Bail-in vs bail-out:

Bank resolution and liability structure*

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Abstract

We study the optimal liability structure of a bank under different resolution regimes and capital requirements. We do so by developing a structural model, allowing for bail-in and default events triggered either endogenously or by an external regulator, for a bank holding insured deposits and issuing covered (non-bail-inable) and uncovered (bail-inable) debt. As opposed to a bail-out resolution regime, a credible bail-in resolution regime endogenously reduces leverage and mitigates default risk. A strict enforcement of the Common Equity Tier 1 (CET1) capital requirement, as introduced by the Basel III regulation, entails a dramatic reduction of the optimal bank leverage.

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1 Introduction

After the 2007-2008 financial crisis the bank liability structure has been under the spotlight of regulators, who have become acutely aware that public subsidies to large banks (e.g. Morgan and Stiroh (2005), Ueda and Weder di Mauro (2013), Li et al. (2013) and Santos (2014)) could prompt incentives towards conspicuous leverage (e.g. Gadanecz et al. (2008), Gropp et al. (2011), Brandao-Marques et al. (2018), DeYoung et al. (2013) and Afonso et al. (2015)). The 2010 Basel III global regulatory standards have introduced, among other measures, more stringent minimum capital requirements for financial institutions. In particular, institutions are required to have, at all times, a Common Equity Tier 1 (CET1) capital at least equal to 4.5% of the risk-weighted assets, as well as a Tier1 capital ratio at least equal to 6%. Additionally, in order to prevent further bank bail-outs at government expense, new significant rules on bank resolution in case of serious financial distress have been introduced.[1] Such rules have introduced the bail-in tool, which is applicable to systemically important institutions in case of violations of the aforementioned regulatory requirements on the CET1 or Tier1 capital ratios. A bail-in event entails the demise of the original shares and the conversion of bail-inable bonds into fresh equity. These regulations are complemented by the existence of deposit insurance schemes.

Our paper analyzes the joint impact of the resolution regime and of the regulatory capital requirements on the optimal liability structure of a bank, financed through equity, covered and uncovered debt, as well as deposits. We develop a continuous-time EBIT-based structural model of endogenous default, deriving closed-form pricing formulae for bank liabilities under four different resolution regimes: a *default* regime where there are neither bail-out-type government interventions nor bail-in, a *bail-out* regime where there is a strictly positive probability that the government intervenes in case of bank default, a *bail-in* regime where, if necessary, shareholders are wiped out and uncovered debt is converted into equity to keep

[1]See the Orderly Liquidation provision of the Dodd-Frank Act for the U.S., as well as the 2014 Bank Recovery and Resolution Directive (BRRD) and Single Resolution Mechanism (SRM) for the European Union.

the bank operating as a going concern, and, finally, a *mixed* regime, representing a bail-in regime which credibility is weakened by a strictly positive probability of a bail-out-type government intervention. Bail-in or default are triggered either endogenously by the current shareholders or exogenously by the regulator, which intervenes when the minimum capital requirements are not satisfied.

We model the minimum capital requirements taking into account the Basel III framework, in particular considering a case where the regulator imposes a minimum Tier1 capital ratio equal to 6%, and a more stringent case where the regulator additionally imposes a minimum CET1 capital ratio equal to 4.5%, which necessarily requires a significant amount of tangible equity in the capital structure. For what concerns the liability structure, we distinguish between the case of a commercial bank, where insured deposits account for a substantial fraction of the liability structure, and of an investment bank, where deposits represent a small fraction of the liabilities. The deposit insurance requires the payment of a premium, which is taken to be either fixed or endogenously fair (implying a zero net insurance value). The bank can issue covered debt, which is not bail-inable and does not contribute to the regulatory Tier1 capital, and uncovered debt, which instead is bail-inable and can be considered as part of the regulatory Tier1 capital.

We show that the resolution regime plays a crucial role in optimal debt structure decisions. This is especially true under the lighter Tier1 capital requirement. When there is a market belief of a possible government bail-out, the optimal leverage significantly increases, while credit spreads can even decrease. We find the expected present value of the government subsidy to be substantial. Under the bail-in regime, instead, the shareholders endogenously choose lower levels of leverage with respect to the bail-out regime, as default costs are transferred from the government to bank unsecured claimants, with a significant effect on the valuation of equity and debt. This restores the consistency of the market values of bank claims with the solvency risk of the financial institution. We show that, for different market scenarios, the bail-in regime tends to enhance the tax shield and to reduce the expected present value of the bankruptcy costs, by postponing the final default event with respect to the default and bail-out regimes. The optimal procrastination of the final default event is achieved by tilting the optimal non-deposit debt mix in favor of the uncovered bail-inable securities. Importantly, our mixed-regime analysis highlights the pivotal role of the resolution-scheme credibility, by showing that when there is a non-zero probability of government intervention, either at the bail-in or at the default trigger events, the incentives to increase leverage and to extract value from the implicit government guarantee become similar as in the bail-out regime. These findings apply to both the commercial and the investment bank.

Under a tight regulatory capital requirement, that is when the regulator continuously monitors that the CET1 capital ratio is higher than 4.5%, our model highlights that the optimal non-deposit leverage and default risk are dramatically reduced. This result holds irrespective of the resolution regime and for both types of bank, being very marked in adverse market scenarios, when the optimal non-deposit debt issuance is very small. To the best of our knowledge, this result is novel in the literature and brings an important contribution to the debate on the relative benefits of imposing tight ex-ante capital requirements *vis-à-vis* designing a credible ex-post resolution regulation.

Our novel focus on the joint impact of bank resolution regimes and capital requirements on the liability structure contributes to the existing theoretical literature investigating the determinants of capital structure choices of banking institutions (e.g. Flannery (1994), Diamond and Rajan (2000), Allen et al. (2011; 2015) and Hilscher and Raviv (2014)). Our paper is closely related to the contributions by Helberg and Lindset (2014), Hugonnier and Morellec (2015), Sundaresan and Wang (2017) and Berger et al. (2018), who employ continuous-time structural models of endogenous default (e.g. Black and Cox (1976), Fischer et al. (1989) and Leland (1994)) to study the optimal bank liability structure. Helberg and Lindset (2014) analyze the effects of asset encumbrance, depositor preferences and the presence of a government guarantee or a bail-in resolution regime. However, they do not consider the presence of regulatory capital requirements, nor the possibility of issuing covered debt. Hugonnier and Morellec (2015) develop a dynamic model aimed at assessing the effects of liquidity and Tier1 capital requirements. However, they do not account for different resolution frameworks (their analysis is centered on the default regime only) or tighter capital requirements. Sundaresan and Wang (2017) determine the optimal mixed financing strategy between insured deposits and non-deposit debt, for a value-maximizing bank that faces a regulatory Tier1 capital constraint and a fair deposit insurance premium. In contrast to our paper, they focus only on the default regime and they do not consider more stringent capital requirements, such as the minimum CET1 capital ratio imposed by Basel III. In a recent contribution, Berger et al. (2018) numerically solve a dynamic model aimed at determining the optimal regulatory policies and intervention triggers under three different resolution regimes, including bail-out and bail-in. Although they consider the bail-in resolution regime, they do not study the optimal mix between uncovered and covered non-deposit debt. Covered debt is senior even to deposits and, although not supported by guarantee schemes, current regulations explicitly exclude the possibility, for the resolution authorities, to exercise write-down or conversion powers on covered bonds.

The remainder of the paper is organized as follows. Section 2 introduces the structural model and provides closed-form formulae to price the corporate claims under the different resolution regimes. Section 3 presents the numerical results of the analysis. Section 4 concludes. The mathematical derivations are relegated to an Appendix.

2 Model description

In this Section we introduce the valuation formulae for the liabilities of a bank, notably equity, insured deposits, covered and uncovered bonds. Two important determinants are at play: corporate taxes (the bank is subject to a fixed tax rate τ) and bankruptcy/bail-in costs, depending on the resolution framework in force. We assume these costs to be a proportion ε

(bankruptcy) or $\xi < \varepsilon$ (bail-in) of the fair value of the assets at the moment of bankruptcy or bail-in event. The bank is subject to one out of four possible (mutually exclusive) resolution frameworks and one out of two distinct regulatory capital requirements, which affect the shareholders' incentives leading to the choice of the liability structure.

We focus on the optimal liability structure for a given portfolio of risky assets that generate a cash-flow X. Following Goldstein et al. (2001), we assume that the dynamics of the EBIT process X under the objective probability measure $\mathbb{P}$ is a geometric Brownian motion:

$$\frac{dX}{X} = \alpha \mathrm{d}t + \sigma \mathrm{d}W, \tag{1}$$

where α represents the growth prospects of the cash-flows, σ is the cash-flow volatility, and W is a Wiener process representing the only source of uncertainty in the model. Given the before-tax cash-flow process, we denote with V the claim on the after-tax cash-flows and interpret it as the asset value. Given a constant risk-free interest rate r, a tax rate τ and a market price of cash-flow risk λ, we show in Appendix A that V is proportional to the EBIT:

$$V = \frac{X\left(1-\tau\right)}{r + \sigma\lambda - \alpha},$$

where the denominator $r + \sigma\lambda - \alpha$ is required to be strictly positive. As there is a one-to-one relation between the asset value and the EBIT, in all our analyses we decided to fix the initial value of the assets at $V_0 = 100$, evaluating the corresponding amount of initial cash-flow X_0. In Appendix A we show that, similarly to X, also V follows a geometric Brownian motion, consistent with the choice made by Helberg and Lindset (2014) and Sundaresan and Wang (2015; 2017) to model the asset value of a large bank. As in their works, if the assets are of the same risk category and under the assumption that investors have full information about the assets, we can interpret V as the fair value of the risk-weighted assets (RWA). Before deriving the claim valuation formulae under the different resolution regimes, we describe the liabilities that we consider in the bank capital structure, which are represented in the right column of Table 1.

