital structure, risks, funding cost and on the consequences of all these aspects on the market for bank bonds.

[1] Notably, the paper by McAndrews et al (2014), as well as that of Sommer (2014), hardly mention the BRRD or any European initiative. At the same time, much of the discussion within Europe on its own resolution mechanisms ignores the DFA prospective.

The introduction of the "on-going concern" bail-in and the increase in capital requirements have a profound effect on the decision about the optimal liability structure, both in terms of optimal leverage ratio and optimal financing instruments composition of the liability side. Bulow and Klemperer (2013) suggested that banks should hold just equity and convertible debt but not standard nonconvertible capital instruments. At the same time, Tarullo (the Fed governor, 2013) declared that holding more long-term debts can improve the bank capital structure and make it stronger. Recently, DeAngelo and Stulz (2015) provided a rational for leverage in a bank without asset risk and nondeposit debt but with (uninsured) deposits. Allen et al. (2015) rationalized the high leverage of banks without nondeposit debt by assuming deposits as a cheaper funding source than equity.

However, in 2016 the new European directive concerning bank resolution took hold and, as any time the policymakers adopt a new law, it modified the banks' optimal response, in terms of capital structure. For this reason, the aim of this study is to analyse the main bank resolution frameworks and the optimal liability structure decisions for each of them.

To reach these objectives, I developed an EBITs based structural model in continuous-time (as in Goldstein, Ju, & Leland, H., 2001) that incorporates the institutional features of an insured bank. Indeed, I analytically solved for the optimal liability structure of a bank that, under distinct resolution regimes, at time zero issued two types of nondeposit debt and common equity while taking a fixed amount of insured deposits, for which a proportional and fixed insurance premium must be paid. Focusing on the shareholders' optimal decisions concerning the leverage ratio and the combination between covered bond (not bail-inable) and uncovered bond (the bail-inable ones), I also contributed to the literature related to the Modigliani Miller I theorem for banks (Figure 1), extending it in a kind of "3D version".

Moreover, I run this analysis for two types of bank, characterized by two distinct deposit/asset (D/A) ratio: a Commercial bank whit D/A equal to 35%, and an Investment bank whit D/A equal to 0%. Both banks operate in a market with two important frictions (corporate taxes and bankruptcy and/or restructuring costs) and face two types of regulatory capital requirements (mutually exclusive): a stringent and a relaxed ones. In both cases the minimum amount of Tier1 capital must be at least equal to 6% of the RWAs but, while in the relaxed version there are not constraints on the minimum Cet1 capital that the bank must hold, in the stringent one a minimum Cet1 = 4.5% of the RWAs is also required. Finally, the model calls for authority intervention when one of these minimum requirements are violated, and the consequences of the authority intervention depends on the resolution regime in force.

Using this type of model, I also contributed to the literature that attempts to apply the structural framework of endogenous default, who pioneers were Merton (1974, 1977) and Leland (1994), to bank capital structure. Traditionally, these models have been applied only to corporate firms claims evaluation, while financial firms have been excluded because were considered "different" from other companies[2]. The first theories on bank's optimal capital structure were developed by Flannery (1994), Myers and Rajan (1998), Diamond and Rajan (2000), and Allen et al. (2011). Recently, some empirical studies suggested that there are considerable similarities between banks' and non-financial firms' capital structures (Berger et al, 2008; Gropp and Heider, 2010). Flannery (2012) argued that corporate finance theory applies equally well to financial firms, although modifications are required. Also, the International Monetary Fund, in the Global Financial Stability Report of October 2013, used a Merton-based model to numerically analyse the impact of regulatory reforms on the pricing of bank liabilities. Sundaresan and Wang (2017) used a similar model to determine the optimal mix financing, between insured deposits and nondeposit debt, for a value maximizing bank that faces regulatory closure constraint. Chen et al. (2013) and Hilscher and Raviv (2012) analysed more complex debt structures (including contingent capital).

Another important contribution is provided by Helberg and Lindset (2014). They analysed how optimal bank capital and bond risk are influenced by (among others) asset encumbrance,

[2] Rajan and Zingales (1995) eliminated financial firms from their sample saying that the level of leverage of these companies were strongly influenced by both explicit and implicit investor insurance scheme and because also regulations (minimum capital requirements) may directly affect capital structure.

depositor preference and bail-in resolution framework by using a standard corporate finance model which incorporates the idiosyncrasies of banking. Nevertheless, to the best of my knowledge, there are no contributions in the literature focused on the optimal mix between covered and uncovered nondeposit debt, both in the financial and nonfinancial fields.

This is an interesting focus because the BRRD explicitly excludes the possibility, for the resolution authorities, to exercise the write-down or conversion powers to covered bonds. Since banks' capital structures tend to be determined by the tradeoff between the marginal costs of debt (e.g., bankruptcy costs) and the marginal benefits of debt (e.g., tax incentives, cash flow incentives, regulatory requirement incentive), to the extent that bail-in could increase the marginal cost of debt, banks could shift toward secured borrowing (e.g., covered bonds) to reduce the funding costs and possibly to circumvent bail-in. A high amount of covered bonds in the liability structure, while it could bring benefits to banks (lower costs) and investors (protection)[3], it could also cause a potentially undesirable impact on issuer balance sheets and on the efficacy of bank resolution frameworks (bail-in) and on the deposit insurance schemes.

Independently of bail-in proposals, the increasing popularity of covered bonds has already raised questions as to whether there should be limits to protect against the structural subordination of unsecured creditors (ECBC, 2011). In fact, in many countries, explicit issuance limits on covered bonds are already in force (IMF Staff Discussion Note, 2012).

The focus made on the optimal financing strategies for the two standard types of bank (Commercial Vs Investment), along with the comparative analysis between four distinct resolution frameworks and two distinct regulatory capital requirements, represents the novelty of my contribution in this fascinating branch of literature.

The main result of the research is that: only under the "on-going bail-in" framework the shareholders of the investment bank have the right incentives to implement an "optimal

[3] They are cheaper because investors are protected by collateral. A covered bond typically provides a preferential claim on segregated assets and entails a degree of over-collateralization to improve its credit rating, thus undermining the position of senior unsecured creditors by encumbering the highest quality assets.

mixed financing strategy" between covered bonds and bail-inable ones, while in the bail-out framework it is possible to determine only an optimal leverage ratio, achievable for whatever combination of the two bonds. Moreover, for a risk adjusted probability (of government bail-out) sufficiently high, this optimal level of leverage coincides with the maximum level achievable in compliance with the regulatory closure constraint. Doing so, shareholders maximise their return on equity (Admati et al., 2012; Avgouleas and Cullen, 2014a).

This brief explanation is sufficient to well understand why regulators agree on the new resolution framework. Even if a stringent minimum Cet1 requirement represents the best solution to reduce the "too-big-to-fail" incentive of the bank[4], the detrimental consequences, generated by the simultaneous imposition of stringent capital requirement and the bail-in framework, under adverse market conditions, are of extraordinary importance, especially for a Commercial bank. Relaxing the capital requirements, also under adverse market conditions, both types of bank are able to enhance bank value and, under the bail-in framework, the too-big-to-fail incentive of the bank is also well mitigated. Therefore, a macro-prudential policies' rethinking, in banking, is needed.

A big effort to optimally design a credible resolution regulation should be more efficient, and more effective, than trying to impose a bank-specific minimum amount of regulatory capital to each bank. Consequently, the "ex-ante" capital requirements become less necessary and can be relaxed, with a sizeable impact in terms of complexity and costs' reduction in regulating the banking system. Nevertheless, the bank-specific imposition of regulatory capital, provided by the MREL and TLAC standards, should be still a key component of the regulatory framework because it allows to manage the structural differences, in both the asset and liability sides, among banks. However, it should be managed carefully, considering the different market conditions in which a bank operates, not only in the present but also in the future.

The following is the plan of the paper: in section 1 the structural model is introduced;

[4] In line with the well-know “more skin in the game” principle.

in section 2 the asset pricing formula are provided, in section 3 the base cases results, under different market conditions, are discussed; the conclusion in section 4; then the main figures, tables and references. In the appendix there are the main arguments concerning the current regulatory framework in banking, the assumptions on the base case parameters' values, the results of the comparative static analysis and the proofs of all theorems.

1 Model description

In this paragraph are presented the claims' evaluation formulas of a complex bank in which the liability side is composed by equity, insured deposits, covered and uncovered bonds (Figure 2), while the asset side is composed by an ex-ante well determined portfolio of assets and the charter value, that is given by the difference between bank value and asset value. This bank operates in a market with two important frictions: corporate taxes (the bank is subject to a fix tax rate τ) and bankruptcy/restructuring costs (depending on the resolution framework in force). In addition, the bank must pay a fixed deposit-insurance premium, express as a fraction φ of the total deposit D, and it is subject to four (mutually exclusive) resolution frameworks and two distinct regulatory capital requirements.

All these considerations will provide a broad-spectrum illustration of the shareholders' incentives about the bank liability structure decision, under distinct resolution frameworks and capital requirements frameworks.

To understand the effects of the resolution tool on the pricing of the bank's bonds, I focused only on the shareholders decision concerning the liability structure for a given portfolio of bank's risky assets (V) that generate cash-flows (X). This focus allowed to rule out issues of endogenous asset substitution[5].

The principal-agent conflict, between bank's management and bank's shareholders, is also ruled out because, although it might play an important role for the choice of the liability

[5] Green (1984), Harris and Raviv (1991) are two examples of those part of literature that has point out that corporate debt may create incentives to substitute assets with much higher risk.

structure (see Admati et al., 2013), I assumed that managers perfectly act in the interest of their shareholders, maximizing the total value of the bank. Therefore, following Goldstein et al. (2001), I assumed that the EBIT dynamics under the objective measure is a geometric Brownian motion:

$$\frac{dX}{X} = \alpha dt + \sigma dW \tag{1}$$

where r is the risk-free interest rate, α represents the grow prospect of the cash-flows, σ is the volatility of cash-flows, and W is a Wiener process[6]. All these parameters are supposed to be constants.

This kind of diffusion process is coming in for severe criticism. As perfectly synthesized by Helberg & Lindset (2014): "*bank's loan portfolio has little upside and significant downside. However, the upside potential of a bank's EBIT is given mainly by investment banking, loan origination, cash management, advisory services, and mutual funds. Large banks have increased their reliance on the latter category over the last decades. This fact is reflected in changes to the banks' income distribution*"[7].

For this reason, as in their paper, I primarily studied large banks with an income distribution as already described. These types of banks are part of the groups of the so called "too-big-to-fail" institutions[8]. Duffie and Lando (2001) developed a framework in which the true process was continuous, but stock and bond prices exhibit discontinuities due to imperfect information. However, this framework, like those of Sundaresan and Wang (2015), is desirable for CoCos analysis while for standard secured/unsecured debt valuation the standard Brownian motion is widely accepted in literature.

Given the cash-flows process, the after-tax asset value (major part of Figure 2) is calcu-

[6] Starting with the assumption that the asset cash-flow follows a geometric Brownian motion with volatility σ, in the appendix D.1 is shown that also the asset value follows the same stochastic process.

[7] Brunnermeier et al. (2012) as well as Stiroh (2004) find that non-interest income substantially grew since the 1980s up to the 2007, respectively for the ten largest US bank holding companies and for the US commercial banks.

[8] So, the value process is less representative of smaller o regional banks for which the bail-in tool cannot be applied. It is also less representative of more loan oriented financial institutions, like mortgage banks, that could be better described by a jump diffusion process.

lated (using the Gordon's formula):

$$V = \frac{X(1-\tau)}{r + \sigma\lambda - \alpha} \tag{2}$$

where τ is the tax-rate, λ captures the market price of risk and the payout rate, $\delta = r + \sigma\lambda - \alpha$, must be greater than zero. Since this is an EBITs based structural model, developed in continuous time, I fixed the initial value of the asset at $V_0 = 100$, evaluating the appropriate amount of cash-flows (X) by using the inverse formula.

Thanks to the perfect information assumption, it is possible to interpret V as the fair accounting asset value. If the assets are of the same risk category, we can interpret V as the value of risk-weighted assets (RWAs). Therefore, the instantaneous cash-flows of the assets δV, paid as either dividend to equity holders or liabilities to the other stakeholders, is $\delta V = X(1-\tau)$. In order to keep the model tractable, since I focused on the tradeoff between two distinct bonds, as in Helberg and Lindset (2014), I assume that deposits are fixed[9] and totally insured[10].

Without deposit insurance, borrowing through deposits brings the risk of bank run if depositors believe that the bank has difficulty in repaying their deposits promptly upon their demand[11]. Therefore, since deposits are fully insured, the bank's net liability on deposits, excluding deposit insurance premium, is $c_{dep} = rD$. It implies that its book value D is always equal to its market value $\mathcal{D}$ [12]. Concerning the deposit-insurance, as in Helberg and Lindset (2014), the bank must pay a fixed premium, express as a fraction φ of the total deposit D, exogenously determinate by national bank authorities. Therefore, the bank's liability on deposit insurer is equal to $i = \varphi D$, while the value of the perpetuity is $I = \frac{i}{r}$.

[9] Considering (D) as the bank's core insured deposits that counts as stable funding, in compliance with articles 421 and 427 of the regulation (EU) n° 575/2013 of the European Parliament and of the Council.

[10] The implicit assumption is that depositors never deposit more than the maximum amount guaranteed for deposit repayment by a DGS, according to Article 6 of directive 2014/49/UE, in a single banking account. On the contrary, in case of bank default, they will lose the part exceeding that amount.

[11] This model does not address this type of risk, for models on bank run see Diamond and Dybvig (1983), Allen and Gale (1998) and others.

[12] Proof in the appendix D.3.

Both these banks' liabilities are tax-deductible.

The other important sources of bank's funding are bonds, which are the second and third part of the liability side in Figure 2. The benefit of using bonds, is that the coupon payments can be deducted from taxable profits, reducing the overall tax burden. Furthermore, as long as the bank is solvent, earnings before interest and taxes are assumed to be larger than the deductible coupon payments and deposit-insurance premiums. The nondeposit debt is composed by covered bonds and uncovered ones, for this reason I call the owners of the two types of bond, respectively, C-type and U-type bondholders.

The covered bond (C-bond) offers to investors a dual recourse, both to a defined part of the bank's loan portfolio (the cover pool) as well as a claim on the bank. If the issuer defaults on its outstanding covered bonds, the C-type bondholders, if necessary, sell the loans in the cover pool to cover their claims before other. Consequently, they have a de facto, although also de jure, first priority on assets in a bank failure[13]. For this reason, this type of bond cannot be considered as T2 capital as in Sundaresan and Wang (2017). At this step, if the post-bankruptcy value of the bank at default, $V_D(1-\varepsilon)$, is lower than the book value of the C-bond ($C = \frac{c}{r}$), they will be only partially reimbursed while, on the contrary, they will be entirely reimbursed and the C-bond will be considered risk-less. Summarizing, the C-type bondholders at default will receive $M = \min\left[C;\ V_D(1-\varepsilon)\right]$. The C-bond comes with costs: its yield contains a credit spread, in excess to the risk-free rate, to compensate the debt holders for bearing the risk of bankruptcy. The credit spread arises endogenously in the model, it depends on the risk of assets, on the composition of the liability structure and on the regulatory regime we are dealt with. Thus, a bank's choice of liability structure affects the credit spread, which I solve endogenously along with the debt value. Let the liability on C-bond be c and the market value be $\mathcal{C}$, the pricing equation of the covered bond is:

[13]The Insolvency Ranking in the Italian banking jurisdictions provides that deposits held by individuals or SME are junior respect the secured claims. This broad category includes preferential claims with different ranks, that shall be paid in full with a preference over the unsecured debts. It includes: - claims secured by mortgage or pledge (specific lien); - claims secured by general lien. Art. 91, par. 1, BL. Art. 111 and 111-quater of the of the insolvency law (r.d. 1942/267).

$$\frac{1}{2}\sigma^2 V^2 \mathcal{C}'' + (r-\delta)V\mathcal{C}' - r\mathcal{C} + c = 0 \tag{3}$$

where $\mathcal{C}'$ and $\mathcal{C}''$ are the first and second derivatives of $\mathcal{C}$ with respect to V.

The uncovered bond (U-bond) is the key financing instruments of the model because its value strictly depends on the regulatory regime we are dealt with. In the on-going bail-in regime (paragraph 1.1) it plays a crucial role because when the original equity is lost, the bank can be restructured and not liquidated. The U-type bondholders convert their claims in to equity (Figure 3.a) affording the bail-in procedure costs ξV_B, that are assumed to be proportional to the asset value at bail-in (V_B)[14]. Since they become the new equity holders of the bank, they can benefit from the tax shield generated by the other liabilities until default. In the bail-out framework, according to the standard national insolvency proceedings, when the original equity is lost the bank fails and the owner of C-bonds are paid before depositors and U-type bondholders (Figure 3.b). What is left, after this first step, is reimbursed firstly to depositors, then to U-type bondholders.

However, as described at paragraph 1.2, in this framework there could be a government intervention aims at liquidating the bank assets and at reimbursing all the owners of nondeposit debt. The possibility of a State intervention, explained by the so called "too-big-to-fail status of a bank", is perceived by investors and it affects the market value of the bonds. As for the C-bond, also for the U-bond the bank pays an endogenous determined credit spreads depending on the risk of the assets, the composition of the liability structure and the regulatory regime in force. Let the liability on U-bond be u and the market value be $\mathcal{U}$, the pricing equation of the U-bond is:

$$\frac{1}{2}\sigma^2 V^2 \mathcal{U}'' + (r-\delta)V\mathcal{U}' - r\mathcal{U} + u = 0 \tag{4}$$

where $\mathcal{U}'$ and $\mathcal{U}''$ are the first and second derivatives of $\mathcal{U}$ with respect to V.

[14] The assumption is that the restructuring costs are paid by the U-type bondholders without impairment of the bank's assets.

Shareholders garner all the residual value and earnings of the bank after paying the contractual obligations on debt. Since interest expenses are deductible from earnings for tax purposes, the flow of tax savings is $\tau\left[c+u+D\left(r+\varphi\right)\right]$. The dividend continuously paid to the equity holders is the difference between the asset cash-flows and the after-tax liability associated with total debt: $\delta V-\left[c+u+D\left(r+\varphi\right)\right]\left(1-\tau\right)$. Therefore, the pricing equation of equity value $\mathcal{S}$, before bail-in event, is:

$$\frac{1}{2}\sigma^2 V^{\;2}\mathcal{S}''+(r-\delta)V\mathcal{S}'-\mathcal{S}r+\delta V-\left[c+u+c_{dep}+i\right](1-\tau)=0 \tag{5}$$

where $\mathcal{S}^{'}$ and $\mathcal{S}^{''}$ are the first and second derivatives of $\mathcal{S}$ with respect to V. It is possible to read this value as the amount of money that investors are willing to pay in order to buy the shares of a bank with these specific features, in terms of cash-flows generation and level of indebtedness. The equity value obviously depends on the parameters involved in the formula but, it crucially depends on the bail-in and/or default boundaries level, discussed in detail in the next sections.

Finally, when it is possible to apply the bail-in tool to a distressed bank, the flow of tax savings, after bail-in, becomes $\tau\left[c+D\left(r+\varphi\right)\right]$, and the dividend paid to the new bank's shareholders is modified accordingly. The pricing equation of the equity value at bail-in ($\widehat{\mathcal{S}}$), so for $V=V_B$, but before bankruptcy, is:

$$\frac{1}{2}\sigma^2\;V_B^2\widehat{\mathcal{S}}''+(r-\delta)V_B\widehat{\mathcal{S}}'-\widehat{\mathcal{S}}r+\delta V_B-\left[c+c_{dep}+i\right](1-\tau)=0 \tag{6}$$

where $\widehat{\mathcal{S}}^{'}$ and $\widehat{\mathcal{S}}^{''}$ are the first and second derivatives of $\widehat{\mathcal{S}}$ with respect to V_B.

1.1 Credible on-going bail-in framework

Bail-in is a statutory power of a resolution authority. The aim of this resolution tool is to restructure the liabilities of a distressed bank by writing down its bail-inable debt and/or converting it in to equity such that the bank remains a going concern, restoring it to health ("open bank" bail-in process) without recourse to public funds.

To study bail-in system, I constructed a regime that mimics the cornerstones of the EU-wide rules[15]. The Bail-in tool is implemented to a distressed bank when the asset values drops below a certain threshold V_B. To apply the tool the bank must hold a "sufficient"[16] amount of bail-inable debt in order to restore at least the minimum Cet1 capital ratio. Therefore, when the asset value drops below a certain threshold V_B, the original equity holders of the bank are totally wiped out, the insured depositors, as well as the C-type bondholders[17], will carry their claims to the restructured bank, whereas to the U-type bondholders is given the ownership of the bank. They also afford the restructuring costs ξV_B that are supposed to be, as in Helberg & Lindset (2014), lower than the bankruptcy ones. So, the bail-in tool directly affects only the U-type bondholders whom have to both take the losses and convert their remaining claims into equity (figure 3.a).

The original equity holders of the bank can choose to leave it before the authority intervention. Absent authority intervention, there exists an optimal point for the original equity holders to leave the bank, allowing U-type bondholders to be bailed-in and to take its ownership. This "bail-in" decision maximizes the equity value and it is called the endogenous bail-in[18]. Therefore, let V_{EB} be the point of endogenous bail-in, without authority intervention, the equity holders choose to leave the bank only if $V = V_{EB}$.

However, according to the current European rule, the Article n. 92 of the CRR establishes that institutions shall, at all times, satisfy (among other, see figure A.2) the following capital requirements (as a percentage of the RWAs exposure): 4,5% of Common Equity Tier1 (Cet1), 6% of Tier1 and 8% of total capital ratio.

[15] For details on regulation see the "Regulatory Framework" in the appendix.

[16] "Sufficient", in regulatory terms, means that if the bail-in tool is applied, losses could be absorbed and the Common Equity Tier 1 ratio of the institution could be restored to a level necessary to enable it to continue to comply with the conditions for authorisation and to continue to carry out the activities for which it has been authorised under Directive 2013/36/EU or Directive 2014/65/EU. The need to meet, at all times, a minimum requirement for own funds and eligible liabilities, is required by Article 45 of BRRD.

[17] The article n. 44 of BRRD explicitly exclude this category of bonds from the bail-inable one. Therefore, they are not (directly) affected by the bank restructuring.

[18] Similar to the endogenous default derived by Leland (1994) for firms without deposits.

If the amount of Tier1 capital (β) (sum of CET1 + AT1 capital) drops below the required 6%. in the absence of contingent capital available for conversion, the resolution authority applied the bail-in tool under the fundamental conditions, explained by the article n. 45 of BRRD, that losses are absorbed and the minimum Cet1 ratio is restored. Only complying with these conditions a bank can continue to carry out the activities for which it is authorised, on the contrary the bail-in tool cannot be applied and the bank must be liquidated. Nevertheless, if the tool can be applied, the minimum amount of capital required to run bank activity is only the mandatory one. Therefore, only if the bank is not in compliance with the mandatory capital (ψ) requirement ($CET1 = 4,5\%$ of RWAs) it will face regulatory closure. Indeed, nothing related to the minimum amount of AT1 (or T2) capital, that the bank must hold immediately after the bail-in tool implementation, is mentioned. A similar expression, which leads to the same conclusion, is present in the article n. 46 of the same directive.