Deposits In the study of the optimal bank structure, we focus on the choice of funding through equity and bonds of different nature. We consider instead deposits as a stable funding source for a given bank, representing thus a fixed fraction of the total assets. We also assume that deposits are totally insured.[2] Without deposit insurance, borrowing through deposits entails the risk of bank runs if depositors believe that the bank has difficulty in repaying their deposits promptly upon their demand. The continuous interest payment on deposits, excluding the deposit insurance premium, is $d = rD$. This implies that the book value of deposits D is equal to their market value $\mathcal{D}$. In the baseline analysis, we make the same assumption as in Helberg and Lindset (2014) by considering that the bank pays a fixed insurance premium, expressed as a fraction φ of the total deposit D, exogenously determined by national banking authorities.[3] Therefore, the continuous payment to the deposit insurer is equal to $i = \varphi D$, while the present value of a corresponding default-free perpetuity is $I = \frac{i}{r}$. These payments to depositors and insurer are tax-deductible. As a robustness check, we also consider the case where, as in Sundaresan and Wang (2017), the constant proportional insurance fee φ is set to a fair value, that is a value that makes the insurance contract to be worth zero for both the bank and the insurer.

Covered bonds An important source of funding is represented by bonds. The non-deposit debt is composed by covered bonds (C-bonds) and uncovered bonds (U-bonds), owned respectively by C- and U-bondholders. As for deposits, a benefit of debt financing is that interest payments are tax-deductible.

C-bonds, which are very common in European countries, offer a dual recourse to investors, both to a defined part of the bank loan portfolio, the cover pool, as well as a claim on

[2] An implicit assumption is that depositors never deposit, in a single bank account, more than the maximum amount guaranteed for deposit repayment by the deposit guarantee scheme.

[3] A fixed insurance premium implies, as in Helberg and Lindset (2014), a nontrivial net present value of deposit insurance. Nontrivial net present values of deposit insurance apply also to deposit-dependent insurance premia, like those assumed in Hugonnier and Morellec (2015).

bank assets. If the issuer defaults on its outstanding covered bonds, C-bondholders, if necessary, have the right to sell the loans in the pool to cover their claims before the other liabilityholders. Consequently, they have a first priority on the assets in a bank failure and they are senior even to bank deposits. For this reason, they cannot be considered as Tier 2 capital.

In our model, the C-bond pays a continuous coupon c and its market value, which we endogenously determine, is $\mathcal{C}$. If it were default-free, it would be a perpetuity with present value $\frac{c}{r} = C$, which represents the book value of the C-bond. In the event of default, considering proportional bankruptcy costs ε, if the post-bankruptcy value of the bank at default, $(1-\varepsilon) V_D$, is lower than the book value C, C-bondholders are only partially reimbursed, otherwise they are entirely reimbursed. Eventually, C-bondholders receive $\mathcal{C}_D = \min[C, (1-\varepsilon) V_D]$ at default. The C-bond delivers a credit spread, $\frac{c}{\mathcal{C}} - r$, to compensate C-bondholders for bearing default risk. The credit spread is endogenously determined in the model, as it depends on the cash-flow risk, on the composition of the liability structure and on the regulatory regime in place. Thus, the choice of the liability structure affects the credit spread, which we determine endogenously by evaluating the market value of C-bonds $\mathcal{C}$ as a function of the current asset value V.

Uncovered bonds The U-bond is a key financing instrument of the model, as its value strictly depends on the regulatory regime in place. In the bail-in regime, which we describe in Section 2.1, when the original equity capital is lost, the bank can be restructured and not liquidated. U-bondholders have their claims converted into equity and, concurrently, bear a bail-in cost ξV_B, assumed to be proportional to the asset value at bail-in (V_B) according to a constant $\xi < \varepsilon$. We assume that the restructuring costs are paid by U-bondholders, having thus an impact on the U-bond market value, without entailing an impairment of the bank assets. Since U-bondholders become the new shareholders of the bank, they can benefit from the tax shield generated by the other liability payments until default. In the bail-out regime, which we describe in Section 2.2, according to the standard insolvency proceedings applied when the bank defaults, the original equity is wiped out and C-bondholders are paid first, then depositors and finally U-bondholders.

We denote the U-bond market value with $\mathcal{U}$ and the continuous coupon it pays with u. $U = \frac{u}{r}$ is the present value of the associated default-free perpetuity and represents the book value of the U-bond. In our model, the credit spread is thus $\frac{u}{\mathcal{U}} - r$ and endogenously depends on the riskiness of the assets, the composition of the liability structure and the regulatory regime in force.

Equity Shareholders benefit from all the residual value and earnings of the bank, after paying debt interests and costs. Since interest expenses are deductible from earnings for tax purposes, the flow of tax savings is $\tau\,[d + i + c + u]$. 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: $(1 - \tau)\,X - (1 - \tau)\,[d + i + c + u]$. We denote with $\mathcal{S}$ the endogenously-determined market value of equity.

Finally, where the bail-in regime is in place and after a distressed bank is bailed-in by the original U-bondholders, through a conversion of their claims into equity, the flow of tax savings to the new equityholders becomes $\tau\,[d + i + c]$. We denote with $\widehat{\mathcal{S}}$ the market value of equity after bail-in.

The claim values crucially depend on the particular resolution framework applied and the bail-in/default barrier levels, that can be determined endogenously or by the regulator. We discuss the bail-in regime in Section 2.1, the bail-out regime in Section 2.2 and a mixed regime in Section 2.3.

2.1 Bail-in regime

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 into equity, such that the bank remains a going concern, restoring it to health without recurring to public funds. To study the effects of the bail-in resolution regime, we consider that bail-in takes place when the asset value of a distressed bank drops below a certain threshold V_B. In order for the bail-in to happen, the bank must hold a sufficient amount of bail-inable debt in order to absorb losses and restore a minimum level of CET1 capital ratio, required to carry out the activities it has been authorized for. Therefore, when the asset value drops below a certain threshold V_B, the original equityholders of the bank are totally wiped out, the insured depositors, as well as C-bondholders,[4] carry their claims to the restructured bank, whereas the ownership of the bank is given to U-bondholders. Therefore, the bail-in tool directly affects only the U-bondholders, who bear the bail-in costs ξV_B and have their remaining claims converted into equity.

The original equityholders of the bank can choose to give up on their claims before the authority intervention. Absent any authority intervention, there exists an optimal point for the original equityholders to leave the bank, allowing U-bondholders to be bailed-in and to take bank ownership. This bail-in decision maximizes the equity value and is thus referred to as endogenous bail-in. Let V_{EB} be the asset value at which endogenous bail-in takes place.

However, Basel III regulations establish that banking institutions shall, at all times, satisfy several capital requirements. In particular, the bank must hold an amount of CET1 capital at least equal to a fraction $\psi = 4.5\%$ of its RWA. If, at any moment, it turns out that the CET1 capital ratio is too low ($CET1/RWA < \psi$), the regulator triggers a bail-in conversion of U-bonds into equity, provided that the U-bond conversion allows to restore the minimum CET1 capital ratio. Otherwise the bank regulatory closure occurs. Furthermore, the bank must hold an amount of Tier1 capital, that is the sum of CET1 and Additional Tier 1 (AT1) capital, at least equal to a fraction $\beta = 6\%$ of its RWA. When the minimum Tier1 capital ratio is not satisfied ($Tier1/RWA < \beta$), in the absence of contingent capital available for conversion, the resolution authority applies the bail-in tool under the condition

[4]Regulations (e.g. article n. 44 of BRRD) explicitly exclude covered bonds from bail-in.

that losses are absorbed and the minimum CET1 capital ratio is restored. Therefore, if the CET1 capital requirement ($CET1/RWA \geq \psi$, where $\psi = 4.5\%$) can be satisfied after bail-in, the U-bonds are converted into equity and the bank continues to operate, otherwise the bank faces regulatory closure. Based on these regulations, we consider two different specifications of the capital requirement, the first being more stringent and the second being more relaxed.