Based on the interpretation of the mentioned BRRD' s articles, I set the authority intervention for the implementation of bail-in tool at assets value V_{RB} such that $Tier1 < 6\%$ of RWAs. For the same reasons, the authority intervention for regulatory closure is set at assets values V_{RD} such that $CET1 < 4,5\%$ of RWAs. Formally, the total Tier1 is the sum of CET1 and AT1 and in the model it is given by the sum of the tangible equity (S) and the book value of U-bonds (U). Following Sundaresan and Wang (2017), I defined V_{RB} as the threshold in which the resolution authority applies the bail-in tool to the bank. If this threshold is a fraction β of the book value of assets ($\beta = 6\%$), then:

$$\underbrace{V_{RB} - [D + C + U]}_{CET1} + \underbrace{U}_{AT1} = \beta V_{RB}$$

which implies that:

$$V_{RB} = \frac{D + C}{1 - \beta}$$

where C and U are the book values of the nondeposits debt as in Hugonnier and Morellec (2017). This regulatory boundary definition represents the "relaxed" version of the minimum capital requirement imposition because there is not control on the minimum amount of CET1 that the bank must hold. When the regulatory boundary is defined in this term, the shareholders could comply with the total Tier1 requirement substituting part of the mandatory Cet1 requirements with the cheaper AT1 capital. The stringent version of this rule, that required the assumption of a "credible and perpetual (instant by instant) control" by the authority on the respect of this requirement, is obtained solving the system between the two capital requirements:

$$\begin{cases} \underbrace{V_{RB} - [D + C + U]}_{CET1} = \underbrace{\psi}_{4.5\%} V_{RB} \\ \underbrace{V_{RB} - [D + C + U]}_{CET1} + \underbrace{U}_{AT1} = \underbrace{\beta}_{6\%} V_{RB} \end{cases}$$

The following theorem[19], summarizes the relation between the bail-in's regulatory boundary and the book value of the U-bond issued.

Theorem 1 *Given the liability structure (D, C, U) presented in terms of book values, the regulatory bail-in boundary is equal to:*

$$V_{RB} = \begin{cases} \frac{D + C + U}{1-\psi} & \text{for } U \geq \Delta \\ \frac{D + C}{1-\beta} & \text{for } 0 \leq U < \Delta \end{cases}$$

$$\text{where } \Delta = \frac{D+C}{1-\beta}(\beta - \psi)$$

while the regulatory closure boundary is:

$$V_{RD} = \frac{D+C}{1-\psi}$$

In the next chapters, the results obtained imposing the two versions of the minimum capital requirements will be compared.

The following Theorem 2[20], provides the relation between bank value and liability structure.

[19] Derived in the appendix D.4.
[20] Derived in the appendix D.5.

Theorem 2 *Given the liability structure (I, D, C, U) and the regulatory boundaries described in Theorem 1, the applied boundaries in the bail-in framework are:*

$$V_B = \max\{V_{EB}, V_{RB}\};$$

$$V_D = \begin{cases} \max\{V_{ED}, V_{RD}\} & \text{if bail-in is feasible;} \\ V_B & \text{otherwise.} \end{cases}$$

The market values for deposits, covered bond, uncovered bond, equity at time zero, equity at bail-in and the total bank value are, respectively:

$$\mathcal{D} = D; \tag{7}$$

$$\mathcal{C} = C\left(1-\left[\frac{V}{V_D}\right]^{\gamma}\right)+M\left[\frac{V}{V_D}\right]^{\gamma}; \tag{8}$$

$$\mathcal{U} = U\left(1-\left[\frac{V}{V_B}\right]^{\gamma}\right)+K\left[\frac{V}{V_B}\right]^{\gamma}; \tag{9}$$

$$\mathcal{S} = V-(I+D+C+U)(1-\tau)\left(1-\left[\frac{V}{V_B}\right]^{\gamma}\right)-V_B\left[\frac{V}{V_B}\right]^{\gamma}; \tag{10}$$

$$\widehat{\mathcal{S}} = V_B-(I+D+C)(1-\tau)\left(1-\left[\frac{V_B}{V_D}\right]^{\gamma}\right)-V_D\left[\frac{V_B}{V_D}\right]^{\gamma}; \tag{11}$$

$$\mathcal{BV} = \mathcal{S}+\mathcal{C}+\mathcal{U}+\mathcal{D} \tag{12}$$

with:

$$M = \min\left[C;\ V_D(1-\varepsilon)\right], \tag{13}$$

$$K = \begin{cases} \left[\widehat{\mathcal{S}}-V_B\xi\right] & \text{if bail-in is feasible;} \\ \left[V_B(1-\varepsilon)-C-D\right]^{+} & \text{otherwise.} \end{cases} \tag{14}$$

where γ is presented in the appendix D.2 and $[x]^{+}=x$ if $x \geq 0$ and $[x]^{+}=0$ if $x<0$.

The decision variables that shareholders can "manipulate" to achieve the optimal bank liability structure are two, namely the coupon payments on bonds C and U. Indeed, $c_{dep}=rD$ by non-arbitrage opportunities and φ is exogenously determinate by national authorities. The boundaries V_B and V_D are decided by shareholders but only when the optimal endogenous boundaries are greater than the regulatory ones[21].

Depicted the close form pricing formulas of the claims, the optimal book values for the two bonds are determined by a numerical optimization thanks to which we obtain the

[21] In the appendix 4 is also shown the derivation of the endogenous optimal bail-in and default boundaries (V_{EB}^{*}, V_{ED}^{*}).

fundamental optimal values: C^*, U^*, V_D^* and V_B^*. Substituting these optimal values into the formulas described in Theorem 2, all the variables in the tables are determined. In particular, the variable "*%Bk V. U-Bond*" is calculated as:

$$\frac{U^*}{U^* + C^*} * 100$$

and it indicates, in per cent terms, how much U-bonds are issued compared to C-bonds. If there is not indeterminacy, it means that shareholders, in maximising the total value of the bank, are able to define an optimal strategy, in terms of funding instruments mix, to reach the desired optimal value of leverage.

1.2 Bail-out framework

In this framework I used the same techniques of the previous subparagraph but taking into account the risk adjusted market's beliefs (p) about the probability of a government intervention, in case of default. Indeed, up to now, any systemic bank fallout was dealt by the regulator re-capitalizing and nationalizing the domestic financial institutions (Dübel, 2013), through public funds-based capital injections. Therefore, I defined $p \in [0, 1]$ as a measure of the market's beliefs about the probability that, given default, the event "bail-out" takes place.

In this framework, absent authority intervention, there exists an optimal point for the original equity holders to leave the bank. This default decision maximizes the equity value and it is called the endogenous default. Therefore, let V_{ED} be the point of endogenous default, without authority intervention, the equity holders choose to leave the bank if and only if the asset value V reaches V_{ED}. However, also in this framework the bank must hold a minimum Tier1 capital requirements as in the previous subparagraph, therefore also the regulatory closure boundary must be considered.

Let $V_D^* = \max[V_{ED},\ V_{RD}]$ be the applied default boundary, when it is reached, according to the standard national insolvency proceedings, the bank fails and the C-type bondholders are paid before depositors and U-type bondholders (Figure 3.b). What is left, after this first step, is reimbursed firstly to depositors, then to U-type bondholders[22]. However, the national government can decide to intervene liquidating the bank assets and reimbursing all the owners of nondeposit debt. The possibility of a State intervention, explained by the so called too-big-to-fail status of a bank, is perceived by investors and it generates an additional value for the bonds reducing the sensitivity of the debtholders toward risk. Indeed, if the government will fully reimburse the losses suffered by bondholders for sure ($p = 1$), their claims become risk-free assets.

The value transfer from the government has a distorting impact on the shareholders optimal decisions both concerning leverage and the mix of financing sources.

Postponing the comment to the results in the next chapter, at this step is important underline that, when the optimal default barrier V_D^* is reached the bank fails and there could be six possible scenarios:

- Post bankruptcy value of bank's asset is not sufficient to pay back the C-type bondholders and "Bail-out not takes place": C-type will lose a part of their investments while U-type bondholders entirely will lose their investments;

- Post bankruptcy value of bank's asset is not sufficient to pay back the C-type bondholders and "Bail-out takes place": C-type bondholders as well as U-type bondholders are fully repaid; in this case, the government will reimburse the book value of their bonds paying any shortcoming with respect to the post-bankruptcy value of bank's asset ($V_D^*(1-\varepsilon)$);

- Post bankruptcy value of bank's asset is sufficient to pay back the C-type bondholders but the money left at this step are not sufficient also to reimburse depositors[23]

[22] This is the description of the standard "Default framework" presented in the tables, where $p = 0$.

[23] The insolvency hierarchy in this simple case is: firstly, must be reimbursed the owners of secured claims (covered bond), then covered depositors and, at the end, the owners of the senior unsecured bonds. Art. 91, parr. 1 and 1-bis, D.Lgs. 385/1993 (Banking Law – BL); Art. 111, R.D. 267/1942 (Insolvency Law - IL).

and "Bail-out not takes place": C-type bondholders are fully repaid by bank's asset selling and the insured deposits will be reimbursed by the national DGS; the U-type bondholders entirely will lose their investments;

- Post bankruptcy value of bank's asset is sufficient to pay back the C-type and the money left at this step are sufficient/not sufficient also to reimburse depositors and "Bail-out takes place": C-type bondholders are fully repaid by bank's asset selling while U-type bondholders will receive the book value of their bond thanks government reimbursement;

- Post bankruptcy value of bank's asset is sufficient to pay back the C-type and the money left at this step are sufficient also to reimburse depositors and "Bail-out not takes place": the U-type bondholders will receive the amount called "RAV" (remaining asset value) defined as the minimum between the book value U and the bank's asset value net of bankruptcy costs, net of all other liabilities reimbursement; formally:

$$RAV = \min \left\{ U; [V_D(1-\varepsilon) - C - D]^+ \right\}.$$

- Post bankruptcy value of bank's asset is sufficient to reimburse all the debtholders: the government will not intervene because it is not necessary. In this specific case $RAV = U$ because, since the value of post-bankruptcy bank's asset is sufficiently large to fully repay all the debtholders, the bank bonds are both risk-less and the market values coincide with the book values.

Given the possible scenarios and considering the two versions of the regulatory closure boundary:

$$\underbrace{V_{RD} - [D + C + U] \quad + U}_{\text{Stringent: 4.5\%Cet1 \& 1.5\%AT1}} = 6\% V_{RB};$$

$$\underbrace{V_{RD} - [D + C + U] \quad + U}_{\text{Relaxed: no minimum Cet1\%}} = 6\% V_{RB}.$$

Theorem 3[24], provides the relation between bank value and liability structure for the bail-out regime.

Theorem 3 *For* $0 \leq p \leq 1$*, given the liability structure* (I, D, C, U) *and the boundaries described above, the applied boundary in the bail-out framework is:*

$$V_D = \max\{V_{ED,}\ V_{RD}\}\ ;$$

The market values for deposits, covered bond, uncovered bond, equity at time zero and the total bank value are, respectively

$$\mathcal{D} = D\ ; \tag{15}$$

$$\mathcal{C} = C\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right) + [pC + (1-p)M]\left[\frac{V}{V_D}\right]^{\gamma}; \tag{16}$$

$$\mathcal{U} = U\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right) + [pU + (1-p)RAV]\left[\frac{V}{V_D}\right]^{\gamma}; \tag{17}$$

$$\mathcal{S} = V - (I + D + C + U)(1-\tau)\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right) - V_D\left[\frac{V}{V_D}\right]^{\gamma}; \tag{18}$$

$$\mathcal{BV} = \mathcal{S} + \mathcal{C} + \mathcal{U} + \mathcal{D} \tag{19}$$

with:

$$M = \min\left[C;\ V_D(1-\varepsilon)\right]; \tag{20}$$

$$RAV = \min\left\{U;\ \left[V_D(1-\varepsilon) - C - D\right]^{+}\right\} \tag{21}$$

where γ *and* $[x]^{+}$ *as before.*

Depicted the close form pricing formulas of the claims, the optimal values of C^*, U^* and V_D^* are determined as before.

1.3 Mixed Framework

This framework is a mix of the previous two. It is based on the bail-in model but it takes also in to account the possibility of a government intervention, at any trigger event (bail-in or default). The assumption of this regime is that there is uncertainty concerning the resolution regime that will be applied to a stressed bank when the asset values will reach both the boundaries levels V_B^* and V_D^*, described in Theorem 2.

[24]Derived in the appendix D.6.

Let define the variable p_1 as the risk adjusted market's beliefs concerning the "credibility" of the bail-in tool implementation. If the market believes that this framework is credible and that the bail-in tool will be applied for sure, the variable p_1 assumes value equal to zero. On the contrary, if the market believes that, for sure, there will be a public support aimed at reimbursing all the bank's debtholders at bail-in trigger, the variable p_1 assumes value equal to one. For each value of $p_1 \in (0, 1)$ the resolution framework that will be applied at bail-in trigger is uncertain because, even if the bail-in regime calls for bank restructuring and U-bond conversion, there could be a government intervention that, for whatever reason, could decide to liquidate the bank avoiding bonds conversion, repaying all the bank's bondholders.

Under this mixed resolution regime, when V reaches the bail-in trigger the original amount of equity is lost independently from the regulatory regime that will prevail; in fact, if the bail-in tool is applied the shareholders' equity are totally wiped out and the bank is restructured with the U-type bondholders that become the new bank's shareholders while, if the government intervention prevails, only debtholders will be reimbursed after bank liquidation. Moreover, this regime takes into account the possibility of a government intervention also at default event. In this case, if at bail-in there has not been a government intervention, only the C-bond will be entirely reimbursed because the U-bond has been already bailed-in.

Therefore, I defined the variable $p_2 \in [0, 1]$ as the risk adjusted market's beliefs concerning the probability of a government bail-out that occurs when the restructured bank fails. By construction, if $p_1 = p_2 = 0$ the results are the same of the "credible on-going bail-in" case discussed at paragraph 1.1, while for $p_1 \in [0, 1]$ and $p_2 \in [0, 1]$, with $p_1 = p_2 \neq 0$ and $p_1 = p_2 \neq 1$, the effect of the resolution regime's uncertainty spreads to the level of V_B^* and V_D^* towards the optimal book values of C^* and U^*.

At time zero, all these events are known by bondholders and are taken into account at the underwriting moment. Theorem 4[25], provides the relation between bank value and liability structure for the mixed regime.

[25] Derived in the appendix D.7.

Theorem 4 *For* $0 \leq p_1 \gtreqless p_2 \leq 1$, *given the liability structure* (I, D, C, U) *and the regulatory boundaries* V_{RD} *and* V_{RB} *described in Theorem 1, the applied boundaries in the mixed framework are:*

$$V_B = \max\{V_{EB}, V_{RB}\};$$

$$V_D = \begin{cases} \max\{V_{ED}, V_{RD}\} & \textit{if bail-in is applied;} \\ V_B & \textit{otherwise.} \end{cases}$$

The market values for deposits, covered bond, uncovered bond, equity at time zero, equity at bail-in and the total bank value are, respectively

$$\mathcal{D} = D; \tag{22}$$

$$\mathcal{C} = C - \left[\frac{V}{V_B}\right]^{\gamma} \left\{(1-p_1) \left\{\left[\frac{V_B}{V_D}\right]^{\gamma} (1-p_2)(C-M)\right\}\right\}; \tag{23}$$

$$\mathcal{U} = U - \left[\frac{V}{V_B}\right]^{\gamma} \{(1-p_1)[U-K]\}; \tag{24}$$

$$\mathcal{S} = V - (I+D+C+U)(1-\tau)\left(1 - \left[\frac{V}{V_B}\right]^{\gamma}\right) - V_B \left[\frac{V}{V_B}\right]^{\gamma}; \tag{25}$$

$$\widehat{\mathcal{S}} = V_B - (I+D+C)(1-\tau)\left(1 - \left[\frac{V_B}{V_D}\right]^{\gamma}\right) - V_D \left[\frac{V_B}{V_D}\right]^{\gamma}; \tag{26}$$

$$\mathcal{BV} = \mathcal{S} + \mathcal{C} + \mathcal{U} + \mathcal{D} \tag{27}$$

with:

$$M = \min[C;\ V_D(1-\varepsilon)];$$

$$K = \begin{cases} \left[\widehat{\mathcal{S}} - V_B\xi\right] & \textit{if bail-in is feasible;} \\ [V_B(1-\varepsilon) - C - D]^+ & \textit{otherwise.} \end{cases}$$

where γ *and* $[x]^+$ *as before.*

Notice that in case of government intervention $V_D = V_B$ and both the value of equity ($\mathcal{S}$) and the value of equity at bail-in ($\widehat{\mathcal{S}}$) are equal to zero. The optimal values of C^*, U^*, V_D^* and V_B^* are determined as before.

2 Model results: base cases analysis

In the base cases analysis, the assumptions I made on the parameters' value (table 1) were driven by literature, in particular from the most recently contributions in this area: Helberg and Lindset (2014) and Sundaresan and Wang (2017). The discussion about the assumptions is available in the appendix (B).

In table 2 and 3, I compared the results for two types of bank (Commercial and Investment bank) according to four regulatory regimes: default, bail-out, credible on-going bail-in and the mixed framework. The main difference between the two tables is the regulatory capital requirements that the bank must met. In table 2, only a general total Tier1 capital constraint is imposed. It means that the sum of Cet1 capital (T=V-D-C-U) and book value of U-bond (U), that represents the AT1 capital[26], must be at least equal to 6% of the RWAs (V). No constraints are imposed on the minimum value of tangible equity, that can be negative in practice[27]. In table 3, the sum of tangible equity and book value U-bond must still be equal to 6% of the RWAs but a minimum 4.5% of Cet1 capital is also imposed. This regulatory constraint is more stringent than the previous one because it requires that the bank must hold, instant by instant, a larger amount of the highest quality capital (the core tier1). The implicit assumption behind this constraint was that the regulatory authority is able to verify, instant by instant, the compliance of the bank to the minimum requirement.

Looking at the model's results under the bail-in framework, for a commercial bank, the market value of C-bond is always equal to its book value (this is true for both table 2 and 3) because the post-bankruptcy value of the assets at default are always sufficiently large to

[26]Even if I explicitly excluded CoCo bonds from the analysis, the intrinsic features of the on-going concern bail-inable debt make this kind of instruments quite similar to CoCos that qualify as additional tier1 capital. The main difference between the two is that while in CoCos a well specified threshold for conversion (equity ratio not lower than 7%) is present, the conversion of bail-inable debt is a statutory power of a resolution authority, therefore the threshold for conversion is uncertain. However, given the assumption of perfect information, in this model the bondholders are able to perfectly identify the conversion threshold. It implies that the U-bond can been seen as CoCo that qualify as AT1 capital because, at trigger event, it can be converted into equity, restoring the bank to health.

[27]For example, the U.S. operation of Deutsche Bank reported a total asset value of \$355 billion and a negative \$5.68 billion Tier1 capital in its December 2011 filing as a bank holding company (Sundaresan and Wang, 2017).

entirely reimburse the C-type bondholders. Indeed, if the issuer defaults on its outstanding, C-type bondholders have a de facto, although also de jure, first priority on assets in a bank failure and their claims become risk-less. Therefore, from a shareholders' point of view, the insured deposits and the C-bond are in such way "substitutes" for one another, and a substitution effect between the two instruments takes place when their relative price changes. In fact, as the amount of insured deposits increases, since it is considered fixed in the capital structure, the optimal amount of C-bond reduces, and the insurance premium paid by the bank increases. For D/A=35% the commercial bank does not issue any C-bond and the liability structure becomes suboptimal with respect the investment bank ones.

In fact, since the investment bank does not hold insured deposits, it can decide the "pure" optimal combination between covered and uncovered bonds. This explains why the investment bank generates a higher charter value than a commercial bank. However, its shareholders implement a bank value improving "mixed financing strategy" (black point in Figure 5) only in the bail-in regimes (it does not matter if it is credible or not), while in the default and bail-out frameworks this "optimal bonds mix" is indeterminate.

Under these regimes, shareholders take only care about the optimal leverage ratio and the regulatory requirements. The mix financing strategy does not play any role because the value of the bank increases only due to the external source provided by the implicit government guarantee. This last result is demonstrated by the fact that any combination of the two bonds, that allows to reach the desired level of leverage, is optimal (red line in Figure 4). It implies that does not exist a specific combination of the two bonds that is able to create additional value, and this result hold independently from the regulatory capital requirements imposed. Nonetheless, it is important to clarify two key aspects: i) the exact optimal bonds' combination itself has not a real meaning because changing the parameters' value also the optimal combination of the bonds changes; it is actually the existence (or not) of a whatever optimal combination that matters because it implies that the bail-in resolution framework directly affects the decision about the optimal liability structure of the bank; ii) the indeterminacy of the bonds mix, in the bail-out regime, does not necessarily mean that an optimal mixed financing strategy cannot exist[28], it simply implies that the bail-out resolution framework itself, is not a key driver for the liability structure decision.

Comparing the results for the four regimes under the assumption of “standard” market conditions (columns with the label “STD”), we can see that the credible bail-in framework is able to generates a risk-mitigation effect. Indeed, for a bank with a sufficiently large deposit/asset ratio, the shareholders' incentives to increase leverage reduce. Even when only a relaxed Tier1 requirement is imposed, the level of total leverage is only 80% (against the 92% generated by the bail-out regime). The mitigation effect generated by this resolution framework, even if less pronounced, is present also imposing a tightening Cet1 constraint. In this last case, the rigidity of the control on the minimum capital requirement plays a crucial role because it induces shareholders to reduce leverage, lowering the probability of default (or to be bailed-in) and mitigating the too-big-to-fail incentive of the large bank. For this reason, we can affirm that a stringent control on the minimum Cet1 capital generates the highest risk-mitigation effect[29] (leverage is around 45%) that is bigger than the one generated by the bail-in regime itself.

On the other hand, however, a tightening capital requirement also reduces the bank value and, consequently, the charter value (around 12%-14% for STD, according to the regimes). Relaxing the constraint on the minimum Cet1 capital, the level of leverage increases for all the regimes (around 80%-90%) as well as the bank value. These important results, highlight the crucial role played by regulation in affecting the trade-off between "risk" and "additional value" generated by the liability structure of a bank. Indeed, even if a larger amount of tangible equity implies smaller losses for depositors and debtholders after liquidation, a tightening Cet1 requirement significantly reduces the bank value leading shareholders to leave earlier the bank business, especially in case of adverse market conditions.