Tier1&CET1 capital requirement The more stringent capital requirement is fully based on Basel III regulations. Before bail-in is triggered, the regulator perpetually monitors both the CET1 and the Tier1 capital ratios. In our model, the CET1 capital is given by the book value of equity (tangible equity), $V - [D + C + U]$. The total Tier1 is the sum of CET1 and AT1 capital. In our model, we consider the U-bond to represent AT1 capital. The total Tier1 capital is then given by the sum of the book value of equity, $V - [D + C + U]$, and the book value of U-bonds (U). The following conditions must therefore hold at all times:

$$\begin{cases} \underbrace{V - [D + C + U]}_{CET1} \geq \psi \underbrace{V}_{RWA} \\ \underbrace{V - [D + C + U]}_{CET1} + \underbrace{U}_{AT1} \geq \beta \underbrace{V}_{RWA} \end{cases}, \tag{2}$$

which implies that $V \geq V_{RB}$, where:

$$V_{RB} = \max\left(\frac{D + C + U}{1 - \psi}, \frac{D + C}{1 - \beta}\right). \tag{3}$$

When the asset value breaches the barrier V_{RB} from above, the regulator triggers the bail-in event, provided two conditions. The first is that that the requirement on the CET1 capital ratio can be satisfied after bail in. The amount of CET1 capital after bail-in is $V - [D + C]$, therefore, for the bail-in to take place, it must be that $V_B - [D + C] \geq \psi V_B$, where V_B is the actual bail-in barrier. The second condition is that the market value of U-bonds at bail-in is non-negative (limited liability of U-bondholders), which entails that the market value of the converted U-bond just after bail-in $\widehat{\mathcal{S}}\,(V = V_B)$, net of the bail-in costs ξV_B, is non-negative. If bail-in has successfully occurred, the regulatory closure boundary is instead reached when the amount of CET1 capital falls below the minimum requirement and no bail-inable capital is available anymore. Hence, the regulator will monitor that the following condition is satisfied:

$$\underbrace{V - [D + C]}_{CET1} \geq \psi \underbrace{V}_{RWA},$$

which implies that $V \geq V_{RD}$, where:

$$V_{RD} = \frac{D + C}{1 - \psi}. \tag{4}$$

Tier1 capital requirement Along the lines of Sundaresan and Wang (2017), we also consider a less stringent capital requirement, where the regulator only checks for the Tier1 ratio. In this case, the threshold asset value V_{RB} at which the resolution authority enforces the bail-in corresponds to the violation of the following condition:

$$\underbrace{V - [D + C + U]}_{CET1} + \underbrace{U}_{AT1} \geq \beta \underbrace{V}_{RWA}, \tag{5}$$

which implies that $V \geq V_{RB}$, where:

$$V_{RB} = \frac{D + C}{1 - \beta}. \tag{6}$$

This regulatory boundary represents a less stringent capital requirement, as before bail-in there is no control on the minimum amount of CET1 capital that the bank must hold and the shareholders can comply with the total Tier1 requirement substituting part of the mandatory CET1 capital with AT1 capital. Only after bail-in occurs, the regulator controls that the CET1 requirement is satisfied, which corresponds, as for the Tier1&CET1 requirement, that $V \geq V_{RD}$, where V_{RD} is given in (4). The conditions for the applicability of the bail-in tool are the same as for the Tier1&CET1 capital requirement.

Absent any authority intervention, there exists an optimal asset value for the current equityholders to leave the bank. This decision maximizes the equity value and corresponds to an endogenous bail-in or default barrier, respectively V_{EB} and V_{ED}, depending on whether the current equityholders are the original equityholders or the U-bondholders which claims have been converted into equity to bail-in the bank.[5] Since bail-in and default are triggered as soon as either an endogenous or regulatory barrier is reached, the actual bail-in and default barriers are respectively $V_B = \max[V_{EB}, V_{RB}]$ and $V_D = \max[V_{ED}, V_{RD}]$.

The following Theorem, which proof is in Appendix D, provides the closed-form pricing formulae for the corporate claims and the total bank value under the bail-in regime.

Theorem 1 *Given the liability structure* (D, C, U)*, the regulatory bail-in boundary* V_{RB} *either in (3) or in (6) and the regulatory default boundary* V_{RD} *in (4), the bail-in and default boundaries in the bail-in regime are:*

$$
\begin{aligned}
V_B &= \max[V_{EB}, V_{RB}], \\
V_D &= \begin{cases} \max[V_{ED}, V_{RD}] & \textit{if bail-in is applicable} \\ V_B & \textit{otherwise,} \end{cases}
\end{aligned}
$$

where $V_{EB} = \frac{\gamma}{\gamma-1}(1-\tau)(D+I+C+U)$ *and* $V_{ED} = \frac{\gamma}{\gamma-1}(1-\tau)(D+I+C)$*. The market values for deposits* $\mathcal{D}$*, covered bond* $\mathcal{C}$*, uncovered bond* $\mathcal{U}$*, equity before bail-in* $\mathcal{S}$*, equity after bail-in* $\widehat{\mathcal{S}}$ *and the total bank value* $\mathcal{BV}$ *are, respectively:*

$$
\begin{aligned}
\mathcal{D} &= D, \\
\mathcal{C} &= C - (C - \mathcal{C}_D)\left[\frac{V}{V_D}\right]^{\gamma}, \\
\mathcal{U} &= U - (U - \mathcal{U}_B)\left[\frac{V}{V_B}\right]^{\gamma},
\end{aligned}
$$

[5] In Helberg and Lindset (2014), who do not explicitly model regulatory capital requirements, this is the only mechanism triggering bail-in or default.

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

where $\gamma = -\left(\frac{\alpha-\sigma\lambda}{\sigma^2}-\frac{1}{2}\right) - \sqrt{\left(\frac{\alpha-\sigma\lambda}{\sigma^2}-\frac{1}{2}\right)^2 + 2\frac{r}{\sigma^2}}$ *and:*

$$\mathcal{C}_D = \min\left[C, (1-\varepsilon)V_D\right],$$
$$\mathcal{U}_B = \begin{cases} \widehat{\mathcal{S}}(V=V_B) - \xi V_B & \textit{if bail-in is applicable} \\ \min\left[U, \left[(1-\varepsilon)V_B - D - C\right]^+\right] & \textit{otherwise.} \end{cases}$$

The bail-in is applicable if $\widehat{\mathcal{S}}(V=V_B) - \xi V_B > 0$ *and* $V_B - [D+C] \geq \psi V_B$.

The optimal liability structure, which we numerically determine in Section 3, is obtained by maximizing the bank value $\mathcal{BV}$ with respect to the book value of covered debt, C, and of uncovered debt, U.

2.2 Bail-out regime

In this framework, rather than considering the re-capitalization of the bank by U-bondholders, we take into account the possibility that a government intervention, in the case of a default event, covers part of the debt obligations of the bank in order to preserve the financial system. This scenario was very likely before the introduction of the bail-in tool, as the response to most systemic bank fallouts consisted in the re-capitalization and nationalization of the financial institution through publicly-funded capital injections.

We model the possibility of a bail-out introducing a risk-adjusted probability of a government intervention, $p \in [0,1]$, which represents the market belief about the probability that, given default, the government bails-out the bank. As for the bail-in framework, absent any regulatory intervention, there is an optimal asset level at which the shareholders decide to default. It is possible to determine in closed form this endogenous default barrier V_{ED}. Furthermore, there is the possibility that the regulator forces the bank to close its activity when a capital requirement is not satisfied. As for the bail-in regime, we consider two different requirements, corresponding to different regulatory default barriers V_{RD}.

Tier1&CET1 capital requirement This requirement is more stringent and implies that the asset value satisfies the same conditions as in (2). In the bail-out regime, this means that $V \geq V_{RD}$, where:

$$V_{RD} = \max\left(\frac{D+C+U}{1-\psi}, \frac{D+C}{1-\beta}\right). \tag{7}$$

Tier1 capital requirement This requirement is less stringent and imposes the same condition on the asset value as in (5). This entails that $V \geq V_{RD}$, where:

$$V_{RD} = \frac{D+C}{1-\beta}. \tag{8}$$

Given the regulatory default boundary V_{RD} and the endogenous default boundary V_{ED}, the actual default boundary is $V_D = \max\left[V_{ED}, V_{RD}\right]$. When it is reached, the bank fails and C-bondholders are paid before, in order of priority, depositors and U-bondholders. However, the government can decide to intervene, liquidating the bank assets and reimbursing all the owners of non-deposit debt. The possibility of a state intervention, explained by the so-called *too-big-to-fail* status of a bank, is perceived as plausible by investors and generates an additional value for the bonds, reducing the sensitivity of the debtholders toward risk. In the limit where the government fully reimburses the losses suffered by bondholders ($p = 1$), debt claims become risk-less. On the contrary, when $p = 0$, the government never intervenes to bail-out the bank. We refer to this particular case with *default regime.*

The value transfer from the government has a distorting impact on the capital structure decisions made by shareholders, both in terms of leverage and debt composition. In particular, when the default barrier V_D is reached, the bank fails and two different scenarios may occur: i) the government bails out the bank and, even if the post-bankruptcy asset value

$((1-\varepsilon)\,V_D)$ is not sufficient to pay back C-bondholders, depositors and U-bondholders, all these claimants receive the face value of their claims, as the government covers any shortcoming; ii) the government does not bail out the bank and the post-bankruptcy asset value is used to pay back, in this priority order, C-bondholders, depositors and U-bondholders. In the second scenario, C-bondholders receive the minimum between the face value and the post-bankruptcy asset value ($\mathcal{C}_D = \min\left[C, V_D(1-\varepsilon)\right]$). Depositors are covered by the deposit guarantee scheme, which compensate for any shortcoming with respect to the nominal value of the deposits, D. U-bondholders instead receive the remaining asset value, equal to the minimum between the book value U and the asset value, net of bankruptcy costs and of the book value of all other liabilities ($\mathcal{U}_D = \min\left[U, \left[(1-\varepsilon)\,V_D - D - C\right]^+\right]$).

The following Theorem, derived in Appendix E, provides the closed-form pricing formulae for the corporate claims and the total bank value under the bail-out regime.