[28] There should exist other variables that affect this shareholders' optimal decision, but the resolution framework itself does not play a relevant role.

[29] In line with the "more skin in the game" principle.

For this purpose, in table 2 and 3 are also presented the results, for the two types of bank, under two distinct scenarios related to the market conditions in which the banks operate: i) favourable market conditions (FAV), where the volatility of the cash-flows is low (6%) and the growth prospects of the cash-flows are high (8%); ii) adverse market conditions (ADV), where the volatility of the cash-flows is high (10%) and the growth prospects of the cash-flows are low (2%).

Under favourable market conditions (columns FAV), most of the results already discussed continue to hold. The Cet1 requirement (table 3) have an important mitigation effect on leverage and the optimal amount of U-bond in the liability structure is lower than C-bond. However, a surprising result shows up: when there is the simultaneous imposition of the minimum Cet1 requirement and the bail-in framework, the charter values, for both types of bank, are a bit higher than those generated under the bail-out regime. It means that this regulatory framework, under favourable market conditions, generates the right shareholders' incentives for implementing an "optimal mixed financing strategy", that generates a bit higher additional value than the public subsidy.

This is the bliss point that each regulator would like to achieve because bank value increases, bondholders become more risk-sensitive and the implicit government guarantee, at tax-payer expense, is eliminated. However, the model's results highlight also the detrimental consequences of this double regulatory imposition when the banks face adverse market conditions. In this case (columns ADV), for an investment bank any incentive to issue debt disappears and the bank value is almost equal to the asset value(100.1). Moreover, any difference between bail-out and bail-in framework vanishes because, in both cases, the capital requirements are so tightening that the only way to survive is to build the strongest liability structure, financing the asset side entirely with own equity.

For a commercial bank, the results are more dramatic because the presence of deposit in the capital structure makes it less flexible, and this double regulatory imposition can destroy bank value. Under adverse conditions[30], for shareholders it is optimal to implement a kind of "Escape from bail-in" strategy, avoiding issuing U-bond such that, at trigger event, the regulatory authority cannot implement the bail-in tool because there will not be sufficient bail-inable bonds to convert in to equity. This represents a bank value improving strategy to circumvent the resolution regulation (100.1 Vs 91.6). In fact, if regulator imposes a mandatory minimum amount of bail-inable bonds, with the specific aim of avoiding this strategical decision aimed at circumventing the regulation, the liability structure composition will be suboptimal (values inside the brackets) and some bank value is destroyed because the market value of the U-bond will be negative[31].

This is a strong result, that highlights the importance of avoiding designing optimal macro-prudential policies that can work very well only under favourable market conditions, especially for commercial banks. The IMF discussion note (2012) pointed out the necessity to impose a minimum requirement on banks for issuing unsecured debt[32] in order to reassure the market that a bail-in would be sufficient to recapitalize the distressed institution avoiding potential runs by short-term creditors. The model results suggest that this imposition could be very dangerous if implemented together with tightening minimum capital requirements, especially under adverse market conditions, while it is always feasible if combined with a relaxed versione of the capital requirements.

Indeed, looking at the results of table 2, where only a general Tier1 requirement (6% of RWAs) is imposed, for both types of bank and for all the market conditions, it is optimal to hold a dominant portion of U-bond in the liability structure[33], especially in case of adverse

[30]With this parameters, it holds also for standard conditions, even if the losses in terms of bank value are less pronounced. As the payout rate increases (bad market conditions) the "Escape from bail-in" strategy becomes more appealing than the "mixed financing strategy".

[31]It implies that shareholders should subsidy Investors for issuing the needed minimum amount of bail-inable bond.

[32]This necessity has been translated into the MREL and TLAC standards to which the banks must comply.

[33]The bail-inable bond plays a crucial role because not only it can be converted into equity, postponing the bankruptcy of the bank, but it also counts for regulatory purpose. For this reason, the Investment bank hold a larger amount of U-bond with respect the case where a stringent control on the minimum Cet1 requirement is imposed (78.6% Vs 54% for the STD cases). When the default or the bail-out regimes are in force, the U-bonds lose their crucial role for bank recapitalization, but they are still important for regulatory purpose and for tax shield creation. Obviously, the regulatory purpose is the dominant driver because tax

conditions that make the bail-in event more likely. Moreover, under the bail-in resolution framework the incentive to increase leverage is also partially mitigated, the charter value is higher than the case with the tightening Cet1 requirement and the imposition of holding a minimum amount of bail-inable debt not only is feasible (also for the commercial bank) but it is also optimal because it increases the bank value.

Indeed, the bank's shareholders have incentive to raise both types of bonds because: i) issuing bail-in able bonds the default event is postponed and the probability of default is reduced (as well as the credit spread on C-bond); ii) C-bond becomes cheapest as the amount of U-bond in the capital structure increases.

Given the desired level of total leverage that shareholders want to achieve, only an optimal combination of the two bonds maximize the total value of the bank due to the simultaneous reduction of both the funding costs and the probability of default. These results hold for both types of regulatory constraints, however the optimal combination between the two bonds differs according to the ratio D/A due to the substitution effect, between C-bond and insured deposits, highlighted before.

For this reason, it is also important to understand that forcing banks, with different D/A ratio, to hold the same minimum amount of bail-inable bonds may induce shareholders to bear more risk, modifying for example the composition of the portfolio of assets, in order to compensate for the higher cost of funding. A generalization of this behaviour could enhance the systemic risk in the banking industry. This problem could be particularly important for commercial banks where the credit premiums paid on U-bond are higher than an Investment bank (515 Bps Vs 220 Bps). This result, justify the big effort put by the European Institutions on the recent MREL and TLAC standards, whereby they are trying to assign a bank-specific regulatory capital for each bank. In this sense, the imposition of a

shield can be generated also issuing only C-bonds. For this reason, the optimal mix between C-bond and U-bond, for both types of bank, drastically differs from table 2 (70%-75%) to table 3 (4.1%- 4.3%). In table 3, the regulatory Cet1 capital constraints is dominant, therefore U-bonds loses also importance for regulatory purpose and this explains why the optimal amount of U-bond is only 4% for the Commerical bank (STD case).

bank-specific regulatory capital should still be a key component of the regulatory framework, because it allows to manage the structural differences, in both the asset and liability sides, among banks.

Finally, under the three different market conditions and imposing a relaxed control on capital requirement, the worst resolution regime is the mixed one, where the implementation of the bail-in tool is not so credible. In this framework, with market's beliefs sufficiently large (p=30%), shareholders are induced to build a risky liability structure, increasing leverage up to 95%. This result holds for the Investment bank, while for a Commercial bank with a D/A ratio=35% the worst regime, in absolute, is the bail-out one. Under this framework, the presence of a high amount of deposits in the liability structure generates a higher level of leverage, a higher bank -and charter- value than a bank without deposits (in line with Sundaresan and Wang, 2017). More leverage pushes up the tax benefit of debt as well as bankruptcy costs and default boundary, that moves from 26.8 (Inv-Bank) and 36.6 (Com-Bank) for the bail-in regime to, respectively, 62.7 and 74.3. Moreover, a high leverage leads to lower market value of equity and a lower regulatory capital held by the bank.

These results clearly show the moral hazard problem discussed at the beginning of the paper. It is sufficient just a small belief about government bail-out to induce shareholders to increase the level of bank indebtedness due to the sizeable impact on their ROE. The key element of these results is the bondholders' insensitivity toward risk. In fact, the presence of the government guarantee on bank debt is distortive and it leads to creditor inertia.

The greater are the beliefs about government intervention, the more debtholders became risk-insensitive, increasing the incentives of shareholders to build a risky capital structure. This is confirmed by DeYoung et al. (2013) who argued that this type of protection makes bank depositors and borrowers passive counterparties, reducing banks' exposure to market discipline and encouraging bank managers to take greater insolvency risk. Indeed, the mechanism that links default risk and market value of debt breaks down because both the risk and cost of default shift from shareholders and debtholders to the government (ultimately on taxpayers). With this broken market feedback mechanism, the bonds' market values are not perfectly aligned with bank risks. These results suggest that in a World where the market beliefs, about government bail-out, are sufficiently large, any differences between investment banks and commercial banks disappear.

Although the comparison may seem exaggerated, thank to this model has been possible to replicate and clearly understand the main causes of the big financial crisis: the high bank's incentive to increase leverage and to reduce at minimum the own capital resources; the investors' insensibility toward the risk concerning the capital structure of the banks; the low level of effort put in trying to evaluate the true risks of the financial instruments sold in the markets; the excessive market confidence about the State implicit guarantee. This brief explanation is sufficient to well understand why regulators of all the World agree on the new bail-in resolution framework.

Generally, when it is in force, the incentive to increase leverage is mitigated and the regulatory capital (endogenously optimally determined by shareholders) held by the two banks is above the required one. The theoretical reason of this result is that shareholders internalize, in their objective function, what will happen to the U-type bondholders when bail-in tool will be applied. Since the costs of bank failures are shifted to both bank shareholders and to certain classes of bank creditors, according to a well define hierarchy, bondholders are more risk-sensitive and this allows to restore market discipline by aligning bank funding costs more closely with risks.

With this model, even far to be completed and totally exhaustive, has been possible to clearly highlight many of the problems that have led the banking system one step away from collapse, convincing authorities of all the World that a new regulatory framework was necessary. The stringent control on the minimum Cet1 capital requirement as well as the adoption of the bail-in framework seem appropriate solutions to mitigate the incentive to raise leverage, reducing default risk and making debtholders more risk-sensitive. However, the bail-in tool "*is not a panacea and should be considered as one element of a comprehensive* *solution to the TBTF problem*" (IMF 2012, pag.3) and a stringent Cet1 requirement should be managed carefully, considering also the different market conditions in which the bank operates, in the present but also in the future.

3 Conclusion

Thanks to this theoretical model, I shed light on the optimal liability structure of a commercial and an investment bank for a given set of distinct resolution frameworks and capital requirements. In doing so, I also introduced an extension of the Modigliani Miller I theorem, a kind of "3D version". Indeed, I determined the optimal bank's liabilities combination (black point in Figure 5), among different financing instruments, which allows shareholders to reach the desired optimal level of leverage.

The first main result of the research is that only under the on-going bail-in framework the shareholders of the investment bank have the right incentives to implement an "optimal mixed financing strategy", between covered and bail-inable bonds, while in the bail-out framework, as well as in default regime, any combination between the two financial instruments, that allows them to reach the desired leverage ratio, were actually optimal (red line in Figure 4) and whether an optimal financing strategy exists, it is driven by other variables but not by the resolution framework itself.

The results concerning the bail-out regime, well supported by the literature, suggest that shareholders have the distorted incentive in increasing leverage as much as possible. From the debtholders point of view, the presence of an implicit government guarantee on bank bonds makes them less risk-sensitive. This is confirmed by DeYoung et al. (2013) who argued that this type of protection makes bank depositors and borrowers passive counterparties, reducing banks' exposure to market discipline and encouraging bank managers to take greater insolvency risk. For this reason, regulators of all the World agree on the new bail-in resolution framework, that replaces the public subsidy with private "penalty", forcing banks to internalize the cost of risks which they assume.

When the bail-in framework is in force, shareholders implement an endogenous optimal risk mitigation strategy choosing a leverage ratio almost always lower than the optimal level under bail-out regime. Moreover, they also balance the optimal mix composition among bonds, in order to take advantage on the variations in their relative costs. Variations in the required credit spreads highlight that debtholders become more risk-sensitive toward the bank's capital structure.

The second main result is that imposing a stringent control on the minimum Cet1 requirement allows to generate the strongest risk-mitigation effect, in line with the well-known "more skin in the game" principle. However, stringent capital requirements should be managed carefully, especially if applied simultaneously with the bail-in resolution framework. When they are both in force, the different market conditions in which the bank operates must be considered because it could compromise not only the "effective implementation" of the bail-in tool but also the existence of the commercial banks in the future.

When the bank operates in favourable market conditions, the simultaneous imposition of the minimum Cet1 requirement and the bail-in regulatory framework allows to achieve the bliss point for regulators because bank value increases, bondholders become more risk-sensitive and the implicit government guarantee, at tax-payer expense, is eliminated. However, the model's results highlight also the detrimental consequences of this double regulatory imposition when the bank faces adverse market conditions. In this last case any incentive to issue debt disappears, the bank value decreases and for a commercial bank becomes optimal to circumvent the bail-in regulation implementing a kind of "escape from bail-in" strategy avoiding issuing bail-inable bonds such that, at trigger event, the authority can either close the bank or save it, at tax-payer costs. In this situation, a mandatory imposition of holding a minimum amount of bail-inable bonds in the liability structure is suboptimal, destroying bank value. Indeed, since the market value of the U-bond will be negative it implies that shareholders should subsidy Investors for issuing the required amount of bail-inable bonds.

Relaxing capital requirements, also under adverse market conditions, both types of bank are able to enhance bank value and, under the bail-in framework, the too-big-to-fail incentive of the bank is also well mitigated. Therefore, a macro-prudential policies' rethinking, in banking, is needed. A big effort to optimally design a strong and credible resolution regulation should be more efficient, and more effective, than trying to impose a bank-specific minimum amount of regulatory capital to each bank. Consequently, the "ex-ante" capital requirements become less necessary and can be relaxed, with a sizeable impact in terms of complexity and costs' reduction in regulating the banking system. Nevertheless, the bank-specific imposition of regulatory capital, provided by the MREL and TLAC standards, should be still a key component of the regulatory framework because it allows to manage the structural differences, in both the asset and liability sides, among banks. However, it should be managed carefully, considering the different market conditions in which a bank could operate, not only in the present but also in the future.

Thanks to the overall theoretical model it has been possible to highlight many theoretical and empirical results known in the banking literature concerning regulation, financial crisis, optimal liability structure, moral hazard issue behind the too-big-to-fail status, funding costs, etc. However, an empirical extension aimed at testing these results has primary importance, because they are of extraordinary importance, both from a financial and regulation point of view.

References

Admati, A. R., DeMarzo, P. M., Hellwig, M. F., & Pfleiderer, P. C. (2012). Debt overhang and capital regulation.

Admati, A. R., DeMarzo, P. M., Hellwig, M. F., & Pfleiderer, P. C. (2013). The leverage ratchet effect.

Admati, A. R., DeMarzo, P. M., Hellwig, M. F., & Pfleiderer, P. C. (2013). Fallacies, irrelevant facts, and myths in the discussion of capital regulation: Why bank equity is not socially expensive.

Admati, A. R., & Hellwig, M. F. (2014). The bankers' new clothes: What's wrong with banking and what to do about it. Princeton University Press.

Afonso, G., Santos, J. A., & Traina, J. (2014). Do'too-big-to-fail'banks take on more risk?. Federal Reserve Bank of New York, Economic Policy Review, Vol. 20, Special Issue: Large and Complex Banks.

Allen, F., Carletti, E., & Marquez, R. (2011). Credit market competition and capital regulation. The Review of Financial Studies, 24(4), 983-1018.

Allen, F., Carletti, E., & Marquez, R. (2015). Deposits and bank capital structure. Journal of Financial Economics, 118(3), 601-619.

Avgouleas, E., & Cullen, J. (2014a). Market discipline and EU corporate governance reform in the banking sector: Merits, fallacies, and cognitive boundaries. Journal of Law and Society, 41(1), 28-50.

Avgouleas, E., & Cullen, J. (2014b). Excessive Leverage and Bankers' Pay: Governance and Financial Stability Costs of a Symbiotic Relationship. Colum. J. Eur. L., 21, 1.

Bank for International Settlements (2017). Basel III:Finalising post-crisis reforms. ISBN 978-92-9259-022-2 (online).

Bank for International Settlements (2006). International Convergence of Capital Measurement and Capital Standards. ISBN web: 92-9197-720-9

Bank of Italy. Decreto legislativo 1° September 1993, n. 385. Testo unico delle leggi in materia bancaria e creditizia, versione aggiornata al decreto legislativo 14 novembre 2016, n. 223.

Black, F., & Cox, J. C. (1976). Valuing corporate securities: Some effects of bond indenture provisions. The Journal of Finance, 31(2), 351-367.

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. Journal of political economy, 81(3), 637-654.

Berger, A. N., DeYoung, R., Flannery, M. J., Lee, D., & Öztekin, Ö. (2008). How do large banking organizations manage their capital ratios?. Journal of Financial Services Research, 34(2-3), 123-149.

Brandao Marques, L., Correa, R., & Sapriza, H. (2013). International evidence on government support and risk taking in the banking sector. IMF, Working Paper,

Bulow, J., & Klemperer, P. (2013). Market-based bank capital regulation.

Chen, N., Glasserman, P., Nouri, B., & Pelger, M. (2013). CoCos, bail-in, and tail risk.

Chen, N., & Kou, S. (2009). Credit spread, implied volatility, and optimal capital structures with jump risk and endogenous defaults. Mathematical Finance, 19, 343-378.

Čihák, M., Demirgüç-Kunt, A., Martinez Peria, M., & Mohseni-Cheraghlou, A. (2012). Bank regulation and supervision around the world: a crisis update.The World Bank Policy Research Working Paper 6286.

Coffee Jr, J. C. (2011). Systemic risk after Dodd-Frank: contingent capital and the need for regulatory strategies beyond oversight. Columbia Law Review, 795-847.

Commission Delegated Regulation (EU) 2016/1450, (23 May 2016): supplementing Directive 2014/59/EU of the European Parliament and of the Council with regard to regulatory technical standards specifying the criteria relating to the methodology for setting the minimum requirement for own funds and eligible liabilities.

Conlon, T., & Cotter, J. (2014). Anatomy of a bail-in. Journal of Financial Stability, 15, 257-263.

Crosbie, P., & Bohn, J. (2003). Modeling default risk.

DeAngelo, H., & Stulz, R. M. (2015). Liquid-claim production, risk management, and bank capital structure: Why high leverage is optimal for banks. Journal of Financial Economics, 116(2), 219-236.

Dell'Ariccia, G., Laeven, L., & Marquez, R. (2014). Real interest rates, leverage, and bank risk-taking. Journal of Economic Theory, 149, 65-99.

Demirgüç-Kunt, A., Karacaovali, B., & Laeven, L. (2005). Deposit insurance around the world: a comprehensive database. World Bank, Washington, DC.

DeYoung, R., Kowalik, M., & Reidhill, J. (2013). A theory of failed bank resolution: Technological change and political economics. Journal of Financial Stability, 9(4), 612-627.

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. The review of economic studies, 51(3), 393-414.

Diamond, D. W., & Rajan, R. G. (2000). A theory of bank capital. The Journal of Finance, 55(6), 2431-2465.

Directive 94/19/EC, of the European Parliament and of the Council, (30 May 1994) on deposit-guarantee schemes

Directive 2013/36/EU, of the European Parliament and of the Council, (26 June 2013) on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC

Directive 2014/49/EU, of the European Parliament and of the Council, (16 April 2014) on deposit guarantee schemes.

Directive 2014/59/EU, of the European Parliament and of the Council, (15 May 2014) establishing a framework for the recovery and resolution of credit institutions and investment firms and amending Council Directive 82/891/EEC, and Directives 2001/24/EC, 2002/47/EC, 2004/25/EC, 2005/56/EC, 2007/36/EC, 2011/35/EU, 2012/30/EU and 2013/36/EU, and Regulations (EU) No 1093/2010 and (EU) No 648/2012, of the European Parliament and of the Council.

Directive 2014/65/EU, of the European Parliament and of the Council, (15 May 2014) on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU.

Dübel, A. (2013). The capital structure of banks and practice of bank restructuring (No. 2013/04).

Duffie, D., & Lando, D. (2001). Term structures of credit spreads with incomplete accounting information. Econometrica, 69(3), 633-664.

European Commision, Brussels, 11.10.2017: comunication on completing the Banking Union, COM(2017) 592 final.

European Commision, Strasbourg, 24.11.2015: Proposal for a regulation of the European Parliament and of the Council amending Regulation (EU) 806/2014 in order to establish a European Deposit Insurance Scheme. COM(2015) 586 final, 2015/0270 (COD).

Financial Stability Board (2011): Policy Measures to Address Systemically Important Financial Institutions, (www.fsb.org/2011/11/r_111104bb/).

Financial Stability Board (2015): Principles on Loss-absorbing and Recapitalisation Capacity of G-SIBs in Resolution Total Loss-absorbing Capacity (TLAC).

Financial Stability Board (2017): 2017 list of global systemically important banks (G-SIBs).

Flannery, M. J. (1994). Debt maturity and the deadweight cost of leverage: Optimally financing banking firms. The American Economic Review, 84(1), 320-331.

Flannery, M. J. (2005). "No Pain, No Gain: Effecting Market Discipline via Reverse Convertible Debentures." In Capital Adequacy beyond Basel: Banking, Securities and Insurance, H. S. Scott, ed. Oxford:

Oxford University Press.

Flannery, M. J. (2012). Corporate finance and financial institutions. Annu. Rev. Financ. Econ., 4(1), 233-253.

Flannery, M. J., & Nikolova, S. (2004). Market discipline of US financial firms: Recent evidence and research issues. Market discipline across countries and industries, 87-100.

Flannery, M.J., & Rangan, K. P. (2008). What caused the bank capital build-up of the 1990s. Review of Finance 12 (2), 391–429.

Gadanecz, B., Tsatsaronis, K., & Altunbas, Y. (2008). Spoilt and lazy: the impact of state support on bank behaviour in the international loan market. International Journal of Central Banking, Vol. 8(4), 121-173.

Goldstein, R., Ju, N., & Leland, H. (2001). An EBIT-based model of dynamic capital structure. The Journal of Business, 74(4), 483-512.

Goodhart, C., & Avgouleas, E. (2014). A critical evaluation of bail-ins as bank recapitalisation mechanisms. Centre for Economic Policy Research Discussion Paper10065, July 2014.

Gordon, J. N., & Ringe, W. G. (2015). Bank resolution in the European Banking Union: a transatlantic perspective on what it would take. Colum. L. Rev., 115, 1297.

Gropp, R., & Heider, F. (2010). The determinants of bank capital structure. Review of Finance 14 (4), 587–622.

Gropp, R., Hakenes, H., Schnabel, I. (2011). Competition, Risk-shifting, and Public Bail-Out Policies. Review of Financial Studies. Vol. 24(6), 2084-2120.

Harding, J. P., Liang, X., & Ross, S. L. (2007). The optimal capital structure of banks: Balancing deposit insurance, capital requirements and tax-advantaged debt.

Helberg, S., & Lindset, S. (2014). How do asset encumbrance and debt regulations affect bank capital and bond risk?. Journal of Banking & Finance, 44, 39-54.

Henriques, R. (2011). The Great Bank Downgrade: What Bail-In Regimes Mean for Senior Ratings?. JP Morgan Chase Europe Credit Research, January, 7.

Hilberink, B., & Rogers, L. C. (2002). Optimal capital structure and endogenous default. Finance and Stochastics, 6(2), 237-263.