Theorem 2 *For $0 \le p \le 1$, given the liability structure (D, C, U) and the regulatory default boundary V_{RD} either in (7) or in (8), the default boundary in the bail-out regime is:*

$$V_D = \max\left[V_{ED}, V_{RD}\right].$$

where $V_{ED} = \frac{\gamma}{\gamma-1}(1-\tau)(D+I+C+U)$. The market values for deposits $\mathcal{D}$, covered bond $\mathcal{C}$, uncovered bond $\mathcal{U}$, equity $\mathcal{S}$ and the total bank value $\mathcal{BV}$ are:

$$\begin{aligned}
\mathcal{D} &= D, \\
\mathcal{C} &= C - (1-p)\,(C - \mathcal{C}_D)\left[\frac{V}{V_D}\right]^{\gamma}, \\
\mathcal{U} &= U - (1-p)\,(U - \mathcal{U}_D)\left[\frac{V}{V_D}\right]^{\gamma}, \\
\mathcal{S} &= V - V_D\left[\frac{V}{V_D}\right]^{\gamma} - (1-\tau)\,(D+I+C+U)\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right), \\
\mathcal{BV} &= \mathcal{D} + \mathcal{C} + \mathcal{U} + \mathcal{S},
\end{aligned}$$

where $\gamma = -\left(\frac{\alpha-\sigma\lambda}{\sigma^2} - \frac{1}{2}\right) - \sqrt{\left(\frac{\alpha-\sigma\lambda}{\sigma^2} - \frac{1}{2}\right)^2 + 2\frac{r}{\sigma^2}}$ *and:*

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

2.3 Mixed regime

This regime is a mix of the bail-in and bail-out regimes. It is based on the bail-in model, but it also takes into account the possibility of a government intervention, at any trigger event (bail-in or default). The assumption of this regime is that there is an uncertainty concerning the resolution regime that is applied to a distressed bank when the asset value reaches either of the bail-in or the default boundaries, V_B or V_D.

Let p_1 be the risk-adjusted probability of a bail-out taking place when bail-in would be the appropriate resolution. If $p_1 = 0$, the market believes that the bail-in will be applied with certainty once the bail-in barrier is reached. On the contrary, if $p_1 = 1$, the market believes that for sure there will be a public intervention aimed at reimbursing all bank liabilities when bail-in is triggered. If $0 < p_1 < 1$, the resolution framework applied at the bail-in trigger is uncertain because, even if the bail-in regime calls for a U-bond conversion into equity, there could be a government intervention avoiding the conversion and covering all debt claims.

In this framework, when V reaches the bail-in trigger V_B, the original amount of equity is lost irrespective of a government intervention. If the bail-in tool is applied the bank is restructured, with U-bondholders becoming the new shareholders. If instead the government intervention prevails, depositors and debtholders will be partially reimbursed after bank liquidation.

Moreover, this regime takes into account the possibility of a government intervention also at the default trigger. In this case, if at the bail-in trigger there has not been a government intervention, only the C-bond will be entirely reimbursed because the U-bond has already been bailed-in. We denote with $p_2 \in [0, 1]$ the risk-adjusted probability of a government bail-out occurring when the restructured bank fails. By construction, if $p_1 = p_2 = 0$ the results are the same of the bail-in case discussed in Section 2.1.

The following Theorem, derived in Appendix F, provides the closed-form pricing formulae for the corporate claims and the total bank value under the mixed regime.

Theorem 3 *For $0 \leq p_1 \leq 1$ and $0 \leq p_2 \leq 1$, given the liability structure (D, C, U), the regulatory bail-in boundary V_{RB} either in (3) or in (6) and the regulatory default boundary V_{RD} in (4), the bail-in and default boundaries in the mixed regime are:*

$$\begin{aligned} V_B &= \max\left[V_{EB}, V_{RB}\right], \\ V_D &= \begin{cases} \max\left[V_{ED}, V_{RD}\right] & \textit{if bail-in is applicable} \\ V_B & \textit{otherwise,} \end{cases} \end{aligned}$$

where $V_{EB} = \frac{\gamma}{\gamma-1}(1-\tau)(D+I+C+U)$ and $V_{ED} = \frac{\gamma}{\gamma-1}(1-\tau)(D+I+C)$. The market values for deposits $\mathcal{D}$, covered bond $\mathcal{C}$, uncovered bond $\mathcal{U}$, equity before bail-in $\mathcal{S}$, equity after bail-in $\widehat{\mathcal{S}}$ and the total bank value $\mathcal{BV}$ are, respectively:

$$\begin{aligned} \mathcal{D} &= D, \\ \mathcal{C} &= C - (1-p_1)(1-p_2)(C - \mathcal{C}_D)\left[\frac{V}{V_D}\right]^{\gamma}, \\ \mathcal{U} &= U - (1-p_1)(U - \mathcal{U}_B)\left[\frac{V}{V_B}\right]^{\gamma}, \\ \mathcal{S} &= V - V_B\left[\frac{V}{V_B}\right]^{\gamma} - (1-\tau)(D+I+C+U)\left(1 - \left[\frac{V}{V_B}\right]^{\gamma}\right), \\ \widehat{\mathcal{S}} &= V - V_D\left[\frac{V}{V_D}\right]^{\gamma} - (1-\tau)(D+I+C)\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right), \\ \mathcal{BV} &= \mathcal{D} + \mathcal{C} + \mathcal{U} + \mathcal{S}, \end{aligned}$$

where $\gamma = -\left(\frac{\alpha-\sigma\lambda}{\sigma^2} - \frac{1}{2}\right) - \sqrt{\left(\frac{\alpha-\sigma\lambda}{\sigma^2} - \frac{1}{2}\right)^2 + 2\frac{r}{\sigma^2}}$ and:.

$$\mathcal{C}_D = \min\left[C, (1-\varepsilon)V_D\right],$$

$$\mathcal{U}_B = \begin{cases} \widehat{\mathcal{S}}(V = V_B) - \xi V_B & \textit{if bail-in is applicable} \\ \min\left[U, \left[(1-\varepsilon)V_B - D - C\right]^+\right] & \textit{otherwise.} \end{cases}$$

The bail-in is applicable if $\widehat{\mathcal{S}}(V = V_B) - \xi V_B > 0$ *and* $V_B - [D + C] \geq \psi V_B$.

It is worth noting that, in the case of a government intervention at the bail-in barrier, V_B automatically becomes V_D and both the value of equity, $\mathcal{S}$, and the value of equity at bail-in, $\widehat{\mathcal{S}}(V = V_B)$, approach zero.

3 Numerical analysis

In this Section, we use the pricing formulae for the corporate claims in Theorems 1, 2 and 3 to numerically evaluate the optimal bank liability structure, under different assumptions on the resolution regime, the market conditions, the nature of the bank and different possible regulatory capital requirements. We consider an initial asset value $V_0 = 100$ and a given amount of deposits D, assumed to be 40 for a commercial bank and 10 for an investment bank.[6] In the base case, we assume parameter values in line with the existing literature, in particular with the ones used by Helberg and Lindset (2014). We consider a constant default-free interest rate $r = 3\%$. For what concerns the EBIT process, in the base case we set the EBIT volatility σ at 8%, the growth prospects α at 4% and the market price of the cash-flow risk λ at 0.5, which make the base case risk-neutral drift of the cash-flow process to be zero. The bankruptcy costs are defined as a fraction ε of the asset value, which we set to be equal to 20%, while the proportional bail-in costs ξ are chosen to be half of the bankruptcy costs, being thus equal to 10%. The tax rate τ is 28% and the annual rate of insurance premium φ is 0.15%, close to the average value observed by Demirgüç-Kunt et al. (2008) for the majority of relevant countries. In Section 3.3 we extend this baseline specification by

[6] Some examples of deposits-to-total liabilities ratios for banks with a relevant commercial nature are: JP Morgan Chase, 52.9% in 2013 and 56.8% in 2017, BNP Paribas, 35.5% in 2013 and 46.1% in 2017, Intesa SanPaolo, 34.1% in 2013 and 36.3% in 2017. Some examples among investment banks are: Goldman Sachs 7.8% in 2013 and 15.0% in 2017, Morgan Stanley, 14.1% in 2013 and 18.7% in 2017.

considering a proportional insurance premium that is fairly determined, that is the value of φ that makes the net insurance value equal to zero. For the bail-out and mixed regimes, we set the base case risk-adjusted probability of government intervention p to 30%,[7] which is plausible considering that we are considering systemically important banks and that the risk adjustment tends to overweight the probability associated to bad states of the economy.[8] The base case parameter values, as well as the shifted values for α, σ, r and p used in the comparative static analysis, are summarized in Table 2. In the following, we determine the optimal debt structure in terms of the book value of C- and U-bonds, namely C and U, by numerically maximizing the total market value of the bank ($\mathcal{BV}$).

Before proceeding with a detailed analysis that considers different market scenarios, we hereby summarize some of our key findings, examining at first the case of an investment bank ($D = 10$). Figure 1 represents the most relevant quantities of the optimal capital structure as a function of the risk-adjusted probability of government intervention p. The dark red lines correspond to the bail-out regime, which for $p = 0$ degenerates into the default regime, while the light blue lines represent the mixed regime, which for $p = 0$ degenerates into the bail-in regime. The left column refers to the lighter capital requirement, where the regulator monitors that the Tier1 capital, which is the sum of CET1 capital (book value of equity, $V - D - C - U$) and AT1 capital (book value of uncovered debt, U), remains at least equal to 6% of the RWA (V). No constraints are imposed on the minimum value of tangible equity, that can even be negative.

In the *bail-out* regime, the total nominal amount of non-deposit (covered and uncovered) debt issued is sharply increasing in p, as the possibility of a capital injection by the government in case of severe distress incentivizes the bank to raise more debt and default earlier. The default boundary rises accordingly and the upper bound to the total amount of issued

[7]In the mixed regime, in order not to introduce too many degrees of freedom, we consider $p_1 = p_2 = p$, implying that the risk-adjusted probability of bail-out is the same conditional on the fact that either the bail-in or the default barrier is reached.

[8]Berndt et al. (2018) calibrate a pre- to post-Lehman reduction of the CDS-implied government bail-out probability for G-SIB and D-SIB ranging between 20% and 50%.

debt is reached when the leverage is so high that the bank defaults immediately, that is when the default barrier coincides with the initial asset level $V_0 = 100$. The optimal amount of covered debt is nearly half of the total non-deposit debt issued. The bank is incentivized to issue covered debt as, being it senior even to deposits, in case of default it would be reimbursed by means of the recovered asset value, while deposits would be reimbursed with the remaining liquidation value and then by the deposit insurer. If only uncovered debt had been issued, the recovered asset value would have been used first to reimburse deposits, making the deposit insurance at least partially worthless to the bank, and then, if possible, the liquidation value would have been used to partially reimburse U-bondholders. However, U-bonds are AT1 capital, which level is monitored by the regulator. The issuance of a certain amount of uncovered debt is thus essential, as this allows to lower the regulatory default boundary. The total market value of the bank is sharply increasing in p, driven by the rise of the expected present value of the government subsidy, which increases from 0 to about 100 and accounts for more than half of the total bank value for $p = 1$. It is worth noting that the difference between the total bank value and the government subsidy is decreasing in p. This means that the rise of the bank value is mostly attributable to an increasing extraction of value from the government, rather than to the p-dependent net contribution of the tax shield, the bankruptcy costs and the net deposit insurance value. Finally, the credit spread of the uncovered debt is sharply increasing with p up to the point where total debt reaches the maximum value, as the reduction of the expected time-to-default sharply increases the perceived riskiness of the debt. However, for higher values of p, the credit spread decreases until, for $p = 1$, the debt becomes risk-less and thus the credit spread is zero. Once the maximum debt capacity is reached (the default barrier equals V_0), an increase of the probability of bail-out entails a reduction of the credit spreads, as it makes debtholders less sensitive to default risk by enhancing the expected recovery of their claims.

Focusing on the fully-credible *bail-in* regime ($p = 0$) and the partially-credible bail-in regime (namely the *mixed* regime, $p > 0$), it can be noticed that, despite a slightly higher level of total debt for a given value of p than in the bail-out regime, the amount of covered debt issued is smaller and accounts for a significantly lower fraction of the total non-deposit debt, while the fraction of uncovered (bail-inable) debt is higher. The non-deposit debt increases with p until the bail-in barrier, also increasing in p, reaches the initial asset level $V_0 = 100$, that is when bail-in takes place immediately. Importantly, the default barrier under the bail-in/mixed regimes is far lower than under the default/bail-out regimes, resulting in a beneficial postponement of the final bankruptcy. This increases the present value of the tax shield and reduces the impact of bankruptcy costs, ultimately increasing the bank value. This phenomenon is the driver of the higher optimal fraction of uncovered debt issued under the bail-in/mixed regimes than under the default/bail-out regimes, as a higher fraction of uncovered debt issued entails a lower default barrier. If compared to those in the bail-out regime, the present value of the government subsidy and the total bank value are slightly higher and follow a similarly increasing pattern. This is due to the fact that, under the mixed regime, the government can decide to bail the bank out either at the bail-in or at the default barrier. Comparing the values on the y-axis of the first graph, the total amount of debt issued under the bail-in regime is slightly higher than under the default regime, but, as long as the bail-in regime is credible ($p = 0$), the total debt is lower than its level under the bail-out regime calculated for p higher than 10%. These results highlight how the introduction of a credible bail-in regime entails a strong reduction of the risk taken by the bank in liability structure choices. However, if the credibility of the bail-in regime is damaged ($p > 0$, i.e. mixed regime), then most of the beneficial effects of the bail-in tool vanish when p is conspicuous enough. This is also confirmed by the pattern of the uncovered debt credit spread under the mixed regime, which follows a similar inverse-V-shaped pattern as in bail-out regime. For a given value of p, the level of the credit spread is lower than in the bail-out regime, despite the bail-in barrier in the mixed regime being higher than the default barrier in the default regime. This happens because, absent a government intervention, under the mixed regime there is a strong upside potential for U-bondholders at bail-in, thanks to the conversion of their claims into equity, making them better off than under the bail-out regime.

The graphs on the right of Figure 1 refer to the Tier1&CET1 capital requirement, which imposes also a minimum CET1 capital ratio of 4.5%. As can be noticed, this tighter requirement makes the optimal levels of debt to be significantly lower than under the Tier1 requirement for all resolution regimes. Furthermore, even when the probability of bail-out is high, the bail-in and default barriers do not increase with p, which means that the incentive to default earlier in order to extract value from the government is mitigated. Consequently, the present value of the government subsidy is negligible for any value of p. This fact, together with the lower tax shield caused by the reduced levels of debt, makes the total bank value to be lower than under the Tier1 capital requirement. The U-bond credit spread, thanks to the lower bankruptcy risk, is far lower than under the Tier1 capital requirement and, for the bail-in/mixed regime, it even reaches negative values: this is caused by the fact that, even for the baseline value of the growth prospects ($\alpha = 4\%$), the upside potential entailed by the possible conversion of a relatively small amount of U-bonds into equity outweights the negative price impact of the risk of final default, which takes place at an asset level significantly below the bail-in barrier.

Finally, Figure 2 refers to the case of a commercial bank ($D = 40$) and confirms most of the aforementioned key findings. The higher level of deposits entails that the optimal nominal amount of non-deposit debt issued is lower than for the investment bank, the difference being close to 30, which is the additional amount of deposits held by our commercial bank. In particular, under the Tier1 capital requirement, there seems to be a substitution effect between covered bonds and deposits: especially for values of p below 0.5, a higher level of deposits entails a lower optimal issuance of covered bonds, while the amount of uncovered debt is similar between the two banks. Indeed, also for the commercial bank it is important to issue a substantial amount of uncovered debt, as it contributes to the Tier1 capital and allows to lower the regulatory default barrier. Under the tighter Tier1&CET1 capital requirement, the more stringent regulatory default condition is given by the amount of CET1 capital (tangible equity), and thus the optimal amount of U-debt is very small for the default/bail-out resolution regimes. The issuance of U-bonds is instead dominant for the bail-in/mixed regimes, even under the tight capital requirement, as they allow to postpone the final default.

In the following of the section we comment Tables 3 to 7, which report the detailed results of comparative statics analyses where α, σ, r and p are varied, obtained for the two types of bank and considering the different resolution regimes already introduced: default, bail-out, bail-in and mixed. The difference between the two panels is the regulatory capital requirement that the bank must meet. In Panel (a) the regulator monitors only the Tier1 capital requirement, while in Panel (b) the more stringent Tier1&CET1 capital requirement is imposed. Section 3.1 focuses on the impact of the resolution regime, Section 3.2 on the different capital requirements and, finally, Section 3.3 shows that our results are robust to the introduction of a fair deposit insurance premium.

3.1 Impact of the resolution regime

Table 3 reports the results of a comparative static analysis where the growth prospects α are varied with respect to their base case value (4%), considering a scenario corresponding to adverse business conditions (2%) and a favorable scenario (6%). In this paragraph we focus on Panel (a), where the less stringent Tier1 capital requirement is imposed. It can be noticed that for a commercial bank the market value of the C-bond is always equal to its book value, irrespective of the capital requirement, because the post-bankruptcy value of the assets at default is sufficiently large to entirely reimburse C-bondholders. As a consequence, the credit spread of the C-bond is equal to zero. This is because C-bondholders have a first priority on the bank assets and their claims are virtually risk-less as soon as there is enough loss-absorption capacity by other financing instruments. Therefore, from the perspective of depositors and C-bondholders, insured deposits and C-bonds are equivalent, as the first are insured by an external entity and the second are backed by bank assets, but their presence entails different incentives for the other claimants. A substitution effect between the two instruments takes place in the optimal liability structure: as the amount of insured deposits increases, the optimal amount of C-bond reduces, and the total insurance premium paid by the bank increases. Consequently, the investment bank ($D = 10$) typically issues a higher amount of C-bond than the commercial bank ($D = 40$). In general, the amount of U-bond issued represents a significant portion of the total outstanding debt, especially in the adverse scenario ($\alpha = 2\%$), as it provides loss-absorption capacity to the liability structure. The U-bond indeed plays a crucial role for regulatory purposes in all regimes, as it is AT1 capital that contributes to the Tier1 ratio monitored by the regulator, thus allowing to lower the regulatory default barrier. Furthermore, in the bail-in and mixed regimes, it is converted into equity when bail-in is applicable, postponing the eventual bankruptcy of the bank.

The bail-out regime, because of the presence of a government subsidy intervening in case of default, incentivizes the shareholders to significantly increase the leverage, and thus the risk of default, with respect to the default regime, where the implicit government guarantee is not present. In the standard scenario ($\alpha = 4\%$), for a commercial bank the leverage increases from 80.7% to 93.4%, and for an investment bank from 80.2% to 91.7%. The situation is more extreme in the adverse scenario ($\alpha = 2\%$), where for a commercial bank the leverage skyrockets from 77.5% to nearly 100.0%, and for an investment bank from 76.2% to 99.4%. Note that, while the leverage is monotonically increasing in α under the default regime, it is decreasing in α under the bail-out regime. Also the initial CET1 and Tier1 capital ratios follow the same pattern and significantly decrease when the government guarantee is introduced. We also report the expected present value of the subsidy injected by the government, which is increasing for worsening business conditions (decreasing α) and reaches very high values (for the commercial bank and $\alpha = 2\%$, it is equal to 48.0 out of a total bank value of 143.8). The value added by the implicit guarantee makes the shareholders choose a very risky debt structure, strongly increasing the level of the default barrier (which is 98.0 for $\alpha = 2\%$) and thus reducing the time-to-default. This takes place despite the consequently high expected bankruptcy costs, which increase when business conditions worsen, and the low expected tax shield. The bank values in the adverse scenario are very high (143.8 for the commercial bank and 135.1 for the investment bank), but these values are ultimately reached through an extraction of value from the government in case of bail-out rather than thanks to the tax-shield effect. Despite a positive probability of government intervention, the riskiness of the U-bond is very high, which is reflected by the very high credit spreads, which in the base case and adverse scenarios are significantly higher in the bail-out regime than in the default regime.