Hilscher, J., & Raviv, A. (2012). Bank Stability and Market Discipline: The Effect of Contingent Capital on Risk Taking and Default Probability.

Huertas, T. F. (2013). The Case for Bail-ins. In Kenadjian, P. S., Ed. The Bank Recovery and Resolution Directive, De Gruyter, e-book.

International Monetary Fund, (April 24 2012), staff discussion note: From Bail-out to Bail-in: Mandatory Debt Restructuring of Systemic Financial Institutions. SDN/12/03.

International Monetary Fund, (October 2013), Global Financial Stability Report, Transition Challenges to Stability.

Ippolito, F., Peydró, J. L., Polo, A., & Sette, E. (2016). Double bank runs and liquidity risk management. Journal of Financial Economics, 122(1), 135-154.

James, C. (1991). The losses realized in bank failures. Journal of Finance 46 (4), 1223–1242.

Koziol, C., & Lawrenz, J. (2009). What makes a bank risky? Insights from the optimal capital structure of banks. Journal of Banking & Finance, 33(5), 861-873.

KPMG, (2012). Bail-in liabilities: Replacing public subsidy with private insurance.

Leland, H. E. (1994). Corporate debt value, bond covenants, and optimal capital structure. The journal of finance, 49(4), 1213-1252.

Leland, H. E., & Toft, K. B. (1996). Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads. The Journal of Finance, 51(3), 987-1019.

Li, Z., Qu, S., & Zhang, J. (2013). Quantifying the Value of Implicit Government Guarantess for Large Financial Institutions. Moody's Analytics.

McAndrews, J., Morgan, D. P., Santos, J. A., & Yorulmazer, T. (2014). What Makes Large Bank Failures So Messy and What to Do about It?.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. The Journal of finance, 29(2), 449-470.

Merton, R. C. (1977). An analytic derivation of the cost of deposit insurance and loan guarantees an application of modern option pricing theory. Journal of Banking & Finance, 1(1), 3-11.

Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. The American economic review, 48(3), 261-297.

Morgan, D. P., & Stiroh, K. J. (2005). Too big to fail after all these years.

Myers, S. C., & Rajan, R. G. (1998). The paradox of liquidity. The Quarterly Journal of Economics, 113(3), 733-771.

Rajan, R. G., & Zingales, L. (1995). What do we know about capital structure? Some evidence from international data. The journal of Finance, 50(5), 1421-1460.

Rawcliffe, G., & Weinfurter, D. (2010). "Resolution Regimes and the Future of Bank Support," Fitch Ratings, Global Special Report, December.

Regulation (EU) No 575/2013, of the European Parliament and of the Council (26 June 2013) on prudential requirements for credit institutions and investment firms and amending Regulation (EU) N 648/2012.

Santos, J. A. (2014). Evidence from the Bond Market on Banks"Too-Big-To-Fail'Subsidy. Federal Reserve Bank of New York, Economic Policy Review, Vol. 20, Special Issue: Large and Complex Banks (March).

Stiroh, K. J. (2004). Diversification in banking: Is noninterest income the answer?. Journal of Money, Credit, and Banking, 36(5), 853-882.

Sundaresan, S. (2013). A review of Merton's model of the firm's capital structure with its wide applications. Annu. Rev. Financ. Econ., 5(1), 21-41.

Sundaresan, S., & Wang, Z. (2015). On the design of contingent capital with a market trigger. The Journal of Finance, 70(2), 881-920.

Sundaresan, S., & Wang, Z. (2017). Bank liability structure.

Tarullo, D. K. (2013, October). Toward building a more effective resolution regime: progress and challenges. In remarks at the Federal Reserve Board and Federal Reserve Bank of Richmond Conference "Planning for the Orderly Resolution of a Global Systemically Important Bank," Washington, DC (October 18).

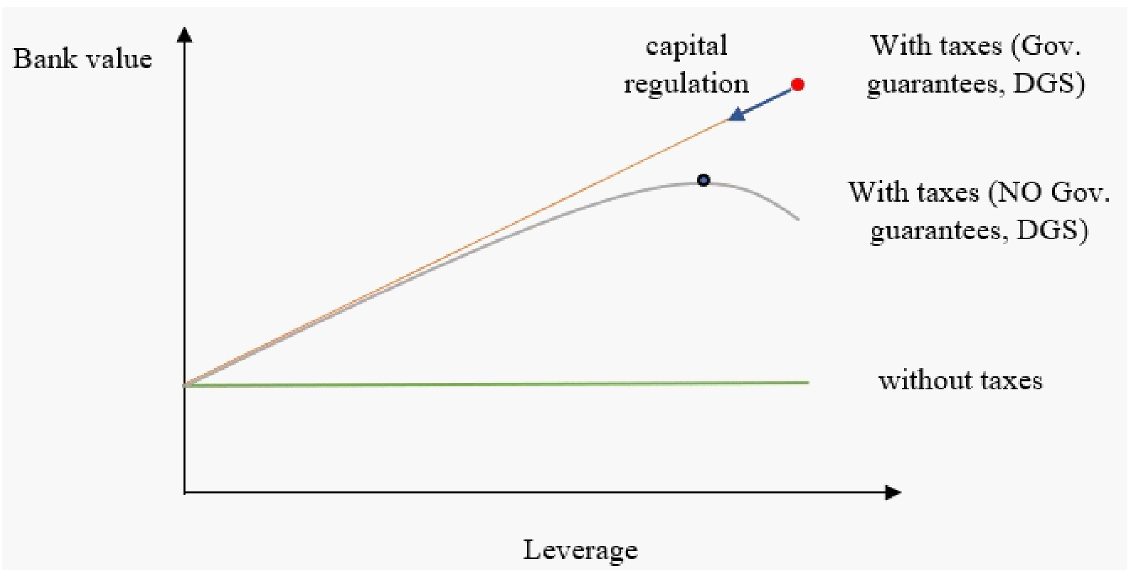
Ueda, K., & di Mauro, B. W. (2011). Quantifying the value of the subsidy for systemically important financial institutions. In The German Institute for Economic Research (DIW, Berlin), Conference Paper, 20th May.

US House of Representatives. (2010). Dodd-Frank Wall Street Reform and Consumer Protection Act. Public Law 111-203 [HR 4173].

Zhou, C. (2001). The term structure of credit spreads with jump risk. Journal of Banking & Finance, 25(11), 2015-2040.

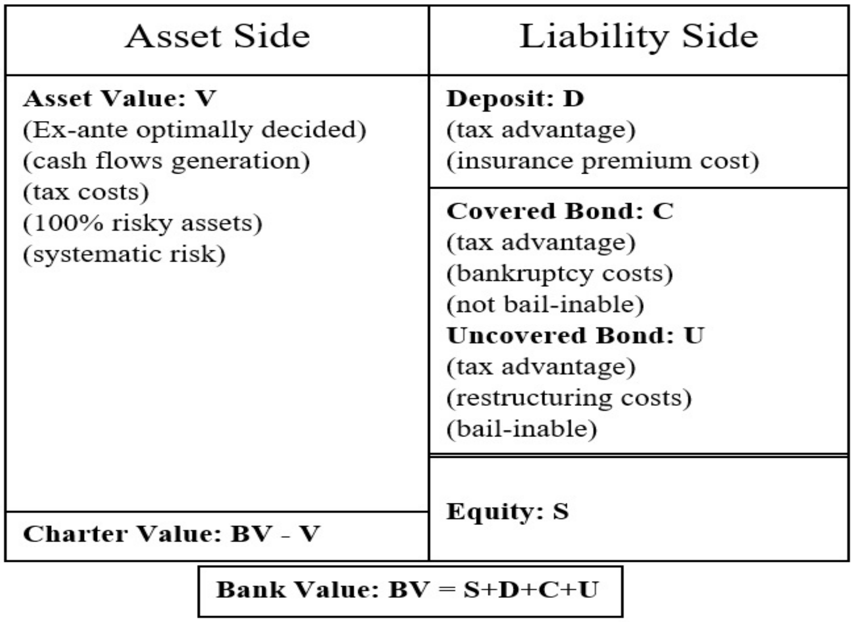
List of Figures

Figure 1: The Modigliani Miller I theorem for bank.



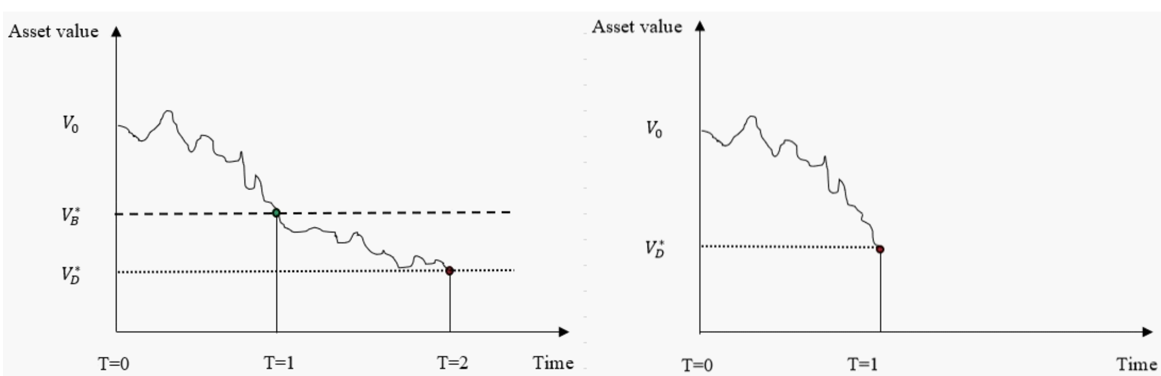
Source: Restatement of the R. DeYoung address notes on "regulating banking" at school of banking and finance at Catholica University, during the 2017 FINEST Winter Workshop.

Figure 2: Bank's balance sheet.



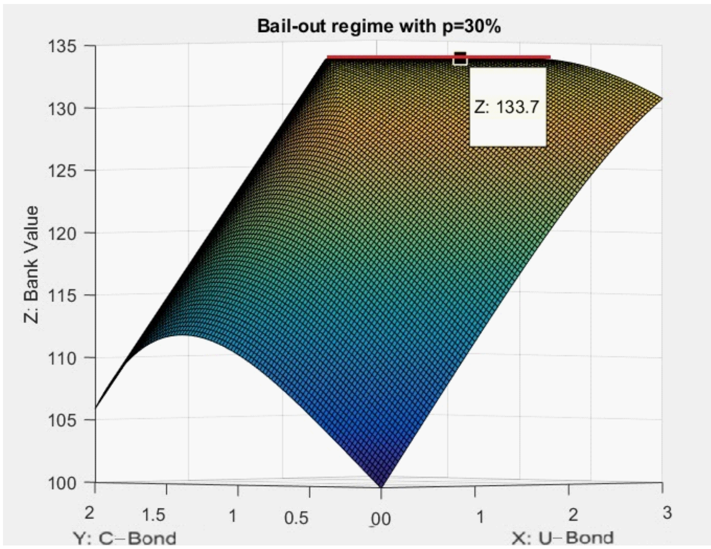
Source: Author.

Figure 3: The bail-in and bail-out models.



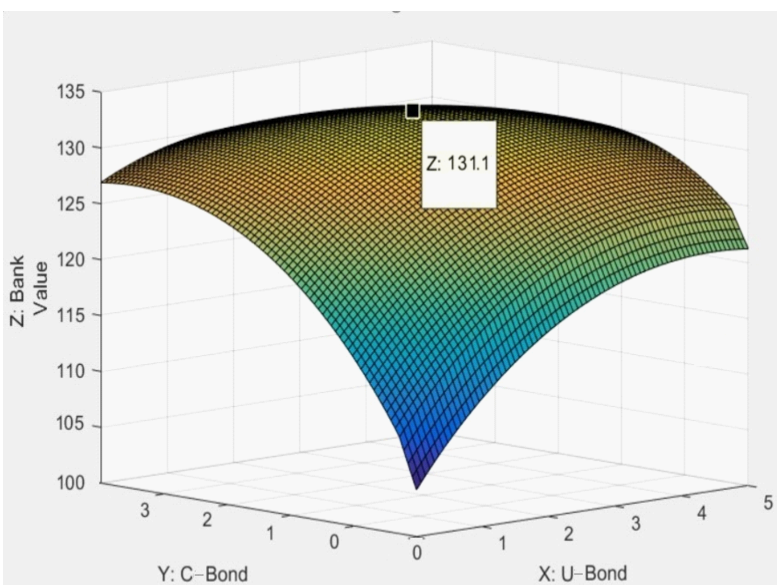
The bail-in model on the left side (3.a), the bail-out model on the right side (3.b). Source: Author.

Figure 4: Indeterminacy of the Mixed Financing Strategy, for the investment bank, under Bail-out framework and relaxed Tier1 requirement.



Source: Author; MATLAB optimization.

Figure 5: Mixed Financing Strategy, for the investment bank, under Bail-in framework and relaxed Tier1 requirement.



Source: Author; MATLAB optimization.

List of tables:

Table 1

Exogenous Parameters	Notation	Base Case Values	Comparative static's range
CF growth prospect	α	5%	[3%, 7%]
CF volatility	σ	8%	[6%, 10%]
Market price of risk	λ	0.6	[0.4, 0.8]
Risk-free interest rate	r	3%	[1%, 5%]
Insurance premium	φ	0.10%	[0.05%, 0.15%]
Corporate taxes	τ	35%	[15%, 55%]
Bankruptcy cost	ε	45%	[25%, 65%]
Restructuring cost	ξ	30%	[15%, 45%]
Tier 1 Requirement	β	6%	-
Cet 1 Requirement	ψ	4.5%	-
Beliefs on Gov. Interv.	$p,\ p_1,\ p_2$	0% or 30%	[10%, 50%]
Insured dep. amount	D	0, 20, 35	-
Initial Asset value	V	100	-

Table 2	Commercial Bank (D=35) under different market conditions and total Tier1=6% requirement											
Total Tier1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=30% , p_2=30%		
Mkt. Conditions	FAV	STD	ADV	FAV	STD	ADV	FAV	STD	ADV	FAV	STD	ADV
Bk V. C-Bond	47.0	22.5	1.3	48.5	34.8	26.5	37.9	0.0	0.1	39.1	5.9	26.5
Bk V. U-Bond	57.0	68.1	293.4	58.0	83.0	499.6	66.5	85.6	283.3	67.6	104.7	499.6
Tot. Bk V. Bond	104.0	90.6	294.7	106.5	117.8	526.1	104.4	85.6	283.4	106.7	110.6	526.1
%Bk V. U-Bond	54.8	75.1	99.6	54.5	70.5	95.0	63.7	100	99.99	63.4	94.7	95.0
Tang. Equity	-39.0	-25.6	-229.7	-41.6	-52.8	-461.2	-39.4	-20.6	-218.4	-41.7	-45.6	-461.1
Mkt.V. C-Bond	47.0	22.5	1.3	48.5	34.8	26.5	37.9	0.0	0.1	39.1	5.9	26.5
Mkt.V. U-Bond	55.0	51.6	54.7	55.8	58.3	180.6	64.5	70.2	46.0	65.4	82.4	168.8
Mkt.V. Equity	9.3	22.8	28.2	7.7	10.9	8.0	9.0	25.3	29.6	7.7	13.7	8.1
Bank Value	146.3	131.8	119.2	147.1	139.0	250.2	146.4	130.4	110.7	147.2	137.0	238.4
Charter Value	46.3	31.8	19.2	47.1	39.0	150.2	46.4	30.4	10.7	47.2	37.0	138.4
%No-Dep. Lev	69.7	56.2	47.0	70.9	67.0	82.8	69.9	53.8	41.7	71.0	64.4	81.9
%Tot. Lev.	93.6	82.7	76.4	94.7	92.2	96.8	93.8	80.6	73.3	94.8	90.0	96.6
Barrier V_{EB}	-	-	-	-	-	-	87.5	58.7	37.3	88.9	70.8	65.4
Barrier V_{RB}	-	-	-	-	-	-	77.6	37.2	37.3	78.8	43.5	65.4
Barrier V_{ED}	87.2	61.2	38.6	88.9	74.3	65.4	46.0	17.4	4.5	46.7	20.3	7.5
Barrier V_{RD}	87.2	61.2	38.6	88.9	74.3	65.4	76.4	36.6	36.7	77.6	42.8	64.4
%C-credit Spr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%U-credit Spr.	0.18	0.96	4.36	0.20	1.27	1.77	0.16	0.66	5.15	0.16	0.81	1.96
	Investment Bank (D=0) under different market conditions and total Tier1=6% requirement											
Bk V. C-Bond	*	*	*	*	*	*	70.7	25.6	0.2	72.3	32.8	28.1
Bk V. U-Bond	*	*	*	*	*	*	69.3	94.0	225.5	69.9	111.7	500.0
Tot. Bk V. Bond	137.0	109.5	184.0	139.1	129.9	560.7	139.0	119.6	225.7	142.2	144.5	528.1
%Bk V. U-Bond	Indet.	Indet.	Indet.	Indet.	Indet.	Indet.	49.9	78.6	99.99	49.2	77.3	94.7
Tang. Equity	-37.0	-9.5	-84.0	-39.1	-29.9	-460.7	-40.0	-19.6	-125.7	-42.3	-44.5	-428.1
Mkt.V. C-Bond	**	**	**	**	**	**	70.7	25.4	0.2	72.3	32.5	23.6
Mkt.V. U-Bond	**	**	**	**	**	**	67.3	79.4	70.5	67.8	90.4	194.8
Mkt.V. Equity	11.0	31.8	50.7	9.7	21.2	8.3	9.1	26.4	43.4	7.7	14.6	10.3
Bank Value	146.1	128.4	111.5	146.8	133.7	234.3	147.1	131.1	114.1	147.9	137.5	228.8
Charter Value	46.1	28.4	11.5	46.8	33.7	134.3	47.1	31.1	14.1	47.9	37.5	128.8
%No-Dep. Lev	92.4	75.3	54.5	93.4	84.1	96.5	93.8	79.9	62.0	94.8	89.4	95.5
%Tot. Lev.	92.4	75.3	54.5	93.4	84.1	96.5	93.8	79.9	62.0	94.8	89.4	95.5
Barrier V_{EB}	-	-	-	-	-	-	87.5	57.7	26.2	88.9	69.7	61.2
Barrier V_{RB}	-	-	-	-	-	-	75.2	27.2	0.2	77.0	34.9	29.9
Barrier V_{ED}	85.6	52.8	21.3	86.9	62.7	65.0	44.2	12.4	0.0	45.2	15.8	3.3
Barrier V_{RD}	85.6	52.8	21.3	86.9	62.7	65.0	74.0	26.8	0.2	75.7	34.3	29.4
%C-credit Spr.	**	**	**	**	**	**	0.00	0.03	0.12	0.00	0.03	0.19
%U-credit Spr.	**	**	**	**	**	**	0.15	0.55	2.20	0.16	0.71	1.57

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:
** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

Table 3	Commercial Bank (D=35) under different market conditions and both Tier1=6% and Cet1=4.5% requirements															
Tier1 and Cet1	Default regime			Bail-out regime			Credible Bail-in regime					Mixed b-in/out regime				
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%					p_1=30% , p_2=30%				
Mkt. Conditions	FAV	STD	ADV	FAV	STD	ADV	FAV	STD		ADV		FAV	STD		ADV	
								Opt.	SubOp.	Opt.	SubOp.		Opt.	SubOp.	Opt.	SubOp.
Bk V. C-Bond	46.9	20.9	0.1	46.9	21.2	0.0	37.9	20.9	0.0	0.0	0.0	37.8	20.9	0.0	0.0	0.0
Bk V. U-Bond	1.3	0.9	0.6	1.3	0.9	0.6	10.6	0.0	18.0	0.0	0.56	10.6	0.0	19.1	0.0	0.56
Tot. Bk V. Bond	48.2	21.8	0.7	48.2	22.1	0.6	48.5	20.9	18.0	0.0	0.56	48.4	20.9	19.1	0.0	0.56
%Bk V. U-Bond	2.7	4.3	85.7	2.7	4.1	100	21.9	0.0	100	N/A	100	21.9	0.0	100	N/A	100
Tang. Equity	16.8	43.2	64.4	16.8	42.9	64.4	16.5	44.1	47.0	65.0	64.44	16.6	44.1	45.9	65.0	64.44
Mkt.V. C-Bond	46.9	20.9	0.1	46.9	21.2	0.0	37.9	20.9	0.0	0.0	0.0	37.8	20.9	0.0	0.0	0.0
Mkt.V. U-Bond	1.3	0.7	0.1	1.3	0.8	0.2	10.7	0.0	16.8	0.0	-8.4	10.7	0.0	18.2	0.0	-8.4
Mkt.V. Equity	44.4	57.4	65.0	44.4	57.2	65.0	44.1	57.9	61.1	65.1	65.05	44.1	57.9	60.0	65.1	65.05
Bank Value	127.5	114.0	100.2	127.5	114.1	100.3	127.6	113.8	112.9	100.1	91.65	127.6	113.8	113.2	100.1	91.65
Charter Value	27.5	14.0	0.2	27.5	14.1	0.3	27.6	13.8	12.9	0.1	-8.4	27.6	13.8	13.2	0.1	-8.4
%No-Dep. Lev	37.7	19.0	0.2	37.8	19.2	0.2	38.1	18.3	14.8	0.0	-9.2	38.0	18.3	16.1	0.0	-9.2
%Tot. Lev.	65.2	49.7	35.1	65.2	49.9	35.1	65.5	49.1	45.9	35.0	29.0	65.4	49.1	47.0	35.0	29.0
Barrier V_{EB}	-	-	-	-	-	-	52.6	-	26.1	-	4.53	52.6	-	26.7	-	4.53
Barrier V_{RB}	-	-	-	-	-	-	87.4	-	55.5	-	37.23	87.4	-	56.7	-	37.23
Barrier V_{ED}	52.4	28.0	4.5	52.4	28.1	4.5	45.9	27.5	17.4	4.5	4.46	45.9	27.5	17.4	4.5	4.46
Barrier V_{RD}	87.1	59.5	37.3	87.1	59.8	37.2	76.3	59.4	36.6	37.2	36.65	76.2	59.4	36.6	37.2	36.65
%C-credit Spr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%U-credit Spr.	0.17	0.87	4.19	0.12	0.57	1.30	-0.03	0.00	0.22	0.00	-1.07	-0.02	0.00	0.15	0.00	-1.10
	Investment Bank (D=0) under different market conditions and both Tier1=6% and Cet1=4.5% requirements															
Bk V. C-Bond	*	*	*	*	*	*	70.6	23.8	.	0.0	.	71.1	26.0	.	0.1	.
Bk V. U-Bond	*	*	*	*	*	*	12.8	27.4	.	2.0	.	12.3	26.9	.	3.6	.
Tot. Bk V. Bond	80.84	44.36	0.76	81.40	47.03	1.65	82.4	50.2	.	2.0	.	83.4	52.9	.	3.7	.
%Bk V. U-Bond	Indet.	Indet.	Indet.	Indet.	Indet.	Indet.	15.5	54.6	.	100	.	14.7	50.9	.	97.3	.
Tang. Equity	19.2	55.6	99.2	18.6	53.0	98.4	16.6	48.8	.	98.0	.	16.6	47.1	.	96.3	.
Mkt.V. C-Bond	**	**	**	**	**	**	70.6	23.6	.	0.0	.	71.1	25.9	.	0.1	.
Mkt.V. U-Bond	**	**	**	**	**	**	12.9	26.4	.	1.8	.	12.4	26.0	.	3.3	.
Mkt.V. Equity	46.9	69.2	99.4	46.5	67.0	98.7	44.6	63.4	.	98.3	.	44.6	61.8	.	96.9	.
Bank Value	127.2	111.5	100.0	127.4	112.2	100.1	128.1	113.3	.	100.1	.	128.0	113.7	.	100.2	.
Charter Value	27.2	11.5	0.0	27.4	12.2	0.1	28.1	13.3	.	0.1	.	28.0	13.7	.	0.2	.
%No-Dep. Lev	63.1	37.9	0.6	63.5	40.3	1.4	65.2	44.1	.	1.8	.	65.2	45.7	.	3.3	.
%Tot. Lev.	63.1	37.9	0.6	63.5	40.3	1.4	65.2	44.1	.	1.8	.	65.2	45.7	.	3.3	.
Barrier V_{EB}	-	-	-	-	-	-	52.1	24.7	.	0.2	.	52.1	25.5	.	0.4	.
Barrier V_{RB}	-	-	-	-	-	-	87.4	53.6	.	2,1	.	87.3	55.4	.	3.8	.
Barrier V_{ED}	50.5	21.4	0.1	50.8	22.7	0.2	44.1	11.5	.	0.0	.	44.4	12.6	.	0.0	.
Barrier V_{RD}	84.7	46.4	0.8	85.2	49.2	1.7	73.9	24.9	.	0.0	.	74.4	27.3	.	0.1	.
%C-credit Spr.	**	**	**	**	**	**	0.00	0.02	.	0.07	.	0.00	0.01	.	0.04	.
%U-credit Spr.	**	**	**	**	**	**	-0.03	0.12	.	0.13	.	-0.02	0.09	.	0.10	.