The bail-in regime, instead, achieves a significant risk-mitigation effect with respect to the bail-out regime, mainly for two reasons: first, it removes the government subsidy in case of default, and second, it allows to postpone default by introducing the possibility of converting uncovered debt into equity in case of distress. In the standard scenario ($\alpha = 4\%$), for both banks the shareholders' incentives to increase leverage are significantly reduced, leading to an optimal leverage just slightly higher to that obtained in the default regime and to a higher Tier1 capital ratio than in both the default and bail-out regimes, as well as a significantly higher CET1 ratio than in the bail-out regime. The same happens in the adverse scenario ($\alpha = 2\%$): for the commercial bank, the leverage reduces from 100.0% in the bail-out regime to 79.8% in the bail-in regime, while for the investment bank it reduces from 99.4% to 77.4%. In the bail-in regime, as opposed to the bail-out regime, also the debt composition significantly changes: especially in the less favorable scenarios, a significantly higher fraction of bail-inable debt (U-bond), as opposed to non-bail-inable debt (C-bond), is required. For example, for the commercial bank in both the adverse and standard scenarios, only the U-bond is issued. It is also interesting to notice that the bail-in barrier ($\max[V_{EB}, V_{RB}]$) is close and slightly above the default barrier in the default regime ($\max[V_{ED}, V_{RD}]$), but the actual default barrier in the bail-in regime is quite lower than in the default regime. This means that a going-concern bail-in allows to increase the expected total life span of the bank. As a consequence, the bank value is similar or slightly higher in the bail-in regime than in the default regime, thanks to a higher tax shield and lower bankruptcy costs. The bank value is unsurprisingly lower than in the bail-out regime, as it does not include the positive expected value of a government subsidy. For both the banks considered and for all values of α, the credit spreads of the U-bond are lower in the bail-in regime than in all other resolution regimes.

However, when the bail-in regime is not credible, as under the mixed regime in the last three columns of Table 3a, the optimal leverage becomes even higher than under the bail-out regime and the levels of CET1 and Tier1 regulatory capital decrease even further. This is because, although combined with the bail-in tool, the implicit guarantee given by the possibility of a bail-out incentivizes the shareholders to implement a riskier capital structure. Because of this, the endogenous bail-in barrier significantly increases, anticipating the moment of a potential bail-out.

In Table 4, we perform a comparative static analysis with respect to variations in the volatility of the cash-flows σ. Focusing on Panel (a), it can be noticed that an increase of σ leads to qualitatively similar results to a decrease of α, as both correspond to a worsening of the business conditions. Indeed, when σ increases, in the default regime there is a decrease of leverage, in an attempt of lowering the default barrier and thus reducing expected bankruptcy costs, and an increase of the credit spread of the U-bond. In the bail-out and mixed regimes there is instead an increase of leverage, as the shareholders seek for an increase of the value of the bail-out option implicitly held by the bank at government expenses. Finally, a credible bail-in regime leads to a mitigation of the leverage ratio with respect to the bail-out regime, to an increase of the fraction of U-bonds with respect to the total debt issued, as well as to lower credit spreads than in all other regimes.

In Table 5, we study the impact on the optimal liability structure of the default-free interest rate r, which can be considered as an indicator of the general market conditions. In Panel (a), similar to an improvement of the business conditions (increasing α in Table 3a), an increase of r entails an increase of the optimal market leverage and of the bank value, thanks to a higher tax shield and a lower present value of bankruptcy costs. Because of an increasing default barrier, the U-bond credit spread is also increasing in r. When the bail-out regime is in force, however, the leverage strongly increases and the expected value of the government subsidy also increases when r decreases. This also leads to an increase of the U-bond credit spread. Interestingly, the bail-in regime can not be applied to the investment bank when $r = 4\%$, as the market value of the U-bond converted in equity would be lower than the bail-in costs that U-bondholders would have to suffer. This means that bail-in does not take place and the optimal capital structure coincides with that obtained for the default regime. For the other values of r the bail-in can be applied. It is effective in reducing leverage with respect to the bail-out regime, while increasing the bank value with respect to the default regime, thanks to a higher expected tax shield and lower bankruptcy costs. In the mixed regime, as in the other analyses, the possibility of a government intervention implies a partial softening of the benefits of bail-in.

Finally, Table 6 shows the impact of variations of the risk-adjusted probability of government intervention p, which does not intervene in the default and bail-in regimes, but plays a crucial role in the bail-out and mixed regimes. As can be noticed, for both banks the leverage is extremely sensitive to the market belief of bail-out. For the commercial bank, the leverage skyrockets to more than 99% in both the bail-out and the default regimes when $p = 50\%$. The results obtained for the mixed regime highlight the importance of the credibility of the bail-in resolution mechanism and of a market perception of unlikelihood of bail-out events. In particular, even for a low risk-adjusted probability of government intervention ($p = 10\%$), it turns out that the optimal leverage in the mixed regime is rather higher than the leverage obtained for the bail-in regime, significantly reducing the risk-mitigating effects of the bail-in resolution framework.

3.2 Impact of a tight capital requirement

The Basel III international framework, effective on January 1, 2013, imposed banks to satisfy also the requirement of a minimum CET1 capital ratio, which is typically more stringent than the requirement of a minimum Tier1 ratio. Differing from the previous literature, which considered only a minimum Tier1 ratio (Sundaresan and Wang, 2017), we want to assess the impact of this additional requirement. Under the same hypotheses made in the previous paragraph, we report the optimal debt structure under the combined Tier1&CET1 capital requirement in Panel (b) of Tables 3 to 6.

In Table 3, comparing Panel (b) to Panel (a), the most evident effect is a very strong reduction of the leverage ratios in all resolution regimes and market scenarios. Especially in the adverse scenario ($\alpha = 2\%$), for all resolution regimes there are low incentives to issue debt and the leverage ratios are very close to the minimum possible value for the commercial bank (40%) and even lower for the investment bank. The bail-in regime is characterized by higher leverage ratios than the other regimes and in most scenarios leads to higher bank values than the bail-out regime, which under tight capital requirements benefits little from the government subsidy. In all regimes, due to the lower tax shield effect, the bank values are always below 120 and often close to the initial asset value (100), thus significantly lower than those in Panel (a). As opposed to when a Tier1 requirement is imposed, the default barrier is lowered and default is postponed in almost all cases, but the effect is particularly evident in the base case and adverse scenarios when a government intervention is plausible (bail-out and mixed regimes). As an extreme example, in the adverse scenario in the bail-out regime, the leverage ratio for an investment bank drops from 99.4% to 30.4% and the default barrier drops from 91.1 in Panel (a) to 34.5 in Panel (b). This significantly increases the time-to-default or bail-out and the consequent extraction of value from the government. These effects are present even when the market belief of government intervention p is increased, as can be noticed in Table 6b. Overall, a strict obligation of having more equity capital, through a constant combined monitoring of both the Tier1 and CET1 capital ratios, implies a significant risk-mitigation effect. Furthermore, in Table 3b, even under the bail-out regime, the optimal leverage decreases when market conditions worsen, rather than increasing as in Table 3a. This is evident also in Tables 4b and 5b, where in all resolution regimes the leverage is respectively decreasing in σ and increasing in r.

In Table 3, it appears that the additional risk-mitigation effect in the bail-in regime under the Tier1&CET1 requirement is milder than under the Tier1 requirement also in the base case ($\alpha = 4\%$) and favorable ($\alpha = 6\%$) scenarios. It mostly consists of a lower default barrier and to a consequent increase of the time-to-default, rather than of a reduction of the leverage ratios. A requirement on the minimum CET1 introduces by itself a very high risk-mitigation effect, even stronger than the introduction of the bail-in regime under a Tier1 requirement. However, by strongly reducing the leverage ratio, it also reduces the tax shield and, as a consequence, the bank value, which is between 109 and 112 in the base case scenario in Table 3b, as opposed to between 121 and 132 in Table 3a. Especially under the base case and favorable scenarios, for both the commercial and the investment bank, a remarkable result shows up: under the bail-in and mixed regimes, the market values of U-bonds are higher than their book values, technically making the credit spreads negative. This is caused by the possibility of conversion of U-bonds into equity, which entails an upside potential that regular bonds do not have.[9] This fact tends to increase the bank value even above the levels obtainable under the default and bail-out regimes, and can be noticed also for low levels of the EBIT volatility in Table 4b and for high levels of the default-free rate in Table 5b.

3.3 Introduction of a fair deposit insurance premium

In this paragraph, we carry out an important robustness check as, along the lines of Sundaresan and Wang (2017), we extend the baseline analysis by considering the case where the continuous proportional insurance premium φ is such that the net insurance value, for which we provide the formula under the different resolution regimes in Appendix G, is equal to zero. This makes the insurance premium to be fair for both the bank and the insurer.