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:

** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

SubOp.: The bank must hold the minimum 1.5%RWAs of bail-inable bonds in order to avoid that the bail-in resolution framework is circumvented.

Appendix To
Bail-in Vs Bail-out: Bank Resolution and Liability Structure

Luca Leanza

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A. Regulatory framework

In order to avoid moral hazard, any failing institution should be able to exit the market, irrespective of its size and interconnectedness, without causing systemic disruption and financial instability. For this reason, it is highly likely that there would be a public interest in placing the institution under resolution, applying resolution tools rather than resorting to normal insolvency proceedings. The objectives of resolution tools, as the bail-in one, are: ensure the continuity of critical functions; avoid adverse effects on financial stability; protect public funds (by minimising reliance on extraordinary public financial support to failing institutions); protect covered depositors, investors, client funds and client assets.

The Article n. 48 of Bank Recovery and Resolution Directive (Directive 2014/59/EU also called BRRD) establishes the sequence the resolution authorities should follow in applying the power to write-down or convert obligations (the bail-in power) of an entity under resolution. Obligations should be reduced according to the following order:

1) Common Equity Tier 1; (for simplicity I am assuming that it is composed only by pure equity[34]);

[34] Article 26 of regulation (EU) n° 575/2013 of the European Parliament and of the Council of 26 June 2013: Common Equity Tier 1 items of institutions consist of the following: (a) capital instruments, provided the conditions in Article 28 or, where applicable, Article 29 are met; (b) share premium accounts related to the instruments referred to in point (a); (c) retained earnings; (d) accumulated other comprehensive income; (e) other reserves; (f) funds for general banking risk. The items referred to in points (c) to (f) shall be recognised as Common Equity Tier 1 only where they are available to the institution for unrestricted and immediate use to cover risks or losses as soon as these occur.

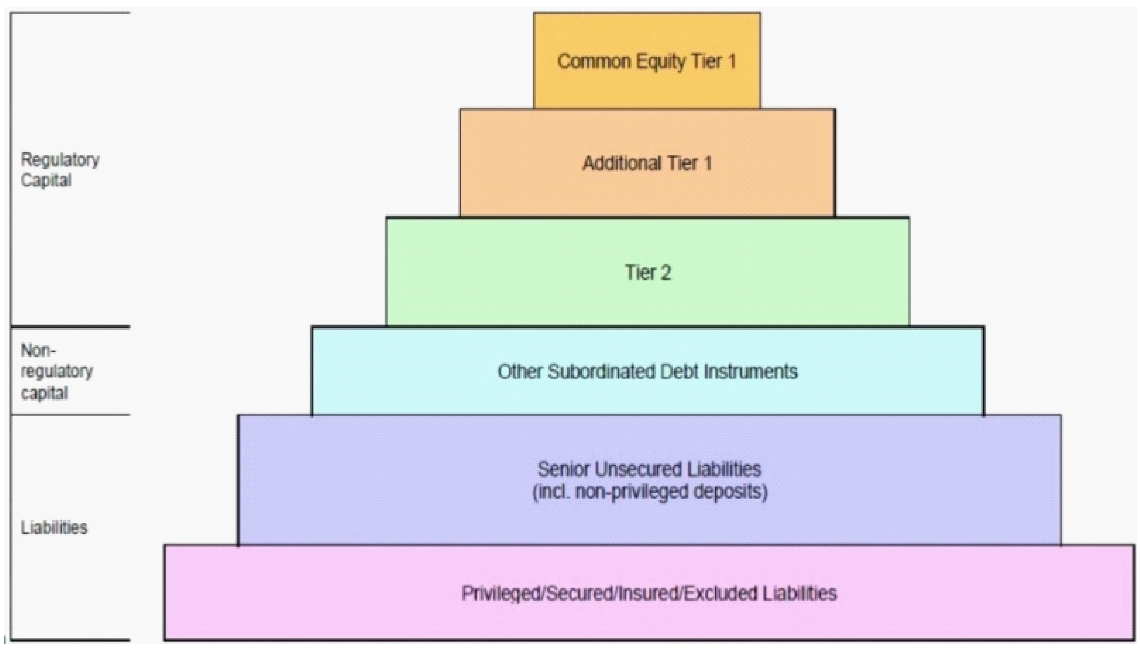
2) Additional Tier 1 instruments[35];

3) Tier 2 instruments[36];

4) Debt subordinated only to senior debt, not considered as regulatory capital, in accordance with the normal insolvency hierarchy (Lower T2 capital);

5) "Other eligible liabilities[37]", that I summarized in "Uncovered Senior Bond"[38], in accordance with the normal insolvency hierarchy.

Figure A.1: Sequence of securities' write down or conversion.



Source: Restatement of 2015 Morrison & Foerster LLP presentation.

Losses should be firstly absorbed by regulatory capital instruments and then they should be allocated to shareholders, through the cancellation or transfer of shares, or through severe

[35] Article 51 and 52 of regulation (EU) n° 575/2013 of the European Parliament and of the Council of 26 June 2013.

[36] Article 63 of regulation (EU) n° 575/2013 of the European Parliament and of the Council of 26 June 2013.

[37] Article 44 point 1 of BRRD: Member States shall ensure that the bail-in tool may be applied to all liabilities of an institution or entity that are not excluded from the scope of that tool pursuant to paragraphs 2 or 3 of this Article.

[38] Even if the better definition should be "uncovered debts" because it includes also the part of deposits from natural persons and micro, small and medium-sized enterprises which exceeds the coverage level provided for in Article 6 of Directive 2014/49/EU).

dilution. Subordinated debt can be written down or converted into equity only if those previous instruments are not sufficient. Therefore, this directive establishes that taxpayers will be last in line to pay the bills of a failing bank while other creditors, according to a pre-defined hierarchy and in compliance with the "No Creditor Worse Off" (NCWO) principle, forfeit some or all their holdings to keep the bank alive. However, not all the bank's capital instruments are bail-inable. Article 44 (point 2) of BRRD expressly exclude the possibility for the resolution authorities to exercise the write-down or conversion powers to some categories of debt instruments as covered deposits, covered bonds, employee remuneration, etcetera. Moreover, to ensure restructuring as a going-concern, each bank needs to prepare a full recovery plan that sets out the measures it will take in distinct scenarios where it is at risk.

The convertible instruments, descripted above, are known as contractual contingent capital instruments with write-off (CoCos). To avoid such bailouts in the future, regulators have raised banks' capital requirements and reconsidered what debt-like instruments should qualify as capital. Supported by academic proposals such as Flannery (2005), some countries have allowed their banks to partially meet higher capital standards by issuing contingent convertibles capital. In general, CoCos are bonds that are converted to equity (or written off) after some triggering event, such as a decline in a bank's capital below a fixed predetermined threshold.

Whene the debt contract is signed the investors perfectly know its characteristics: notional amount, trigger event, rate of conversion, time to maturity, coupon payment, and so on. The novelty introduced by bail-in framework is that, whether after the contractual contingent capital conversion the bank is still distressed, also the outstanding uncovered senior bonds will be affected by the write-down or conversion (statutory) power (IMF Staff Discussion Note, 24 April 2012), always in accordance with the normal insolvency hierarchy. This type of instrument is called bail-inable debt and, along with the not bail-inable one and the insured deposits, forms the bank liability structure of the model (Figure 2).

However, even if I explicitly excluded CoCo bonds from the analysis[39], the intrinsic features of (on-going concern) bail-inable debt make this kind of instruments quite similar to CoCos that qualify as additional tier1 (AT1) capital. The main difference between the two is that while in CoCos a well specified threshold for conversion (equity ratio not lower than 7%[40]) is present, the threshold for conversion of the bail-inable debt is uncertainbecuase it is a statutory power of the resolution authority. However, given the assumption of perfect information, the bondholders of the model are able to perfectly identify both the endogenous and the regulatory conversion threshold. This implies that the uncovered senior bonds can been priced as CoCos that qualify as AT1 capital. In fact, Investors know the level of the boundaries that will be applied for pricing and they know that at trigger event, their claims will be converted into equity, restoring the bank to health without recourse to public funds. With a similar reasoning, Sundaresan and Wang (2017) defined the amount of (the generic) nondeposit debt as Tier2 capital due to the protection that the lower priority of this instrument generates on deposits at bankruptcy.

If the bail-in tool is applied and the bank is recapitalised, the resolution authorities shall determine the amount of recapitalisation which would be sufficient to to satisfy the minimum capital requirements to meet the conditions for authorisation (article n. 45 of BRRD). Only complying with these conditions a bank can continue to carry out the activities for which it is authorised, on the contrary the bail-in tool cannot be applied and the bank must be liquidated. Nevertheless, if the tool can be applied, the minimum amount of capital required to run bank activity is only the mandatory one. Therefore, only if the bank is not in compliance with the mandatory capital (ψ) requirement ($CET1 = 4,5\%$ of RWAs) it will face regulatory closure. Indeed, nothing related to the minimum amount of AT1 (or T2) capital, that the bank must hold immediately after the bail-in tool implementation, is mentioned. A similar expression, which leads to the same conclusion, is present in the article n. 46 of the same directive.

[39] For more details on CoCos see Chen et al. (2013) or Sundaresan and Wang (2015).

[40] Sundaresan and Wang (2015).

Two important pieces of the regulatory framework are related to the so called MREL and TLAC standards.

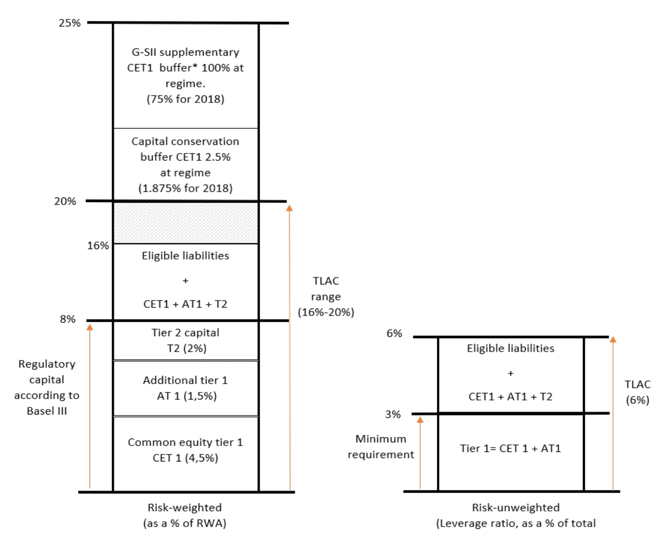
Article 2 paragraph 6 of the Regulatory Technical Standards on minimum requirement for own funds and eligible liabilities (MREL), establish that the capital requirements shall include (among other): (i) a CET1 capital ratio of 4,5%; (ii) a Tier1 capital ratio of 6%; (iii) a minimum total capital ratio of 8% (all measured as a percentage of the risk weighted assets (RWAs) amount). Under the current rules, when preparing bank resolution plans, resolution authorities have to fix a bank-specific level of MREL that reflects the foreseen resolution approach, along with an appropriate deadline to achieve it. This MREL requirement should ensure that shareholders and creditors bear losses regardless of which resolution tool (e.g. the bail-in tool or the bridge bank tool) is applied. In this way MREL ensures sufficient loss-absorbing and recapitalisation capacity to enable orderly resolution, facilitating the continuity of critical functions without recourse to public funds. For the same purpose, in addition to the mandatory amount of 4.5% of Cet1 capital requirement, all banks are required to hold a capital conservation buffer and a countercyclical capital buffer (both shall be covered by CET1 capital) to ensure that they accumulate a sufficient capital base in prosperous times to enable them to absorb losses in the event of a crisis. The main difference between the mandatory 4,5% of CET 1 and the additional requirements is the penalty in case of not compliance. Indeed, if a bank does not comply with the additional buffers, it has to limit or stop payments of dividends (or bonuses) while, if the bank does not comply with the mandatory capital requirement, it faces resolution because the conditions for authorisation, to run bank activity, are no more respected.

The Financial Stability Board's "Total Loss-absorbing Capacity" (TLAC) standard (2015) has set minimum levels of loss absorption and recapitalisation capacity at the largest, globally systemically, important banks (G-SIBs). This standard was specifically designed to deal with the too-big-to-fail problem at the international level and, thus it has been formulated differently from MREL. However, both concepts aim at the same regulatory objective which is to enhance effectiveness of resolution by asking banks to hold sufficient amounts of readily bail-inable liabilities (essential to safeguard financial stability and public funds).

Finally, the third pillar of the banking union concerns the European deposit insurance scheme (EDIS) for bank deposits in the Euro area, proposed in November 2015 by the European Commission. This proposal was adopted as a part of a broader package of measures to deepen the economic and monetary union and complete the banking union. However, for the time being the EDIS is not effective and the national DGSs are still in force. For this reason, in the paper, I complied with the Italian DGS in treating the insured deposits.

In conclusion, it is important to highlight an additional prudential measure, the leverage ratio (LR). It has been contemplated to enhance financial stability by determining capital requirements on the basis of non-risk weighted assets and it is measured as the ratio between the amount of regulatory capital of an institution and its (gross) total assets. In this way it is possible to prevent the building up of excessive leverage during economic upswings and it can act as a backstop to internal model-based capital requirements. All the regulatory capital requirements mentioned in the chapter are summarized in the following figure (A.2):

Figure A.2: Summary of regulatory capital requirements.



Source: FINMA | Annual Report 2014.

B. Discussion of base case parameters

As in Helberg and Lindset (2014), I assumed a flat term structure for the risk-free rate setting it to 3%, in line with the (2014) US and German 30-year government bond rate. Asset risk represents the most important parameters that affect bank leverage and liability structure. It is measured by asset volatility that is typically inferred from accounting data and market prices. For the standard case (STD) analysis I assumed an asset volatility of 8%. In Chen et al. (2013), who used a total volatility of 20.6% (combining diffusion and jumps process), the value for the diffusion part has been fixed to 8%, while Crosbie and Bohn (2003) found that the banking industry had asset volatility lower than other industries (at the end of 2003 it was around $5-6\%$ for small banks). However, for the comparative static I analysed results for the range [6%, 10%] where 6% is used for the cases of "favorable" market conditions (FAV) while 10% is used for the "adverse" market conditions. Since I performed an EBITs' based analysis, assumptions on the market price of risk (λ) and cash-flows' growth prospects (α) are also needed. I assigned the value 0.6 at the market price of risk (λ), considering the range [0.4, 0.8] in the comparative static analysis, and 5% at the cash-flows growth prospects for the standard case, analysing the range [2%, 8%] respectively for the ADV and FAV market conditions. The bankruptcy costs were defined as a fraction ε of the asset value at default and I set this value at 45%[41]. Concerning the tax rate τ, I set a value of 35%, that is more in line with the European level of taxation. Helberg and Lindset (2014) fixed it at 28% while Sundaresan and Wang (2017) at 15%. However, also in this case I tested for a wide range of values in order to understand the robustness of the general results. The same test has been done for the insurance premium rate, fixed at $0,10\%$ with a range that went from [0.05%, 0.15%]. This parameter was imposed following Helberg & Lindset (2014) who set a value close to the average value observed by Demirgüç-Kunt et al. (2005) for the majority of relevant countries. Finally, the World Bank's 2011–2012 Bank

[41] This value includes the indirect costs such as the expenses incurred in the liquidation and sale of assets, losses associated with forced liquidation, etc.

Regulation and Supervision Survey (BRSS)[42] found that, for banks in the relevant sample of countries, the ratio between insured deposits and assets, on average, was around 35%. For this reason, I set the Deposits/Asset ratio at 35% for a commercial bank, bringing this ratio at 0% when the case of the Investment bank is analysed. The aim of this double analysis is to understand the main differences between the two distinct banks, that are subject to the same resolution regimes and capital requirements.

C. Comparative Static Analysis

This analysis allows to understand the first order effects of model's key parameters variations as the risk-free rate, asset volatility and growth prospects of cash-flows.

At the end of these comments are shown the most important tables[43] that follow this structure:

- on the central columns are presented the results for the standard base case;
- on the left columns are presented the results obtained for a low value of the parameter analysed, keeping constant all the others (STD);
- on the right columns are presented the results obtained for a low value of the parameter analysed, keeping constant all the others (STD).

This structure has been used for each parameters' analysis, according to the range's values described in table 1. By construction, all the central columns are the same. Moreover, the tables are separated according to the deposit/asset ratio, used to distinguish the two types of banks: commercial (D/A=35%) and investment (D/A=0%) bank.

Looking at the results of the overall tables, also considering all the cases not reported for space constraint, it is possible to observe that in the frameworks whit a positive probability of government intervention the higher are the markets' beliefs (p) concerning the realization

[42] The survey is presented and examined in Ĉihák et al. (2012).
[43] The missing tables are evailable on request.

of this event, the higher is the level of leverage for both types of bank. If the market beliefs are sufficiently large (50% or more) any differences, in terms of total leverage, boundaries' level and regulatory capital, between investment banks and commercial banks disappear (table 10).

These effects are widely mitigated when a minimum Cet1 capital is also required (table 11) or when the bail-in framework is in force. Indeed, when a stringent control on the minimum Cet1 capital is imposed, shareholders increase the level of indebtedness only if the market's beliefs on government intervention are very high, more than those needed when a relaxed total Tier1 capital is required. The reason of this result is that the absence of control on the minimum Cet1 capital increases the shareholders' incentive to issue a great amount of bail-inable bonds. In this way, shareholders not only benefit from the public subsidy on the U-bond but also from the reduction on the capital requirement's cost, substituting part of the Cet1 with the cheaper AT1 capital. Moreover, even if it is a less important value driver, they also generate a high tax shield.

When the minimum 4.5% of Cet1 is required, the possibility to substitute part of this regulatory capital with the cheaper AT1 vanishes and the incentive to issue the costly U-bond drastically reduces.

Looking at the general results for the Investment bank, the indeterminacy of the mix financing strategy is a robust result because it holds for any combination of the parameters' value used in the analysis. As said in the previous paragraph, the main value driver in the bail-out framework is only the external value generated by the implicit government guarantee. Indeed, if it is high enough, it leads to the corner solution where the bank brings the total leverage at maximum and the regulatory capital at minimum. For the commercial bank, under this framework and imposing only a relaxed total Tier1 capital requirement, to a high level of cash-flows risk (table 6) corresponds a high level of leverage that allows shareholders to take advantage of the possible upside, while shifting all the downside risk toward government; instead, in case of low level of volatility, since the probability of default decreases, shareholders prefer a low level of indebtedness in order to not share profits with bondholders, reducing the so called "expropriation effect". The same results hold for the growth prospects parameter (table 8). The higher are the growth prospects of cash-flows, the lower is the amount of debt raised from the market. This strategy allows shareholders to reduce the amount of cash-flows "expropriated" by debtholders. On the contrary, for a low level of growth prospect the amount of debt in the capital structure increases because shareholders exploit the implicit government guarantee to enhance bank value.

Once again, results differ imposing a control on the minimum Cet1 capital or when the bail-in regime is in force. In both cases, the main result is a mitigation of the incentive to increase leverage for both types of bank, in line with the “more skin in the game” principle, but it also causes a severe reduction on bank value, expecially when it is applied simultaneously with the bail-in resolution framework (tables 7 and 9). Obviously, given the presence of deposits in the capital structure, the level of total leverage for a commercial bank is always greater than that of an investment bank while the no-deposit leverage is always lower.

When the bail-in framework is in force, both types of bank held an endogenous optimal level of own capital greater than in the bail-out regime. This result confirm that a "credible" bail-in framework is able to mitigate the too-big-to-fail incentive of the banks, that decide to hold a greater amount of regulatory capital on their own, without any authority imposition. This is a crucial result because, since the global financial crisis of 2007-2009, both the European and U.S. regulators decided to raise capital requirement for banks, especially for those defined as systemically important. The recent MREL and TLAC standards are trying to assign a bank-specific regulatory capital for each bank. This bank-specific regulatory capital imposition is a key component of the regulatory framework that allows to manage the structural differences, in both the asset and liability sides, among banks. However, it should be managed carefully, considering also the different market conditions in which a bank could operate, not only in the present but also in the future (tables 2 and 3 discussed in the paper).