Table 7 shows a comparative static analysis with respect to variations in the growth prospects α. As can be noticed, the value of φ depends on the resolution regime and the

[9] Note that in these cases, the sign of the government subsidy may even be negative, as a bail-out at the bail-in barrier prevents U-bondholders from accessing this upside potential.

business conditions, while the net insurance value is identically equal to zero. Focusing on Panel (a) for the commercial bank, where the effect of deposits is most important, in the default regime the fair premium increases with worsening business conditions (lower α), and the fair premium for the insurance fee in the base case scenario (14.4bps) is very close to the fixed value used in the baseline analysis (15.0bps). All relevant results discussed in Section 3.1 are maintained. For example, there is an increase of leverage in the bail-out regime as opposed to the default regime, although the increase of the insurance cost corresponding to adverse business conditions seems to slightly reduce the extreme effects in Table 7a. Corresponding to the bail-in regime, both a mitigation of leverage and an increase of the expected time-to-default can be noticed. Finally, in Panel (b) it is evident that the introduction of a CET1 capital requirement implies again a strong reduction of leverage for all resolution regimes.

4 Conclusions

We carefully study the effects of different ex-ante capital regulatory requirements and ex-post resolution frameworks on the optimal bank liability structure. We consider banks with different amounts of deposits (a commercial and an investment bank), and identify the optimal issuance policies of covered and uncovered debt under different market scenarios. Our analytically-tractable bank liability structure model is able to handle the richness of the bank non-deposit debt structure, as well as the credibility of the bail-in resolution regime, which are issues that have not been treated by the existing literature.

Our analysis offers an optimal capital structure rationale for a credible implementation of the bail-in resolution framework. Once a credible bail-in regime is in force, the endogenous optimal liability structure chosen by the shareholders implies a significantly lower level of leverage if compared to the liability structure chosen under a bail-out regime, even without the imposition of tight capital constraints. The reason is that shareholders internalize, in their objective function, what happens to holders of uncovered (bail-inable) bonds when bail-in is applied. Since the costs of bank failures, which are not covered by the government anymore, are shifted to equityholders and some debtholders, according to a well-defined hierarchy, it turns out that equity and bond prices are more sensitive to bank risk. This allows to restore market discipline, by more closely aligning bank funding costs with risks.

For our study of the joint impact of capital requirements and resolution regimes on the optimal issuance of bank corporate securities, the choice of the non-deposit debt mix is markedly relevant as, unlike uncovered debt, covered bonds do not contribute to any measure of regulatory capital and are not bail-inable. The benefits of postponing the final default event and of supporting the Tier1 capital requirement favor the issuance of uncovered bail-inable debt. However, the strategic use of the deposit insurance favors the issuance of covered bonds, which have a first priority on the bank's assets. The optimal covered/uncovered debt mix results from balancing this trade-off.

By considering also a mixed regime, in which there is the chance that the government may bail the bank out even in the presence of bail-inable debt, we show that the credibility of the bail-in tool is essential. Indeed, even for a relatively small risk-adjusted probability of bail-out, moral hazard becomes relevant: the incentives for shareholders to raise leverage and to take advantage of the implicit government guarantee significantly affect the optimal debt structure.

Our results importantly contribute to the debate on the incentives generated by tight ex-ante capital requirements versus credible ex-post resolution mechanisms. We show that the imposition of tight capital requirements, such as a minimum CET1 ratio, can be very effective in reducing leverage, mitigating default risk and making liabilityholders more risk-sensitive. Stringent capital requirements, irrespective of the resolution regime, force shareholders to add more *skin in the game*, leading to markedly polar situations with a very low optimal non-deposit leverage.

While making a fresh contribution to the interesting and fast-growing literature on the optimal leverage of regulated financial intermediaries, our analysis leads to a number of avenues for future research, ranging from an even richer capital structure (e.g. adding subordinated debt), to the consideration of more flexible processes for the bank cash-flows as well as of non-leverage risk-enhancing behavior (e.g. asset substitution).

Appendix

A Continous-time processes for EBIT and asset value

As in Goldstein et al. (2001), the EBIT process follows a geometric Brownian motion under the objective probability measure $\mathbb{P}$:

$$\frac{dX}{X} = \alpha \mathrm{d}t + \sigma \mathrm{d}W.$$

Given a constant market price of EBIT risk λ, the EBIT process under the risk-neutral probability measure $\mathbb{Q}$ is:

$$\frac{dX}{X} = (\alpha - \sigma\lambda)\,\mathrm{d}t + \sigma \mathrm{d}W^{\mathbb{Q}}.$$

At any time t, we interpret the after-tax claim over future EBIT X_s $(s > t)$ as the current asset value V_t:[10]

$$V_t = \mathrm{E}_t^{\mathbb{Q}}\left[\int_t^{+\infty} e^{-r(s-t)}\,(1-\tau)\,X_s \mathrm{d}s\right] = \frac{1-\tau}{r+\sigma\lambda-\alpha} X_t.$$

The denominator, $r+\sigma\lambda-\alpha$, must be strictly positive. The instantaneous after-tax cash-flow, $(1-\tau)\,X$, is thus proportional to the asset value:

$$(1-\tau)\,X = (r+\sigma\lambda-\alpha)\,V.$$

Therefore, if the cash-flow process follows a geometric Brownian motion with volatility σ, also the asset value follows a similar process. The asset value process under $\mathbb{P}$ is:

$$\frac{dV}{V} = \alpha \mathrm{d}t + \sigma \mathrm{d}W, \tag{9}$$

[10] In the rest of the paper, we dropped the time subscript for ease of notation.

while under the risk neutral measure $\mathbb{Q}$ it is:

$$\frac{dV}{V} = (\alpha - \sigma\lambda)\,\mathrm{d}t + \sigma \mathrm{d}W^{\mathbb{Q}}. \tag{10}$$

B Perpetual bond valuation

Denote the coupon payment of a generic perpetual debt contract with b, the book value of the contract, equal to its default-free valuation, with $B = \frac{b}{r}$ and its market value with $\mathcal{B}$. The debt value does not depend explicitly on time, but only on the state variable V, which dynamics under $\mathbb{Q}$ is in (10). Applying Itô's lemma to the market value $\mathcal{B}$ and imposing no-arbitrage restrictions, the following equation is obtained:

$$\frac{1}{2}\sigma^2 V^2 \mathcal{B}_{VV} + (\alpha - \sigma\lambda)V\mathcal{B}_V + b = r\mathcal{B}. \tag{11}$$

Two boundary conditions can be imposed. The first is evaluated at the threshold asset value V_T, corresponding to which the firm fails to serve debt obligations and the recovery value of debt, $\mathcal{B}_T$, is paid to the claimants:

$$\mathcal{B}(V = V_T) = \mathcal{B}_T. \tag{12}$$

The second boundary condition imposes that, when the asset value tends to infinity, the debt is default-free:

$$\lim_{V\to\infty} \mathcal{B} = \frac{b}{r} = B. \tag{13}$$

The pricing formula for a perpetual debt contract defaulting at the asset value V_T is:

$$\mathcal{B} = B - (B - \mathcal{B}_T)\left[\frac{V}{V_T}\right]^{\gamma}, \tag{14}$$

where $\left[\frac{V}{V_T}\right]^{\gamma}$ is the value of a security that pays 1 when the trigger event occurs. It can be verified that (14) solves (11) and satisfies the boundary conditions (12) and (13) when:

$$\gamma = -\left(\frac{\alpha-\sigma\lambda}{\sigma^2}-\frac{1}{2}\right)-\sqrt{\left(\frac{\alpha-\sigma\lambda}{\sigma^2}-\frac{1}{2}\right)^2+2\frac{r}{\sigma^2}}. \tag{15}$$

C Equity valuation

As for debt contracts, the equity value does not depend explicitly on time, but only on the state variable V, which dynamics under $\mathbb{Q}$ is in (10). The equity contract continuously pays the after-tax EBIT, $(1-\tau)X = (r+\sigma\lambda-\alpha)V$, deducted liability payments, which for the time being we generically identify with a continuous coupon b and that generate a positive tax shield $b\tau$. Applying Itô's lemma to the market value of equity $\mathcal{S}$ and imposing no-arbitrage restrictions, the following equation is obtained:

$$\frac{1}{2}\sigma^2V^2\mathcal{S}_{VV}+(\alpha-\sigma\lambda)V\mathcal{S}_V+(r+\sigma\lambda-\alpha)V-b(1-\tau)=r\mathcal{S}. \tag{16}$$

Two boundary conditions can be imposed. The first is evaluated at the asset value V_T, corresponding to which the firm fails to serve debt obligations and the equity value is wiped out:

$$\mathcal{S}(V=V_T)=0. \tag{17}$$

The second boundary condition imposes that, when the asset value tends to infinity, the firm will never default in serving debt obligations, and thus, for $B=\frac{b}{r}$, the equity value is asymptotic to $V-(1-\tau)B$:

$$\lim_{V\longrightarrow+\infty}\frac{\mathcal{S}}{V-(1-\tau)B}=1. \tag{18}$$

For an asset value triggering default in debt services equal to V_T, the equity value is:

$$\mathcal{S}=V-V_T\left[\frac{V}{V_T}\right]^{\gamma}-(1-\tau)B\left(1-\left[\frac{V}{V_T}\right]^{\gamma}\right), \tag{19}$$

where $\left[\frac{V}{V_T}\right]^\gamma$ is the value of a security that pays 1 when the trigger event occurs. It can be verified that (16) solves (11) and satisfies the boundary conditions (17) and (18) when γ is equal to the value in (15).