Table 4	Comparative statics for a Commercial Bank (D=35) that faces three different market risk-free rates, imposing only a Total Tier1 requirement																	
Total Tier1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=0% , p_2=30%			p_1=30% , p_2=30%			p_1=30% , p_2=0%		
Risk-free rate	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%
Bk V. C-Bond	16,0	22,5	25,9	43,2	34,8	34,9	0,0	0,0	3,8	0,0	0,0	3,8	3,0	5,9	9,3	3,0	5,9	9,3
Bk V. U-Bond	81,5	68,1	64,5	126,7	83,0	74,1	87,4	85,6	83,4	87,4	85,6	83,4	143,1	104,7	95,6	143,1	104,7	95,6
Tang. Equity	-32,5	-25,6	-25,4	-104,9	-52,8	-44,0	-22,4	-20,6	-22,2	-22,4	-20,6	-22,2	-81,1	-45,6	-39,9	-81,1	-45,6	-39,9
Mkt.V. C-Bond	16,0	22,5	25,9	43,2	34,8	34,9	0,0	0,0	3,8	0,0	0,0	3,8	3,0	5,9	9,3	3,0	5,9	9,3
Mkt.V. U-Bond	50,7	51,6	52,0	60,6	58,3	57,2	59,2	70,2	71,5	59,2	70,2	71,5	90,0	82,4	79,7	90,0	82,4	79,7
Mkt.V. Equity	24,5	22,8	21,4	3,6	10,9	12,4	28,8	25,3	23,1	28,8	25,3	23,1	8,5	13,7	14,2	8,5	13,7	14,2
Bank Value	126,2	131,8	134,2	142,3	139,0	139,4	122,9	130,4	133,3	122,9	130,4	133,3	136,5	137,0	138,2	136,5	137,0	138,2
Charter Value	26,2	31,8	34,2	42,3	39,0	39,4	22,9	30,4	33,3	22,9	30,4	33,3	36,5	37,0	38,2	36,5	37,0	38,2
%No-Dep. Lev	52,8	56,2	58,0	72,9	67,0	66,0	48,1	53,8	56,4	48,1	53,8	56,4	68,1	64,4	64,4	68,1	64,4	64,4
%Tot. Lev.	80,6	82,7	84,1	97,5	92,2	91,1	76,6	80,6	82,7	76,6	80,6	82,7	93,8	90,0	89,7	93,8	90,0	89,7
Barrier V_{EB}	-	-	-	-	-	-	50,2	58,7	63,1	50,2	58,7	63,1	73,7	70,8	72,2	73,7	70,8	72,2
Barrier V_{RB}	-	-	-	-	-	-	37,2	37,2	41,2	37,2	37,2	41,2	40,4	43,5	47,2	40,4	43,5	47,2
Barrier V_{ED}	54,3	61,2	64,8	83,2	74,3	74,4	15,4	17,4	20,3	15,4	17,4	20,3	16,5	20,3	23,1	16,5	20,3	23,1
Barrier V_{RD}	54,3	61,2	64,8	83,2	74,3	74,4	36,6	36,6	40,6	36,6	36,6	40,6	39,8	42,8	46,4	39,8	42,8	46,4
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	0,61	0,96	1,21	1,09	1,27	1,49	0,48	0,66	0,84	0,48	0,66	0,84	0,59	0,81	1,00	0,59	0,81	1,00
	Comparative statics for an Investment Bank (D=0) that faces three different market risk-free rates, imposing only a Total Tier1 requirement																	
Bk V. C-Bond	*	*	*	*	*	*	14,5	25,6	31,4	16,2	27,2	32,9	24,2	32,8	37,6	21,7	30,8	35,9
Bk V. U-Bond	*	*	*	*	*	*	104,2	94,0	90,2	103,0	92,7	88,9	153,7	111,7	101,6	155,2	113,2	103,0
Tang. Equity	-6,2	-9,5	-12,4	-53,2	-29,9	-27,1	-18,7	-19,6	-21,6	-19,2	-20,0	-21,8	-77,9	-44,5	-39,2	-76,9	-44,1	-38,9
Mkt.V. C-Bond	**	**	**	**	**	**	14,2	25,4	31,2	15,9	27,0	32,8	23,7	32,5	37,4	21,1	30,5	35,6
Mkt.V. U-Bond	**	**	**	**	**	**	79,3	79,4	78,6	78,0	78,0	77,3	104,3	90,4	86,2	106,4	92,1	87,8
Mkt.V. Equity	37,8	31,8	28,9	18,0	21,2	20,9	31,9	26,4	23,8	31,7	26,2	23,6	10,3	14,6	14,9	10,5	14,8	15,0
Bank Value	122,8	128,4	131,1	132,9	133,7	135,2	125,5	131,1	133,6	125,6	131,2	133,7	138,2	137,5	138,5	138,0	137,4	138,4
Charter Value	22,8	28,4	31,1	32,9	33,7	35,2	25,5	31,1	33,6	25,6	31,2	33,7	38,2	37,5	38,5	38,0	37,4	38,4
%No-Dep. Lev	69,2	75,3	78,0	86,5	84,1	84,6	74,6	79,9	82,2	74,8	80,0	82,3	92,6	89,4	89,3	92,4	89,2	89,1
%Tot. Lev.	69,2	75,3	78,0	86,5	84,1	84,6	74,6	79,9	82,2	74,8	80,0	82,3	92,6	89,4	89,3	92,4	89,2	89,1
Barrier V_{EB}	-	-	-	-	-	-	47,4	57,7	62,5	47,6	57,9	62,6	71,0	69,7	71,5	70,6	69,5	71,4
Barrier V_{RB}	-	-	-	-	-	-	15,5	27,2	33,4	17,3	29,0	35,0	25,8	34,9	40,0	23,1	32,8	38,2
Barrier V_{ED}	42,4	52,8	57,8	61,1	62,7	65,3	5,8	12,4	16,1	6,5	13,1	16,9	9,7	15,8	19,3	8,6	14,9	18,4
Barrier V_{RD}	42,4	52,8	57,8	61,1	62,7	65,3	15,2	26,8	32,9	17,0	28,5	34,5	25,4	34,3	39,4	22,7	32,3	37,6
%C-credit Spr.	**	**	**	**	**	**	0,02	0,03	0,03	0,02	0,02	0,03	0,02	0,03	0,03	0,03	0,03	0,04
%U-credit Spr.	**	**	**	**	**	**	0,31	0,55	0,73	0,32	0,57	0,75	0,47	0,71	0,89	0,46	0,69	0,87

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:

Tot. Book Value	106,2	109,5	112,4	153,2	129,9	127,1

** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

Table 5	Comparative statics for a Commercial Bank (D=35) that faces three different market risk-free rates, imposing both Tier1 and Cet1 requirements																	
Tier1 and Cet1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=0% , p_2=30%			p_1=30% , p_2=30%			p_1=30% , p_2=0%		
Risk-free rate	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%
Bk V. C-Bond	13,7	20,9	24,7	14,1	21,2	24,9	0,0	0,0	2,2	0,0	0,0	2,2	0,0	0,0	2,8	0,0	0,0	2,8
Bk V. U-Bond	0,8	0,9	1,0	0,8	0,9	1,0	7,6	18,0	20,6	7,6	18,0	20,6	9,4	19,1	21,0	9,4	19,1	21,0
Tang. Equity	50,5	43,2	39,3	50,2	42,9	39,2	57,4	47,0	42,2	57,4	47,0	42,2	55,6	45,9	41,2	55,6	45,9	41,2
Mkt.V. C-Bond	13,7	20,9	24,7	14,1	21,2	24,9	0,0	0,0	2,2	0,0	0,0	2,2	0,0	0,0	2,8	0,0	0,0	2,8
Mkt.V. U-Bond	0,5	0,7	0,8	0,6	0,8	0,8	4,9	16,8	19,8	4,9	16,8	19,8	7,4	18,2	20,3	7,4	18,2	20,3
Mkt.V. Equity	59,5	57,4	55,8	59,1	57,2	55,7	66,0	61,1	58,6	66,0	61,1	58,6	64,3	60,0	57,7	64,3	60,0	57,7
Bank Value	108,7	114,0	116,3	108,7	114,1	116,4	105,8	112,9	115,5	105,8	112,9	115,5	106,7	113,2	115,8	106,7	113,2	115,8
Charter Value	8,7	14,0	16,3	8,7	14,1	16,4	5,8	12,9	15,5	5,8	12,9	15,5	6,7	13,2	15,8	6,7	13,2	15,8
%No-Dep. Lev	13,1	19,0	21,9	13,5	19,2	22,1	4,6	14,8	19,0	4,6	14,8	19,0	6,9	16,1	20,0	6,9	16,1	20,0
%Tot. Lev.	45,3	49,7	52,0	45,7	49,9	52,2	37,7	45,9	49,3	37,7	45,9	49,3	39,7	47,0	50,2	39,7	47,0	50,2
Barrier V_{EB}	-	-	-	-	-	-	18,4	26,1	30,1	18,4	26,1	30,1	19,1	26,7	30,5	19,1	26,7	30,5
Barrier V_{RB}	-	-	-	-	-	-	44,6	55,5	60,6	44,6	55,5	60,6	46,5	56,7	61,5	46,5	56,7	61,5
Barrier V_{ED}	21,1	28,0	31,5	21,3	28,1	31,6	15,4	17,4	19,5	15,4	17,4	19,5	15,4	17,4	19,8	15,4	17,4	19,8
Barrier V_{RD}	51,8	59,5	63,5	52,2	59,8	63,7	36,6	36,6	38,9	36,6	36,6	38,9	36,6	36,6	39,6	36,6	36,6	39,6
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	0,54	0,87	1,10	0,33	0,57	0,73	0,56	0,22	0,21	0,56	0,22	0,21	0,28	0,15	0,16	0,28	0,15	0,16
	Comparative statics for an Investment Bank (D=0) that faces three different market risk-free rates, imposing both Tier1 and Cet1 requirements																	
Bk V. C-Bond	*	*	*	*	*	*	12,1	23,8	30,0	13,5	25,3	31,4	14,4	26,0	32,0	12,9	24,5	30,5
Bk V. U-Bond	*	*	*	*	*	*	25,5	27,4	26,9	24,4	26,1	25,6	26,0	26,9	26,1	27,3	28,2	27,4
Tang. Equity	69,3	55,6	49,7	65,9	53,0	47,4	62,4	48,8	43,1	62,1	48,6	42,9	59,6	47,1	41,9	59,8	47,3	42,0
Mkt.V. C-Bond	**	**	**	**	**	**	11,9	23,6	29,8	13,4	25,2	31,3	14,3	25,9	31,9	12,8	24,3	30,4
Mkt.V. U-Bond	**	**	**	**	**	**	24,0	26,4	26,1	22,9	25,1	24,8	24,8	26,0	25,5	26,0	27,4	26,8
Mkt.V. Equity	78,0	69,2	65,5	75,2	67,0	63,6	72,2	63,4	59,8	71,9	63,1	59,7	69,6	61,8	58,7	69,9	62,0	58,8
Bank Value	106,6	111,5	113,9	107,3	112,2	114,6	108,1	113,3	115,7	108,1	113,4	115,8	108,7	113,7	116,1	108,6	113,7	116,0
Charter Value	6,6	11,5	13,9	7,3	12,2	14,6	8,1	13,3	15,7	8,1	13,4	15,8	8,7	13,7	16,1	8,6	13,7	16,0
%No-Dep. Lev	26,8	37,9	42,5	30,0	40,3	44,5	33,2	44,1	48,3	33,5	44,3	48,5	35,9	45,7	49,4	35,7	45,5	49,3
%Tot. Lev.	26,8	37,9	42,5	30,0	40,3	44,5	33,2	44,1	48,3	33,5	44,3	48,5	35,9	45,7	49,4	35,7	45,5	49,3
Barrier V_{EB}	-	-	-	-	-	-	15,0	24,7	29,2	15,1	24,8	29,3	16,1	25,5	29,9	16,0	25,4	29,8
Barrier V_{RB}	-	-	-	-	-	-	39,4	53,6	59,5	39,7	53,9	59,7	42,3	55,4	60,9	42,1	55,2	60,7
Barrier V_{ED}	12,3	21,4	25,9	13,6	22,7	27,0	4,8	11,5	15,4	5,4	12,2	16,1	5,8	12,6	16,4	5,2	11,8	15,7
Barrier V_{RD}	32,1	46,4	52,7	35,7	49,2	55,1	12,7	24,9	31,4	14,2	26,5	32,9	15,1	27,3	33,5	13,5	25,6	32,0
%C-credit Spr.	**	**	**	**	**	**	0,02	0,02	0,03	0,01	0,02	0,02	0,01	0,01	0,02	0,01	0,02	0,02
%U-credit Spr.	**	**	**	**	**	**	0,06	0,12	0,16	0,06	0,12	0,16	0,05	0,09	0,12	0,05	0,09	0,12

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:

Tot. Book Value	30,70	44,36	50,32	34,13	47,03	52,62

** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

Table 6	Comparative statics for a Commercial Bank (D=35) with different cash-flows' volatilities, imposing only a Total Tier1 requirement																	
Total Tier1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=0% , p_2=30%			p_1=30% , p_2=30%			p_1=30% , p_2=0%		
C.F. Volatility	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%
Bk V. C-Bond	36,7	22,5	13,5	40,5	34,8	46,6	20,3	0,0	0,0	20,3	0,0	0,0	23,2	5,9	1,0	23,2	5,9	1,0
Bk V. U-Bond	58,0	68,1	87,5	61,1	83,0	148,2	74,0	85,6	91,2	74,0	85,6	91,2	77,8	104,7	164,5	77,8	104,7	164,5
Tang. Equity	-29,7	-25,6	-36,0	-36,5	-52,8	-129,8	-29,3	-20,6	-26,2	-29,3	-20,6	-26,2	-36,0	-45,6	-100,5	-36,0	-45,6	-100,5
Mkt.V. C-Bond	36,7	22,5	13,5	40,5	34,8	46,6	20,3	0,0	0,0	20,3	0,0	0,0	23,2	5,9	1,0	23,2	5,9	1,0
Mkt.V. U-Bond	52,5	51,6	52,2	54,7	58,3	62,7	68,5	70,2	58,3	68,5	70,2	58,3	71,6	82,4	97,1	71,6	82,4	97,1
Mkt.V. Equity	15,8	22,8	26,0	11,9	10,9	2,0	16,0	25,3	29,9	16,0	25,3	29,9	12,2	13,7	6,7	12,2	13,7	6,7
Bank Value	140,0	131,8	126,7	142,1	139,0	146,4	139,8	130,4	123,2	139,8	130,4	123,2	141,9	137,0	139,8	141,9	137,0	139,8
Charter Value	40,0	31,8	26,7	42,1	39,0	46,4	39,8	30,4	23,2	39,8	30,4	23,2	41,9	37,0	39,8	41,9	37,0	39,8
%No-Dep. Lev	63,7	56,2	51,9	67,0	67,0	74,7	63,5	53,8	47,3	63,5	53,8	47,3	66,8	64,4	70,2	66,8	64,4	70,2
%Tot. Lev.	88,7	82,7	79,5	91,6	92,2	98,6	88,6	80,6	75,7	88,6	80,6	75,7	91,4	90,0	95,2	91,4	90,0	95,2
Barrier V_{EB}	-	-	-	-	-	-	76,1	58,7	47,9	76,1	58,7	47,9	80,0	70,8	75,8	80,0	70,8	75,8
Barrier V_{RB}	-	-	-	-	-	-	58,9	37,2	37,2	58,9	37,2	37,2	61,9	43,5	38,3	61,9	43,5	38,3
Barrier V_{ED}	76,3	61,2	51,6	80,3	74,3	86,8	32,9	17,4	13,6	32,9	17,4	13,6	34,6	20,3	14,0	34,6	20,3	14,0
Barrier V_{RD}	76,3	61,2	51,6	80,3	74,3	86,8	58,0	36,6	36,6	58,0	36,6	36,6	60,9	42,8	37,7	60,9	42,8	37,7
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	0,32	0,96	2,03	0,35	1,27	4,09	0,24	0,66	1,69	0,24	0,66	1,69	0,26	0,81	2,08	0,26	0,81	2,08
	Comparative statics for an Investment Bank (D=0) with different cash-flows' volatilities, imposing only a Total Tier1 requirement																	
Bk V. C-Bond	*	*	*	*	*	*	50,5	25,6	12,3	51,5	27,2	14,0	54,2	32,8	22,7	53,1	30,8	20,0
Bk V. U-Bond	*	*	*	*	*	*	79,5	94,0	107,3	78,5	92,7	106,1	82,5	111,7	172,7	83,5	113,2	174,2
Tang. Equity	-23,9	-9,5	-6,3	-29,8	-29,9	-66,2	-30,0	-19,6	-19,6	-30,1	-20,0	-20,1	-36,7	-44,5	-95,4	-36,6	-44,1	-94,2
Mkt.V. C-Bond	**	**	**	**	**	**	50,4	25,4	12,0	51,5	27,0	13,7	54,1	32,5	22,0	53,0	30,5	19,3
Mkt.V. U-Bond	**	**	**	**	**	**	74,1	79,4	79,0	73,1	78,0	77,7	76,4	90,4	109,4	77,4	92,1	111,7
Mkt.V. Equity	20,0	31,8	39,2	16,4	21,2	15,9	16,3	26,4	33,2	16,2	26,2	33,0	12,4	14,6	8,1	12,5	14,8	8,3
Bank Value	138,9	128,4	121,5	140,7	133,7	133,7	140,8	131,1	124,2	140,8	131,2	124,3	142,9	137,5	139,6	142,9	137,4	139,3
Charter Value	38,9	28,4	21,5	40,7	33,7	33,7	40,8	31,1	24,2	40,8	31,2	24,3	42,9	37,5	39,6	42,9	37,4	39,3
%No-Dep. Lev	85,6	75,3	67,8	88,3	84,1	88,1	88,4	79,9	73,3	88,5	80,0	73,5	91,3	89,4	94,2	91,3	89,2	94,0
%Tot. Lev.	85,6	75,3	67,8	88,3	84,1	88,1	88,4	79,9	73,3	88,5	80,0	73,5	91,3	89,4	94,2	91,3	89,2	94,0
Barrier V_{EB}	-	-	-	-	-	-	75,8	57,7	45,0	75,8	57,9	45,2	79,7	69,7	73,5	79,6	69,5	73,0
Barrier V_{RB}	-	-	-	-	-	-	53,7	27,2	13,1	54,8	29,0	14,8	57,6	34,9	24,1	56,5	32,8	21,2
Barrier V_{ED}	72,2	52,8	40,0	75,7	62,7	62,5	29,4	12,4	4,6	30,0	13,1	5,2	31,6	15,8	8,5	30,9	14,9	7,5
Barrier V_{RD}	72,2	52,8	40,0	75,7	62,7	62,5	52,9	26,8	12,9	54,0	28,5	14,6	56,7	34,3	23,8	55,6	32,3	20,9
%C-credit Spr.	**	**	**	**	**	**	0,01	0,03	0,08	0,00	0,02	0,06	0,00	0,03	0,09	0,01	0,03	0,11
%U-credit Spr.	**	**	**	**	**	**	0,22	0,55	1,07	0,22	0,57	1,10	0,24	0,71	1,73	0,24	0,69	1,68
*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:																		
Tot. Book Value	123,9	109,5	106,3	129,9	129,9	166,2												
** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.																		

Table 7	Comparative statics for a Commercial Bank (D=35) with different cash-flows' volatilities, imposing both Tier1 and Cet1 requirements																	
Tier1 and Cet1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=0% , p_2=30%			p_1=30% , p_2=30%			p_1=30% , p_2=0%		
C.F. Volatility	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%
Bk V. C-Bond	36,3	20,9	10,4	36,3	21,2	10,6	19,8	0,0	0,0	19,8	0,0	0,0	20,0	0,0	0,0	20,0	0,0	0,0
Bk V. U-Bond	1,1	0,9	0,7	1,1	0,9	0,7	17,1	18,0	5,0	17,1	18,0	5,0	17,2	19,1	6,6	17,2	19,1	6,6
Tang. Equity	27,6	43,2	53,9	27,5	42,9	53,7	28,1	47,0	60,0	28,1	47,0	60,0	27,9	45,9	58,4	27,9	45,9	58,4
Mkt.V. C-Bond	36,3	20,9	10,4	36,3	21,2	10,6	19,8	0,0	0,0	19,8	0,0	0,0	20,0	0,0	0,0	20,0	0,0	0,0
Mkt.V. U-Bond	1,0	0,7	0,5	1,1	0,8	0,5	16,9	16,8	1,9	16,9	16,8	1,9	17,0	18,2	4,4	17,0	18,2	4,4
Mkt.V. Equity	49,7	57,4	62,8	49,6	57,2	62,6	50,1	61,1	68,7	50,1	61,1	68,7	49,9	60,0	67,2	49,9	60,0	67,2
Bank Value	122,0	114,0	108,7	122,0	114,1	108,7	121,8	112,9	105,6	121,8	112,9	105,6	121,9	113,2	106,5	121,9	113,2	106,5
Charter Value	22,0	14,0	8,7	22,0	14,1	8,7	21,8	12,9	5,6	21,8	12,9	5,6	21,9	13,2	6,5	21,9	13,2	6,5
%No-Dep. Lev	30,6	19,0	10,0	30,7	19,2	10,2	30,1	14,8	1,8	30,1	14,8	1,8	30,3	16,1	4,1	30,3	16,1	4,1
%Tot. Lev.	59,3	49,7	42,2	59,4	49,9	42,4	58,8	45,9	35,0	58,8	45,9	35,0	59,0	47,0	36,9	59,0	47,0	36,9
Barrier V_{EB}	-	-	-	-	-	-	42,6	26,1	15,5	42,6	26,1	15,5	42,7	26,7	16,1	42,7	26,7	16,1
Barrier V_{RB}	-	-	-	-	-	-	75,3	55,5	41,9	75,3	55,5	41,9	75,5	56,7	43,6	75,5	56,7	43,6
Barrier V_{ED}	42,9	28,0	17,8	42,9	28,1	17,9	32,6	17,4	13,6	32,6	17,4	13,6	32,7	17,4	13,6	32,7	17,4	13,6
Barrier V_{RD}	75,8	59,5	48,3	75,9	59,8	48,5	57,4	36,6	36,6	57,4	36,6	36,6	57,5	36,6	36,6	57,5	36,6	36,6
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	0,30	0,87	1,75	0,20	0,57	1,05	0,04	0,22	4,76	0,04	0,22	4,76	0,03	0,15	1,54	0,03	0,15	1,54
	Comparative statics for an Investment Bank (D=0) with different cash-flows' volatilities, imposing both Tier1 and Cet1 requirements																	
Bk V. C-Bond	*	*	*	*	*	*	49,9	23,8	9,8	51,0	25,3	11,1	51,2	26,0	12,0	50,1	24,5	10,6
Bk V. U-Bond	*	*	*	*	*	*	21,6	27,4	24,3	20,6	26,1	23,3	20,7	26,9	25,2	21,7	28,2	26,4
Tang. Equity	33,3	55,6	72,7	32,0	53,0	69,1	28,5	48,8	65,9	28,4	48,6	65,6	28,1	47,1	62,8	28,2	47,3	63,1
Mkt.V. C-Bond	**	**	**	**	**	**	49,9	23,6	9,6	50,9	25,2	11,0	51,1	25,9	11,9	50,1	24,3	10,4
Mkt.V. U-Bond	**	**	**	**	**	**	21,4	26,4	22,8	20,5	25,1	21,7	20,6	26,0	23,9	21,5	27,4	25,0
Mkt.V. Equity	55,5	69,2	80,3	54,4	67,0	77,3	51,2	63,4	74,5	51,1	63,1	74,3	50,9	61,8	71,8	50,9	62,0	72,0
Bank Value	120,9	111,5	105,5	121,3	112,2	106,3	122,5	113,3	106,9	122,5	113,4	107,0	122,6	113,7	107,5	122,5	113,7	107,5
Charter Value	20,9	11,5	5,5	21,3	12,2	6,3	22,5	13,3	6,9	22,5	13,4	7,0	22,6	13,7	7,5	22,5	13,7	7,5
%No-Dep. Lev	54,1	37,9	23,9	55,2	40,3	27,2	58,2	44,1	30,3	58,3	44,3	30,6	58,5	45,7	33,3	58,4	45,5	33,0
%Tot. Lev.	54,1	37,9	23,9	55,2	40,3	27,2	58,2	44,1	30,3	58,3	44,3	30,6	58,5	45,7	33,3	58,4	45,5	33,0
Barrier V_{EB}	-	-	-	-	-	-	41,7	24,7	12,8	41,8	24,8	12,9	41,9	25,5	14,0	41,9	25,4	13,9
Barrier V_{RB}	-	-	-	-	-	-	74,9	53,6	35,7	75,0	53,9	36,0	75,3	55,4	38,9	75,2	55,2	38,7
Barrier V_{ED}	38,9	21,4	10,3	39,6	22,7	11,6	29,1	11,5	3,7	29,7	12,2	4,2	29,8	12,6	4,5	29,2	11,8	4,0
Barrier V_{RD}	69,8	46,4	28,6	71,2	49,2	32,4	52,3	24,9	10,2	53,4	26,5	11,7	53,6	27,3	12,6	52,5	25,6	11,1
%C-credit Spr.	**	**	**	**	**	**	0,00	0,02	0,06	0,00	0,02	0,05	0,00	0,01	0,04	0,00	0,02	0,04
%U-credit Spr.	**	**	**	**	**	**	0,03	0,12	0,20	0,03	0,12	0,21	0,02	0,09	0,16	0,02	0,09	0,16

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:

Tot. Book Value	66,67	44,36	27,33	67,97	47,03	30,90

** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

Table 8	Comparative statics for a Commercial Bank (D=35) with different cash-flows' growth prospects, imposing only a Total Tier1 requirement																	
Total Tier1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=0% , p_2=30%			p_1=30% , p_2=30%			p_1=30% , p_2=0%		
C.F. Growth P.	4%	5%	6%	4%	5%	6%	4%	5%	6%	4%	5%	6%	4%	5%	6%	4%	5%	6%
Bk V. C-Bond	16,4	22,5	29,0	39,4	34,8	36,0	0,0	0,0	8,4	0,0	0,0	8,4	1,6	5,9	13,0	1,6	5,9	13,0
Bk V. U-Bond	79,0	68,1	61,8	114,7	83,0	68,6	87,7	85,6	80,2	87,7	85,6	80,2	134,6	104,7	89,0	134,6	104,7	89,0
Tang. Equity	-30,4	-25,6	-25,8	-89,1	-52,8	-39,6	-22,7	-20,6	-23,6	-22,7	-20,6	-23,6	-71,2	-45,6	-37,0	-71,2	-45,6	-37,0
Mkt.V. C-Bond	16,4	22,5	29,0	39,4	34,8	36,0	0,0	0,0	8,4	0,0	0,0	8,4	1,6	5,9	13,0	1,6	5,9	13,0
Mkt.V. U-Bond	51,9	51,6	51,7	61,7	58,3	55,9	62,4	70,2	70,5	62,4	70,2	70,5	90,6	82,4	76,8	90,6	82,4	76,8
Mkt.V. Equity	25,0	22,8	19,8	5,7	10,9	12,7	28,4	25,3	21,0	28,4	25,3	21,0	10,3	13,7	14,0	10,3	13,7	14,0
Bank Value	128,4	131,8	135,6	141,8	139,0	139,6	125,8	130,4	134,9	125,8	130,4	134,9	137,5	137,0	138,8	137,5	137,0	138,8
Charter Value	28,4	31,8	35,6	41,8	39,0	39,6	25,8	30,4	34,9	25,8	30,4	34,9	37,5	37,0	38,8	37,5	37,0	38,8
%No-Dep. Lev	53,2	56,2	59,6	71,3	67,0	65,8	49,6	53,8	58,5	49,6	53,8	58,5	67,1	64,4	64,7	67,1	64,4	64,7
%Tot. Lev.	80,5	82,7	85,4	96,0	92,2	90,9	77,4	80,6	84,4	77,4	80,6	84,4	92,5	90,0	89,9	92,5	90,0	89,9
Barrier V_{EB}	-	-	-	-	-	-	51,5	58,7	66,9	51,5	58,7	66,9	71,7	70,8	74,1	71,7	70,8	74,1
Barrier V_{RB}	-	-	-	-	-	-	37,2	37,2	46,1	37,2	37,2	46,1	38,9	43,5	51,1	38,9	43,5	51,1
Barrier V_{ED}	54,7	61,2	68,1	79,1	74,3	75,6	15,0	17,4	23,9	15,0	17,4	23,9	15,7	20,3	26,4	15,7	20,3	26,4
Barrier V_{RD}	54,7	61,2	68,1	79,1	74,3	75,6	36,6	36,6	45,4	36,6	36,6	45,4	38,3	42,8	50,3	38,3	42,8	50,3
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	1,56	0,96	0,58	2,58	1,27	0,68	1,22	0,66	0,41	1,22	0,66	0,41	1,45	0,81	0,48	1,45	0,81	0,48
	Comparative statics for an Investment Bank (D=0) with different cash-flows' growth prospects, imposing only a Total Tier1 requirement																	
Bk V. C-Bond	*	*	*	*	*	*	16,4	25,6	36,6	18,1	27,2	38,0	25,6	32,8	42,0	23,1	30,8	40,5
Bk V. U-Bond	*	*	*	*	*	*	102,0	94,0	87,1	100,8	92,7	85,9	142,5	111,7	95,0	144,0	113,2	96,3
Tang. Equity	-6,3	-9,5	-15,3	-46,0	-29,9	-26,6	-18,4	-19,6	-23,6	-18,9	-20,0	-23,8	-68,0	-44,5	-37,0	-67,2	-44,1	-36,8
Mkt.V. C-Bond	**	**	**	**	**	**	16,1	25,4	36,4	17,8	27,0	37,8	25,0	32,5	41,8	22,6	30,5	40,3
Mkt.V. U-Bond	**	**	**	**	**	**	79,5	79,4	77,7	78,1	78,0	76,4	101,0	90,4	83,2	103,0	92,1	84,6
Mkt.V. Equity	36,7	31,8	26,4	19,2	21,2	20,0	30,9	26,4	21,6	30,7	26,2	21,5	11,6	14,6	14,6	11,9	14,8	14,7
Bank Value	123,8	128,4	133,3	132,7	133,7	136,6	126,5	131,1	135,7	126,6	131,2	135,8	137,6	137,5	139,6	137,4	137,4	139,5
Charter Value	23,8	28,4	33,3	32,7	33,7	36,6	26,5	31,1	35,7	26,6	31,2	35,8	37,6	37,5	39,6	37,4	37,4	39,5
%No-Dep. Lev	70,3	75,3	80,2	85,5	84,1	85,4	75,6	79,9	84,1	75,8	80,0	84,1	91,6	89,4	89,6	91,4	89,2	89,5
%Tot. Lev.	70,3	75,3	80,2	85,5	84,1	85,4	75,6	79,9	84,1	75,8	80,0	84,1	91,6	89,4	89,6	91,4	89,2	89,5
Barrier V_{EB}	-	-	-	-	-	-	49,2	57,7	66,3	49,4	57,9	66,4	69,9	69,7	73,5	69,5	69,5	73,4
Barrier V_{RB}	-	-	-	-	-	-	17,4	27,2	38,9	19,2	29,0	40,4	27,2	34,9	44,7	24,6	32,8	43,1
Barrier V_{ED}	44,2	52,8	61,9	60,7	62,7	68,0	6,8	12,4	19,6	7,5	13,1	20,4	10,6	15,8	22,5	9,6	14,9	21,7
Barrier V_{RD}	44,2	52,8	61,9	60,7	62,7	68,0	17,1	26,8	38,3	18,9	28,5	39,8	26,8	34,3	44,0	24,2	32,3	42,4
%C-credit Spr.	**	**	**	**	**	**	0,06	0,03	0,01	0,05	0,02	0,01	0,06	0,03	0,01	0,07	0,03	0,02
%U-credit Spr.	**	**	**	**	**	**	0,85	0,55	0,36	0,87	0,57	0,37	1,23	0,71	0,43	1,20	0,69	0,42

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:

Tot. Book Value	106,3	109,5	115,3	146,0	129,9	126,6

** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

Table 9	Comparative statics for a Commercial Bank (D=35) with different cash-flows' growth prospects, imposing both Tier1 and Cet1 requirements																	
Tier1 and Cet1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=30%			p_1=0% , p_2=0%			p_1=0% , p_2=30%			p_1=30% , p_2=30%			p_1=30% , p_2=0%		
C.F. Growth P.	4%	5%	6%	4%	5%	6%	4%	5%	6%	4%	5%	6%	4%	5%	6%	4%	5%	6%
Bk V. C-Bond	14,0	20,9	28,1	14,3	21,2	28,3	0,0	0,0	7,1	0,0	0,0	7,1	0,0	0,0	7,6	0,0	0,0	7,6
Bk V. U-Bond	0,8	0,9	1,0	0,8	0,9	1,0	9,6	18,0	20,0	9,6	18,0	20,0	11,0	19,1	20,2	11,0	19,1	20,2
Tang. Equity	50,2	43,2	35,9	49,9	42,9	35,7	55,4	47,0	37,9	55,4	47,0	37,9	54,0	45,9	37,2	54,0	45,9	37,2
Mkt.V. C-Bond	14,0	20,9	28,1	14,3	21,2	28,3	0,0	0,0	7,1	0,0	0,0	7,1	0,0	0,0	7,6	0,0	0,0	7,6
Mkt.V. U-Bond	0,5	0,7	0,9	0,6	0,8	0,9	7,3	16,8	19,3	7,3	16,8	19,3	9,3	18,2	19,7	9,3	18,2	19,7
Mkt.V. Equity	60,9	57,4	53,8	60,6	57,2	53,7	65,9	61,1	55,8	65,9	61,1	55,8	64,6	60,0	55,1	64,6	60,0	55,1
Bank Value	110,4	114,0	117,8	110,5	114,1	117,8	108,2	112,9	117,2	108,2	112,9	117,2	108,9	113,2	117,4	108,9	113,2	117,4
Charter Value	10,4	14,0	17,8	10,5	14,1	17,8	8,2	12,9	17,2	8,2	12,9	17,2	8,9	13,2	17,4	8,9	13,2	17,4
%No-Dep. Lev	13,1	19,0	24,6	13,5	19,2	24,7	6,7	14,8	22,5	6,7	14,8	22,5	8,5	16,1	23,3	8,5	16,1	23,3
%Tot. Lev.	44,8	49,7	54,3	45,2	49,9	54,5	39,1	45,9	52,4	39,1	45,9	52,4	40,7	47,0	53,1	40,7	47,0	53,1
Barrier V_{EB}	-	-	-	-	-	-	19,0	26,1	33,9	19,0	26,1	33,9	19,6	26,7	34,3	19,6	26,7	34,3
Barrier V_{RB}	-	-	-	-	-	-	46,7	55,5	65,0	46,7	55,5	65,0	48,2	56,7	65,8	48,2	56,7	65,8
Barrier V_{ED}	21,2	28,0	35,0	21,3	28,1	35,1	15,0	17,4	23,2	15,0	17,4	23,2	15,0	17,4	23,5	15,0	17,4	23,5
Barrier V_{RD}	52,1	59,5	67,1	52,4	59,8	67,3	36,6	36,6	44,1	36,6	36,6	44,1	36,6	36,6	44,6	36,6	36,6	44,6
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	1,37	0,87	0,54	0,86	0,57	0,36	0,96	0,22	0,10	0,96	0,22	0,10	0,55	0,15	0,08	0,55	0,15	0,08
	Comparative statics for an Investment Bank (D=0) with different cash-flows' growth prospects, imposing both Tier1 and Cet1 requirements																	
Bk V. C-Bond	*	*	*	*	*	*	14,0	23,8	35,4	15,5	25,3	36,8	16,4	26,0	37,2	14,8	24,5	35,9
Bk V. U-Bond	*	*	*	*	*	*	26,2	27,4	25,9	25,0	26,1	24,7	26,4	26,9	25,0	27,8	28,2	26,3
Tang. Equity	66,7	55,6	44,9	63,4	53,0	42,9	59,8	48,8	38,7	59,5	48,6	38,5	57,2	47,1	37,8	57,4	47,3	37,9
Mkt.V. C-Bond	**	**	**	**	**	**	13,8	23,6	35,3	15,3	25,2	36,7	16,2	25,9	37,1	14,7	24,3	35,8
Mkt.V. U-Bond	**	**	**	**	**	**	24,8	26,4	25,3	23,6	25,1	24,1	25,3	26,0	24,6	26,6	27,4	25,8
Mkt.V. Equity	76,4	69,2	62,5	73,6	67,0	60,9	70,4	63,4	57,2	70,2	63,1	57,0	68,1	61,8	56,3	68,3	62,0	56,4
Bank Value	107,4	111,5	115,9	108,2	112,2	116,5	109,0	113,3	117,7	109,1	113,4	117,8	109,6	113,7	118,0	109,5	113,7	117,9
Charter Value	7,4	11,5	15,9	8,2	12,2	16,5	9,0	13,3	17,7	9,1	13,4	17,8	9,6	13,7	18,0	9,5	13,7	17,9
%No-Dep. Lev	28,9	37,9	46,1	32,0	40,3	47,8	35,4	44,1	51,4	35,7	44,3	51,6	37,9	45,7	52,3	37,6	45,5	52,2
%Tot. Lev.	28,9	37,9	46,1	32,0	40,3	47,8	35,4	44,1	51,4	35,7	44,3	51,6	37,9	45,7	52,3	37,6	45,5	52,2
Barrier V_{EB}	-	-	-	-	-	-	16,7	24,7	32,9	16,8	24,8	33,0	17,8	25,5	33,4	17,7	25,4	33,3
Barrier V_{RB}	-	-	-	-	-	-	42,1	53,6	64,2	42,4	53,9	64,4	44,8	55,4	65,2	44,6	55,2	65,0
Barrier V_{ED}	13,8	21,4	29,6	15,2	22,7	30,7	5,8	11,5	19,0	6,5	12,2	19,7	6,8	12,6	20,0	6,2	11,8	19,2
Barrier V_{RD}	34,8	46,4	57,7	38,3	49,2	59,8	14,7	24,9	37,1	16,2	26,5	38,5	17,2	27,3	39,0	15,5	25,6	37,6
%C-credit Spr.	**	**	**	**	**	**	0,04	0,02	0,01	0,04	0,02	0,01	0,03	0,01	0,01	0,03	0,02	0,01
%U-credit Spr.	**	**	**	**	**	**	0,17	0,12	0,07	0,18	0,12	0,07	0,14	0,09	0,06	0,13	0,09	0,05

*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:

Tot. Book Value	33,26	44,36	55,14	36,56	47,03	57,14

** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.

Table 10	Comparative statics for a Commercial Bank (D=35) with different government bail-out expectations, imposing only a Total Tier1 requirement																	
Total Tier1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=...			p_1=0% , p_2=0%			p_1=0% , p_2=...			p_1=p_2=...			p_1=... , p_2=0%		
B-out Probability	-	-	-	10%	30%	50%	-	-	-	10%	30%	50%	10%	30%	50%	10%	30%	50%
Bk V. C-Bond	22,5	22,5	22,5	25,6	34,8	49,4	0,0	0,0	0,0	0,0	0,0	0,0	0,8	5,9	16,2	0,8	5,9	16,2
Bk V. U-Bond	68,1	68,1	68,1	71,9	83,0	100,5	85,6	85,6	85,6	85,6	85,6	85,6	91,1	104,7	131,8	91,1	104,7	131,8
Tang. Equity	-25,6	-25,6	-25,6	-32,6	-52,8	-84,8	-20,6	-20,6	-20,6	-20,6	-20,6	-20,6	-26,9	-45,6	-83,1	-26,9	-45,6	-83,1
Mkt.V. C-Bond	22,5	22,5	22,5	25,6	34,8	49,4	0,0	0,0	0,0	0,0	0,0	0,0	0,8	5,9	16,2	0,8	5,9	16,2
Mkt.V. U-Bond	51,6	51,6	51,6	53,6	58,3	63,7	70,2	70,2	70,2	70,2	70,2	70,2	74,2	82,4	93,3	74,2	82,4	93,3
Mkt.V. Equity	22,8	22,8	22,8	19,4	10,9	1,9	25,3	25,3	25,3	25,3	25,3	25,3	22,1	13,7	2,2	22,1	13,7	2,2
Bank Value	131,8	131,8	131,8	133,7	139,0	150,0	130,4	130,4	130,4	130,4	130,4	130,4	132,1	137,0	146,7	132,1	137,0	146,7
Charter Value	31,8	31,8	31,8	33,7	39,0	50,0	30,4	30,4	30,4	30,4	30,4	30,4	32,1	37,0	46,7	32,1	37,0	46,7
%No-Dep. Lev	56,2	56,2	56,2	59,3	67,0	75,4	53,8	53,8	53,8	53,8	53,8	53,8	56,8	64,4	74,6	56,8	64,4	74,6
%Tot. Lev.	82,7	82,7	82,7	85,5	92,2	98,7	80,6	80,6	80,6	80,6	80,6	80,6	83,3	90,0	98,5	83,3	90,0	98,5
Barrier V_{EB}	-	-	-	-	-	-	58,7	58,7	58,7	58,7	58,7	58,7	61,8	70,8	88,9	61,8	70,8	88,9
Barrier V_{RB}	-	-	-	-	-	-	37,2	37,2	37,2	37,2	37,2	37,2	38,0	43,5	54,5	38,0	43,5	54,5
Barrier V_{ED}	61,2	61,2	61,2	64,5	74,3	89,7	17,4	17,4	17,4	17,4	17,4	17,4	17,8	20,3	25,3	17,8	20,3	25,3
Barrier V_{RD}	61,2	61,2	61,2	64,5	74,3	89,7	36,6	36,6	36,6	36,6	36,6	36,6	37,4	42,8	53,6	37,4	42,8	53,6
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	0,96	0,96	0,96	1,03	1,27	1,73	0,66	0,66	0,66	0,66	0,66	0,66	0,68	0,81	1,24	0,68	0,81	1,24
	Comparative statics for an Investment Bank (D=0) with different government bail-out expectations, imposing only a Total Tier1 requirement																	
Bk V. C-Bond	*	*	*	*	*	*	25,6	25,6	25,6	26,1	27,2	28,5	27,5	32,8	43,0	27,0	30,8	38,5
Bk V. U-Bond	*	*	*	*	*	*	94,0	94,0	94,0	93,6	92,7	91,7	98,6	111,7	138,2	99,0	113,2	141,3
Tang. Equity	-9,5	-9,5	-9,5	-14,9	-29,9	-57,3	-19,6	-19,6	-19,6	-19,7	-20,0	-20,2	-26,1	-44,5	-81,2	-26,0	-44,1	-79,8
Mkt.V. C-Bond	**	**	**	45,8	**	53,4	25,4	25,4	25,4	25,9	27,0	28,4	27,2	32,5	42,6	26,7	30,5	37,9
Mkt.V. U-Bond	**	**	**	55,2	**	77,7	79,4	79,4	79,4	78,9	78,0	76,8	82,4	90,4	101,7	82,9	92,1	105,7
Mkt.V. Equity	31,8	31,8	31,8	28,8	21,2	9,7	26,4	26,4	26,4	26,3	26,2	26,1	23,1	14,6	2,8	23,1	14,8	3,1
Bank Value	128,4	128,4	128,4	129,8	133,7	140,9	131,1	131,1	131,1	131,1	131,2	131,2	132,8	137,5	147,1	132,7	137,4	146,7
Charter Value	28,4	28,4	28,4	29,8	33,7	40,9	31,1	31,1	31,1	31,1	31,2	31,2	32,8	37,5	47,1	32,7	37,4	46,7
%No-Dep. Lev	75,3	75,3	75,3	77,8	84,1	93,1	79,9	79,9	79,9	79,9	80,0	80,1	82,6	89,4	98,1	82,6	89,2	97,9
%Tot. Lev.	75,3	75,3	75,3	77,8	84,1	93,1	79,9	79,9	79,9	79,9	80,0	80,1	82,6	89,4	98,1	82,6	89,2	97,9
Barrier V_{EB}	-	-	-	-	-	-	57,7	57,7	57,7	57,8	57,9	58,0	60,8	69,7	87,4	60,8	69,5	86,8
Barrier V_{RB}	-	-	-	-	-	-	27,2	27,2	27,2	27,8	29,0	30,4	29,2	34,9	45,8	28,7	32,8	40,9
Barrier V_{ED}	52,8	52,8	52,8	55,4	62,7	75,9	12,4	12,4	12,4	12,6	13,1	13,8	13,3	15,8	20,8	13,0	14,9	18,6
Barrier V_{RD}	52,8	52,8	52,8	51,9	62,7	60,5	26,8	26,8	26,8	27,3	28,5	29,9	28,8	34,3	45,0	28,2	32,3	40,3
%C-credit Spr.	**	**	**	0,20	**	0,19	0,03	0,03	0,03	0,03	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,05
%U-credit Spr.	**	**	**	0,59	**	0,87	0,55	0,55	0,55	0,56	0,57	0,58	0,59	0,71	1,08	0,58	0,69	1,01
*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:																		
Tot. Book Value	109,5	109,5	109,5	114,9	129,9	157,3												
** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.																		

Table 11	Comparative statics for a Commercial Bank (D=35) with different government bail-out expectations, imposing both Tier1 and Cet1 requirements																	
Tier1 and Cet1	Default regime			Bail-out regime			Credible Bail-in regime			Mixed b-in/out regime			Mixed b-in/out regime			Mixed b-in/out regime		
Requriement	B-out with p=0%			B-out with p=...			p_1=0% , p_2=0%			p_1=0% , p_2=...			p_1= p_2=...			p_1=... , p_2=0%		
B-out Probability	-	-	-	10%	30%	50%	-	-	-	10%	30%	50%	10%	30%	50%	10%	30%	50%
Bk V. C-Bond	20,9	20,9	20,9	21,0	21,2	21,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Bk V. U-Bond	0,9	0,9	0,9	0,9	0,9	0,9	18,0	18,0	18,0	18,0	18,0	18,0	18,3	19,1	20,0	18,3	19,1	20,0
Tang. Equity	43,2	43,2	43,2	43,1	42,9	42,8	47,0	47,0	47,0	47,0	47,0	47,0	46,7	45,9	45,0	46,7	45,9	45,0
Mkt.V. C-Bond	20,9	20,9	20,9	21,0	21,2	21,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Mkt.V. U-Bond	0,7	0,7	0,7	0,7	0,8	0,8	16,8	16,8	16,8	16,8	16,8	16,8	17,2	18,2	19,3	17,2	18,2	19,3
Mkt.V. Equity	57,4	57,4	57,4	57,3	57,2	57,0	61,1	61,1	61,1	61,1	61,1	61,1	60,8	60,0	59,2	60,8	60,0	59,2
Bank Value	114,0	114,0	114,0	114,1	114,1	114,1	112,9	112,9	112,9	112,9	112,9	112,9	113,0	113,2	113,5	113,0	113,2	113,5
Charter Value	14,0	14,0	14,0	14,1	14,1	14,1	12,9	12,9	12,9	12,9	12,9	12,9	13,0	13,2	13,5	13,0	13,2	13,5
%No-Dep. Lev	19,0	19,0	19,0	19,1	19,2	19,4	14,8	14,8	14,8	14,8	14,8	14,8	15,2	16,1	17,0	15,2	16,1	17,0
%Tot. Lev.	49,7	49,7	49,7	49,7	49,9	50,1	45,9	45,9	45,9	45,9	45,9	45,9	46,2	47,0	47,8	46,2	47,0	47,8
Barrier V_{EB}	-	-	-	-	-	-	26,1	26,1	26,1	26,1	26,1	26,1	26,3	26,7	27,1	26,3	26,7	27,1
Barrier V_{RB}	-	-	-	-	-	-	55,5	55,5	55,5	55,5	55,5	55,5	55,8	56,7	57,6	55,8	56,7	57,6
Barrier V_{ED}	28,0	28,0	28,0	28,0	28,1	28,2	17,4	17,4	17,4	17,4	17,4	17,4	17,4	17,4	17,4	17,4	17,4	17,4
Barrier V_{RD}	59,5	59,5	59,5	59,6	59,8	59,9	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6
%C-credit Spr.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
%U-credit Spr.	0,87	0,87	0,87	0,76	0,57	0,39	0,22	0,22	0,22	0,22	0,22	0,22	0,19	0,15	0,11	0,19	0,15	0,11
	Comparative statics for an Investment Bank (D=0) with different government bail-out expectations, imposing both Tier1 and Cet1 requirements																	
Bk V. C-Bond	*	*	*	*	*	*	23,8	23,8	23,8	24,3	25,3	26,6	24,5	26,0	27,9	24,0	24,5	25,0
Bk V. U-Bond	*	*	*	*	*	*	27,4	27,4	27,4	27,0	26,1	25,0	27,3	26,9	26,2	27,7	28,2	28,8
Tang. Equity	55,6	55,6	55,6	54,8	53,0	50,8	48,8	48,8	48,8	48,7	48,6	48,4	48,3	47,1	45,9	48,3	47,3	46,2
Mkt.V. C-Bond	**	**	**	**	**	**	23,6	23,6	23,6	24,1	25,2	26,5	24,3	25,9	27,8	23,8	24,3	24,9
Mkt.V. U-Bond	**	**	**	**	**	**	26,4	26,4	26,4	26,0	25,1	24,0	26,3	26,0	25,6	26,7	27,4	28,2
Mkt.V. Equity	69,2	69,2	69,2	68,6	67,0	65,1	63,4	63,4	63,4	63,3	63,1	63,0	62,8	61,8	60,7	62,9	62,0	60,9
Bank Value	111,5	111,5	111,5	111,7	112,2	112,8	113,3	113,3	113,3	113,3	113,4	113,4	113,4	113,7	114,1	113,4	113,7	114,0
Charter Value	11,5	11,5	11,5	11,7	12,2	12,8	13,3	13,3	13,3	13,3	13,4	13,4	13,4	13,7	14,1	13,4	13,7	14,0
%No-Dep. Lev	37,9	37,9	37,9	38,6	40,3	42,3	44,1	44,1	44,1	44,2	44,3	44,5	44,6	45,7	46,8	44,5	45,5	46,6
%Tot. Lev.	37,9	37,9	37,9	38,6	40,3	42,3	44,1	44,1	44,1	44,2	44,3	44,5	44,6	45,7	46,8	44,5	45,5	46,6
Barrier V_{EB}	-	-	-	-	-	-	24,7	24,7	24,7	24,7	24,8	24,9	25,0	25,5	26,1	24,9	25,4	26,0
Barrier V_{RB}	-	-	-	-	-	-	53,6	53,6	53,6	53,7	53,9	54,1	54,2	55,4	56,6	54,1	55,2	56,4
Barrier V_{ED}	21,4	21,4	21,4	21,8	22,7	23,7	11,5	11,5	11,5	11,7	12,2	12,8	11,8	12,6	13,4	11,6	11,8	12,1
Barrier V_{RD}	46,4	46,4	46,4	47,3	49,2	51,5	24,9	24,9	24,9	25,4	26,5	27,9	25,6	27,3	29,2	25,1	25,6	26,2
%C-credit Spr.	**	**	**	**	**	**	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,02	0,02	0,01
%U-credit Spr.	**	**	**	**	**	**	0,12	0,12	0,12	0,12	0,12	0,13	0,11	0,09	0,07	0,11	0,09	0,07
*Indeterminacy: any combination of the two bonds is optimal. The "Total Book Value" of the bonds issued is:																		
Tot. Book Value	44,36	44,36	44,36	45,18	47,03	49,20												
** It is impossible to determine because we cannot distinguish the amount issued for each category of bonds.																		

D. Proofs

D.1:

Given the following GBM for cash-flows,

$$\frac{dX}{X} = \alpha dt + \sigma dW \tag{28}$$

the after-tax asset value is given by:

$$V = \frac{X(1-\tau)}{r + \sigma\lambda - \alpha} \tag{29}$$

The payout rate ($\delta = r + \sigma\lambda - \alpha$) must be greater than zero and the instantaneous cash-flow of the assets δV is:

$$\delta V = X(1-\tau) \tag{30}$$

As explained in Sundaresan and Wang (2017), if the cash-flows follow a geometric Brownian motion with volatility σ, also the assets value follow the same stochastic process. Indeed, the after-tax assets value process, under the objective measure is given by:

$$\begin{aligned} dV/V + \delta dt &= (r + \sigma\lambda)\, dt + \sigma dW \\ \text{solving} &: \\ dV/V &= \alpha dt + \sigma dW \end{aligned} \tag{31}$$

while, the after-tax assets value process, under the risk neutral measure is given by:

$$dV/V = (r - \delta)\, dt + \sigma dW \tag{32}$$

D.2:

The value of the exponent γ_2 is given by:

$$\gamma_2 = -\left(\frac{\alpha - \sigma\lambda\rho}{\sigma^2} - \frac{1}{2}\right) - \sqrt[2]{\left(\frac{\alpha - \sigma\lambda\rho}{\sigma^2} - \frac{1}{2}\right)^2 + 2\frac{r}{\sigma^2}} < 0 \tag{33}$$

and it represents the negative root of the following quadratic equation on γ :

$$y(\gamma) = 0 \tag{34}$$

with:

$$y(\gamma) = \frac{1}{2}\sigma^2(\gamma)^2 + (\alpha - \sigma\lambda\rho - \frac{1}{2}\sigma^2)\ \gamma - r$$

D.3:

Given the after-tax assets value process, under the risk neutral measure:

$$dV/V = (r - \delta)\, dt + \sigma dW \tag{35}$$

let the liability on the general debt contract be b, the book value be B and the debt market value be $\mathcal{B}$. The pricing equation of the debt contract is:

$$\frac{1}{2}\sigma^2 V^2 \mathcal{B}^{''} + (r - \delta)V\mathcal{B}^{'} - r\mathcal{B} + b = 0 \tag{36}$$

where $\mathcal{B}'$ and $\mathcal{B}''$ are the first and the second derivatives of $\mathcal{B}$ with respect to V and $\delta > 0$.

Imposing the following two boundaries conditions and solving the ordinary differential equation (generated by Itô' s Lemma), the general debt formula for a perpetual debt contract is obtained:

- $\mathcal{B}(V = V_T^*) = \omega V_T^*$; at the desired general trigger T (default or bail-in event) the value of the debt contract is equal to a certain value, in this case it is proportional to V_T^* (it could be, for example, the post-bankruptcy value, net of taxes)

- $\lim_{V \longrightarrow +\infty} \frac{\mathcal{B}}{B} = 1$; the value of debt contract, for the asset value very far away from the trigger boundary, becomes a perpetuity equal to $B = \frac{b}{r}$, because $\left(\frac{V}{V_T^*}\right)^\gamma$ tends to zero.

Therefore, the general pricing formula for a perpetual debt contract is:

$$\mathcal{B} = B\left(1 - \left[\frac{V}{V_T^*}\right]^\gamma\right) + \omega V_T^* \left[\frac{V}{V_T^*}\right]^\gamma \tag{37}$$

where $\left[\frac{V}{V_T^*}\right]^\gamma$ is the value of a security that pays 1€ when the trigger event occurs (otherwise it pays nothing) and ωV_T^* is the value of the firm/bank at trigger event.

Let the liability on the insured deposits contract be $c_{dep} = Dr$, using this methodology it is possible to prove that, under the assumption of the model, the value of the insured deposits $\mathcal{D}$ is equal to:

$$\begin{aligned} \mathcal{D} &= \frac{c_{dep}}{r}\left(1 - \left[\frac{V}{V_D^*}\right]^\gamma\right) + \\ &+ \underbrace{D}_{\text{Reimbursement at default}} \left[\frac{V}{V_D^*}\right]^\gamma \\ \text{solving} &: \\ \mathcal{D} &= \frac{c_{dep}}{r} = D \end{aligned} \tag{38}$$

D.4: Proof of Theorem 1

Given the system of regultatory requirements:

$$\begin{cases} \underbrace{V_{RB} - [D + C + U]}_{CET1} = \underbrace{\psi}_{4.5\%} V_{RB} \\ \underbrace{V_{RB} - [D + C + U]}_{CET1} + \underbrace{\frac{u}{r}}_{AT1} = \underbrace{\beta}_{6\%} V_{RB} \end{cases}$$

The two barrier are equal for a unique value of U. By substitution:

$$\begin{cases} V_{RB} - [D + C + U] = \psi V_{RB} \\ \psi V_{RB} + U = \beta V_{RB} \end{cases}$$

$$\begin{cases} V_{RB} = \frac{[D+C+U]}{1-\psi} \\ V_{RB} = \frac{U}{\beta-\psi} \end{cases}$$

Imposing equality between the two boundaries it is possible to find the unique solution in terms of U-bond's book value:

$$\begin{aligned} \frac{U}{\beta - \psi} &= \frac{[D + C + U]}{1 - \psi} \\ \text{with some algebra} &: \\ U &= \frac{[D + C]}{1 - \beta} (\beta - \psi) \ : = \Delta \end{aligned} \tag{39}$$

Therefore, for any U-bond's book value greater or equal than Δ, fulfill the CET1 boundary is a sufficient condition to met also the Tier1 requirement. At the same time, for any U-bond's book value in the range $[0,\ \Delta)$ fulfill the Tier1 boundary condition is a sufficient condition to met also the CET1 requirement. For U-bond's book value equal to Δ the two boundaries coincide.

D.5: Proof of theorem 2

The pricing equation of the equity value S, before bail-in, was:

$$\frac{1}{2}\sigma^2 V^{\ 2}\mathcal{S}'' + (r-\delta)V\mathcal{S}' - \mathcal{S}r + \delta V - [c + u + D\,(r+\varphi)]\,(1-\tau) = 0 \tag{40}$$

where $\mathcal{S}^{'}$ and $\mathcal{S}^{''}$ are the first and second derivatives of $\mathcal{S}$ with respect to V.

Since the equity value depends on its dividend, it is affected by the liability structure. To derive the equity pricing formula two boundary conditions are needed:

- $\mathcal{S}(V = V_B^*) = 0$; the value of the equity cannot be negative, when the bail-in boundary is reached its value must be zero.

- $\lim_{V \longrightarrow +\infty} \frac{\mathcal{S}}{V-[(D+C+U)(1-\tau)]} = 1$;

Solving the ordinary differential equation (generated by Itô' s Lemma), with previous boundary conditions the following equity pricing equation is obtained[44]:

$$\mathcal{S} = V - (I + D + C + U)\,(1-\tau)\left(1 - \left[\frac{V}{V_B^*}\right]^{\gamma}\right) - V_B^*\left[\frac{V}{V_B^*}\right]^{\gamma} \tag{41}$$

The equity value obviously depends on the parameters involved in the formula but, it crucially depends on the bail-in boundary V_B^*, determined in Theorem 2 as the max$[V_{EB,}^*\ V_{RB}^*]$. While V_{RB}^* is explained in Theorem 1, the optimal endogenous bail-in boundary V_{EB}^* can be determined minimising the "negative part of the equity equation":

$$V_{EB}^* = \arg\min_{V_{EB}}\left(V_{EB} - (1-\tau)\,(I + D + C + U)\right)\left[\frac{V}{V_{EB}}\right]^{\gamma} \tag{42}$$

So:

$$\frac{\vartheta}{\vartheta V_{EB}}\left[\left(V_{EB} - (1-\tau)\,(I + D + C + U)\right)\left[\frac{V}{V_{EB}}\right]^{\gamma}\right] = 0 \tag{43}$$

[44]The same formula, expressed in EBITs terms, with its decomposition is presented in annex 6.

The optimal endogenous bail-in boundary, for shareholders, is:

$$V_{EB}^{*} = \frac{\gamma}{\gamma - 1} (I + D + C + U) (1 - \tau) \tag{44}$$

After reorganization, when V reaches the default trigger V_D^*, determined in Theorem 2 as the max$[V_{ED,}^{*}\ V_{RD}^{*}]$, also the "second" amount of equity is lost and the bank fails. Indeed, when $0 < V < V_D^*$ the equity value becomes negative and shareholders should inject new own capital in the capital structure. The presence of insured deposits, gives incentive to shareholders to early declare bankruptcy, leaving the firm to the debtholders, whom will face the bankruptcy costs. This represents a strategic decision that, also thanks to the protection of limited liability, allows them to maximise the value of equity. This is the so called real option value, that is lower in an investment bank due to the absence of deposits.

In order to evaluate the senior unsecured bond contract, I proceed by backward induction. First of all, I analysed the equity value for the new shareholders when V_B^* is reached and the bail-in tool is applicable. At that time, the U-bonds absorb losses (the restructuring costs) and are converted in to equity. With the same previous procedure, imposing the right boundary conditions, it is possible to evaluate the equity pricing equation (evaluated at the bail-in event) and the endogenous optimal default boundary V_{ED} , determined by the U-type bondholders.

The equity value, at bail-in, is equal to:

$$\hat{S} = V_B^* - (I + D + C) (1 - \tau) \left(1 - \left[\frac{V_B^*}{V_{ED}}\right]^{\gamma}\right) - V_{ED} \left[\frac{V_B^*}{V_{ED}}\right]^{\gamma}, \tag{45}$$

and minimising the "negative part of the equity equation at bail-in" the endogenous default boundary shows up:

$$V_{ED}^{*} = \frac{\gamma}{\gamma - 1} (I + D + C) (1 - \tau) \tag{46}$$

Using the pricing formulas provided in D.3 with the following boundaries conditions, the bonds pricing formulas for the bail-in regime are provided.

$$\begin{aligned} \omega V_T^* &= M \\ \omega V_T^* &= K \end{aligned} \tag{47}$$

where:

$$\begin{aligned} M &= \min\left[C;\ V_D(1-\varepsilon)\right]; \\ K &= \begin{cases} \left[\widehat{\mathcal{S}} - V_B\xi\right] & \text{if bail-in is feasible;} \\ \left[V_B\left(1-\varepsilon\right) - C - D\right]^+ & \text{otherwise.} \end{cases} \end{aligned}$$

For C-bond the trigger event is obviously the default one (so $V_T^* = V_D^*$), while for the U-bond the trigger event is the bail-in one (so $V_T^* = V_B^*$)

D.6: Proof of Theorem 3

First of all, the equity pricing formula and the optimal default barrier, are the same of those described in D.5 (and determined in Theorem 2). Indeed, equity value is not affected by the bank recovery and resolution regime in force, therefore shareholders do not care about the consequences at default.

$$S = V - (I + D + C + U)(1-\tau)\left(1 - \left[\frac{V}{V_D^*}\right]^\gamma\right) - V_D\left[\frac{V}{V_D^*}\right]^\gamma \tag{48}$$

with :

$$V_D^* = \max[V_{ED,}^*\ V_{RD}^*] \tag{49}$$

Instead, what really change is the pricing of both types of bond. Under the bail-out regime:

- with a probability equal to p, there is a government intervention at default;
- with a probability equal to $(1-p)$ there is not.

Therefore, p is defined as the risk adjusted market' s beliefs about the probability that, at default, the event "bail-out" takes place.

So, if $p = 1$ it means that government, if necessary, will reimburse the entire face value of the bonds, for sure. This condition implies that both bonds become risk-less and the market values coincide with book values. Using the pricing formulas provided in the D.3 with the following boundaries conditions, the bonds pricing formulas for the bail-out regime are provided.

$$\omega V_T^* = [pC + (1-p)M] \tag{50}$$

$$\omega V_T^* = [pU + (1-p)RAV]$$

where:

$$\begin{aligned} M &= \min\left[C;\ V_D(1-\varepsilon)\right], \\ RAV &= \min\left\{U;\ [V_D(1-\varepsilon) - C - D]^+\right\} \end{aligned}$$

For both types of bond the trigger event is only the default one (so $V_T^* = V_D^*$).

D.7: Proof of Theorem 4

Once again, the equity pricing formula and the optimal boundaries, are the same of those described in D.5 (and determined in Theorem 2). So:

$$\mathcal{S}=V-(I+D+C+U)(1-\tau)\left(1-\left[\frac{V}{V_D^*}\right]^{\gamma}\right)-V_D\left[\frac{V}{V_D^*}\right]^{\gamma} \tag{51}$$

with:

$$V_B^* = \max[V_{EB,}^*\ V_{RB}^*] \tag{52}$$

$$V_D^* = \max[V_{ED,}^*\ V_{RD}^*] \tag{53}$$

in this mixed resolution regime, when V reaches the bail-in trigger the original amount of equity is lost independently from the regulatory regime that will prevail; in fact, if the bail-in tool is applied the shareholders' equity are totally wiped out and the bank is restructured with the U-type bondholders that become the new bank's shareholders while, if the government intervention prevails only debtholders will be reimbursed after bank liquidation. Therefore, I defined $p_1 \in [0,1]$ as the risk adjusted market's beliefs concerning the probability of a government bail-out when the bail-in boundary is reached, while $p_2 \in [0,1]$ is defined as the risk adjusted market's beliefs concerning the probability of a government bail-out that occurs when the asset value of the restructured bank reaches the default boundary. By construction, if $p_1 = p_2 = 0$ the results are the same of the "credible" bail-in case discussed at paragraph 1.1 and derived in D.5, while for $p_1 \in [0,1]$ and $p_2 \in [0,1]$, with $p_1 = p_2 \neq 0$ and $p_1 = p_2 \neq 1$, the bonds pricing evaluation change.

Using the pricing formulas provided in the D.3 with the following boundary condition, the U-bond pricing formula for the mixed regime is provided.

$$\omega V_T^* = [p_1 U + (1-p_1)K] \tag{54}$$

where

$$K = \begin{cases} \left[\widehat{\mathcal{S}} - V_B \xi\right] & \text{if bail-in is feasible;} \\ \left[V_B\left(1-\varepsilon\right) - C - D\right]^{+} & \text{otherwise.} \end{cases}$$

The only trigger event for U-bond is obviously the bail-in one (so $V_T^* = V_B^* = V_D^*$), because whether there is either a government public bail-out or a private bail-in, the U-bond never reachs the second boundary of the model. For the C-bond there are two possible trigger events: they can be fully reimbursed either at the bail-in event (so $V_{T_1}^* = V_B^* = V_D^*$) or at the default event (so $V_{T_2}^* = V_D^* \neq V_B^*$). This complication modifies a bit the general bond pricing formula that becomes:

$$\mathcal{C} = C\left(1 - \left[\frac{V}{V_{T_1}^*}\right]^{\gamma}\left[\frac{V_{T_1}^*}{V_{T_2}^*}\right]^{\gamma}\right) + \omega V_{T_{1,2}}^* \left[\frac{V}{V_{T_1}^*}\right]^{\gamma}\left[\frac{V_{T_1}^*}{V_{T_2}^*}\right]^{\gamma} \tag{55}$$

where:

$$\begin{aligned} \omega V_{T_{1,2}}^* &= \left[\left(p_1 + p_2 - p_1 p_2\right) C + (1-p_1)(1-p_2)M\right] \\ \textit{and} &: \\ M &= \min\left[C;\ V_D(1-\varepsilon)\right], \end{aligned}$$

D.8:

Market value of equity in EBITs terms, and its decomposition in the key elements:

$$S(X) = \frac{X(1-\tau)}{r+\sigma\lambda\rho-\alpha} - (I+D+C+U)(1-\tau) + $$
$$-\left(\frac{X}{X_B^*}\right)^{\gamma}\left(\frac{X_B^*(1-\tau)}{r+\sigma\lambda\rho-\alpha} - (I+D+C+U)(1-\tau)\right)$$

$$\begin{aligned} S(X) = & \underbrace{\frac{X(1-\tau)}{r+\sigma\lambda\rho-\alpha}}_{\text{Asset value}} + \\ & + \underbrace{\tau\left[\left(1-\left(\frac{X}{X_B^*}\right)^{\gamma}\right)(I+D+C+U) + \left(\frac{X}{X_B^*}\right)^{\gamma}\frac{X_B^*}{r+\sigma\lambda\rho-\alpha}\right]}_{\text{Tax-shield (including also the present value of unpaid corporate taxes after bail-in)}} + \\ & -\left(\frac{X}{X_B^*}\right)^{\gamma_2}\left(\frac{X_B^*}{r+\sigma\lambda\rho-\alpha}\right) + \\ & \underbrace{-D\left(1-\left(\frac{X}{X_D^*}\right)^{\gamma}\right)}_{\text{Deposit cost}} - \underbrace{I\left(1-\left(\frac{X}{X_D^*}\right)^{\gamma}\right)}_{\text{Insurance premium cost}} + \\ & \underbrace{-C\left(1-\left(\frac{X}{X_D^*}\right)^{\gamma}\right)}_{\text{Covered bond cost}} - \underbrace{U\left(1-\left(\frac{X}{X_D^*}\right)^{\gamma}\right)}_{\text{Senior bond cost}} \end{aligned}$$