D Proof of Theorem 1 (pricing under bail-in regime)

Before bail-in is triggered at an asset level V_B, the equityholders must obey a continuous payment of the interests on deposits $d = rD$, the insurance premium $i = \varphi D$, as well as the coupons of the C-bond, c, and U-bond, u. The total book value of these liabilities is $D + I + C + U$, which we substitute in (16), together with the bail-in trigger level V_B to obtain the equity value before bail-in:

$$\mathcal{S} = V - V_B \left[\frac{V}{V_B}\right]^\gamma - (1-\tau)(D + I + C + U)\left(1 - \left[\frac{V}{V_B}\right]^\gamma\right). \tag{20}$$

The bail-in boundary can be endogenously chosen by the equityholders (V_{EB}) or exogenously imposed by the regulator (V_{RB}). While the regulatory boundaries are specified in Section 2.1, as in Leland (1994) the optimal endogenous bail-in boundary V_{EB} can be determined by invoking the smooth-pasting condition $\frac{\partial \mathcal{S}}{\partial V}\big|_{V=V_B^*} = 0$:

$$V_{EB} = V_B^* = \frac{\gamma}{\gamma - 1}(1-\tau)(D + I + C + U). \tag{21}$$

The bail-in boundary is given by the most stringent between the endogenous and regulatory barriers, i.e. $V_B = \max[V_{EB}, V_{RB}]$.

After bail-in (provided that it is applicable), the U-bondholders are the new equityholders. We denote the market value of this equity claim with $\widehat{\mathcal{S}}$. When V reaches the default trigger V_D, determined as $\max[V_{ED}, V_{RD}]$, also the amount of equity after bail-in $\widehat{\mathcal{S}}$ is lost and the bank fails. The total book value of deposits and debt after bail-in is $D + I + C$, which we substitute in (16), together with the default trigger level V_D to obtain the equity value after bail-in:

$$\widehat{\mathcal{S}} = V - V_D \left[\frac{V}{V_D}\right]^{\gamma} - (1-\tau)(D+I+C)\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right). \tag{22}$$

Invoking the smooth-pasting condition $\left.\frac{\partial \widehat{\mathcal{S}}}{\partial V}\right|_{V=V_D^*} = 0$, the endogenous default boundary is:

$$V_{ED} = V_D^* = \frac{\gamma}{\gamma - 1}(1-\tau)(D+I+C). \tag{23}$$

In order to price the uncovered bond before bail-in, we proceed by backward induction. The equity value for the new shareholders when V_B is reached and the bail-in tool can be applied is $\widehat{\mathcal{S}}(V = V_B)$. When bail-in occurs, the U-bondholders are liable for the restructuring costs, ξV_B, and U-bonds are converted into equity. When bail-in is applicable, the U-bond value for $V \to V_B^+$ is thus $\widehat{\mathcal{S}}(V = V_B) - \xi V_B$. When bail-in is not applicable, default takes place and U-bondholders receive the part of asset value net of bankruptcy costs and after C-bond and deposits have been repaid, that is $\min\left[U, [(1-\varepsilon)V_B - D - C]^+\right]$. This means that the value of the U-bond at V_B is equal to:

$$\mathcal{U}_B = \begin{cases} \widehat{\mathcal{S}}(V = V_B) - \xi V_B & \text{if bail-in is applicable} \\ \min\left[U, [(1-\varepsilon)V_B - D - C]^+\right] & \text{otherwise.} \end{cases}$$

The bail-in is applicable if $\widehat{\mathcal{S}}(V = V_B) - \xi V_B > 0$ (limited liability of U-bondholders) and $V_B - [D + C] \geq \psi V_B$ (CET1 capital requirement is satisfied after bail-in), otherwise the bank defaults when the asset value reaches the bail-in barrier V_B. This means that the default barrier V_D is:

$$V_D = \begin{cases} \max\left[V_{ED}, V_{RD}\right] & \text{if bail-in is applicable} \\ V_B & \text{otherwise.} \end{cases}$$

Applying (14) to a bond with face value U, trigger asset level V_B and residual value $\mathcal{U}_B$, the U-bond price is obtained:

$$\mathcal{U} = U - (U - \mathcal{U}_B)\left[\frac{V}{V_B}\right]^{\gamma}.$$

The default level for the C-bond is V_D. At default, C-bondholders receive the minimum between the face value C and the value of the assets net of bankruptcy costs:

$$\mathcal{C}_D = \min\left[C, V_D\left(1-\varepsilon\right)\right].$$

The C-bond price is obtained applying again (14):

$$\mathcal{C} = C - \left(C - \mathcal{C}_D\right)\left[\frac{V}{V_D}\right]^{\gamma}.$$

E Proof of Theorem 2 (pricing under bail-out regime)

The equity pricing formula is the same as in Appendix D, the only difference being the trigger event, which is in this case default and occurs at the asset value V_D:

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

The endogenous default boundary V_{ED} can be determined again by invoking the smooth-pasting condition $\frac{\partial \mathcal{S}}{\partial V}\Big|_{V=V_D^*} = 0$:

$$V_{ED} = V_D^* = \frac{\gamma}{\gamma-1}\left(1-\tau\right)\left(D+I+C+U\right).$$

Considering also the presence of a regulatory default barrier, which we discuss in Section 2.2, the actual default barrier is thus $V_D = \max\left[V_{ED}, V_{RD}\right]$.

The pricing of both types of bond is different than in the bail-in regime. Under the bail-out regime, with a risk-adjusted probability equal to p, there is a government bail-out at default, while with a probability equal to $(1-p)$ there is no intervention. For $p = 1$, the government intervenes to ensure that the entire face value of the bonds is reimbursed at default. This condition implies that both bonds become risk-less and their market values coincide with their book values. For $p = 0$, instead, there is no government intervention and the recovery values at default for the two bonds are respectively:

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

The market values of U- and C-bonds are given by a weighted average of the equivalent default-free values (respectively U and C), with weight p, and the defaultable bond values that can be obtained using the pricing formulae in Appendix B, with weight $1-p$. This leads to:

$$\begin{aligned}
\mathcal{U} &= U - (1-p)(U - \mathcal{U}_D)\left[\frac{V}{V_D}\right]^\gamma, \\
\mathcal{C} &= C - (1-p)(C - \mathcal{C}_D)\left[\frac{V}{V_D}\right]^\gamma.
\end{aligned}$$

F Proof of Theorem 3 (pricing under mixed regime)

The equity value $\mathcal{S}$ is the same as in (20), where $V_B = \max\left[V_{EB}, V_{RB}\right]$. The same applies to the equity value after bail-in, $\widehat{\mathcal{S}}$, which is the same as in (22), where $V_D = \max\left[V_{ED}, V_{RD}\right]$. The endogenous barriers V_{EB} and V_{ED} are respectively given in (21) and (23).

The bond valuation is instead different from the previous frameworks. $p_1 \in [0, 1]$ is the risk-adjusted probability of a government bail-out when the bail-in boundary V_B is reached, while $p_2 \in [0, 1]$ is the risk-adjusted probability of a government bail-out when the default boundary V_D is reached.

By construction, if $p_1 = p_2 = 0$, the results are the same of the *credible* bail-in case discussed in Section 2.1 and derived in Appendix D. For $p_1 \neq 0$ and $p_2 \neq 0$, the price for U- and C-bonds are given by a weighted average of the default-free bond values (respectively U and C), with weights equal to the total probability of bail-out for the specific bond (p_1 for the U-bond and $p_1 + (1 - p_1)\, p_2$ for the C-bond), and the defaultable bond values obtained for the bail-in regime given in Theorem 1, with weights equal to the probability of not being bailed-out ($1 - p_1$ for the U-bond and $(1 - p_1)\,(1 - p_2)$ for the C-bond). After some simple algebra, this leads to the following bond prices:

$$\begin{aligned}\mathcal{C} &= C - (1 - p_1)\,(1 - p_2)\,(C - \mathcal{C}_D) \left[\frac{V}{V_D}\right]^{\gamma}, \\ \mathcal{U} &= U - (1 - p_1)\,(U - \mathcal{U}_B) \left[\frac{V}{V_B}\right]^{\gamma}.\end{aligned}$$

G Bank value decomposition

We have already expressed the bank value $\mathcal{BV}$ as the sum of the market values of the liabilities. It is useful to decompose the bank value also in terms of the net present value of the tax shield ($\mathcal{TS}$), of the bankruptcy/bail-in costs ($\mathcal{BC}$), of the government subsidy ($\mathcal{GS}$), which is non-zero when bail-out can happen, and, finally, of the net insurance value ($\mathcal{NIV}$), that is the net worth for the bank of the deposit insurance contract. The bank value can be expressed as:

$$\mathcal{BV} = V + \mathcal{TS} - \mathcal{BC} + \mathcal{GS} + \mathcal{NIV}.$$

Under the default and bail-out regimes, it turns out that:

$$\begin{aligned}\mathcal{TS} &= \tau\,(D + I + C + U) \left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right), \\ \mathcal{BC} &= \varepsilon V_D \left[\frac{V}{V_D}\right]^{\gamma}, \\ \mathcal{GS} &= p\,(C - \mathcal{C}_D + U - \mathcal{U}_D) \left[\frac{V}{V_D}\right]^{\gamma}, \\ \mathcal{NIV} &= \left(D - \min\left(D, [(1 - \varepsilon)\, V_D - C]^{+}\right)\right) \left[\frac{V}{V_D}\right]^{\gamma} - I \left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right).\end{aligned}$$

Under the bail-in regime, when bail-in is feasible, the components of the bank value are:

$$
\begin{aligned}
\mathcal{TS} &= \tau U \left(1-\left[\frac{V}{V_B}\right]^{\gamma}\right) + \tau \left(D+I+C\right) \left(1-\left[\frac{V}{V_D}\right]^{\gamma}\right), \\
\mathcal{BC} &= \varepsilon V_D \left[\frac{V}{V_D}\right]^{\gamma} + \xi V_B \left[\frac{V}{V_B}\right]^{\gamma}, \\
\mathcal{GS} &= 0, \\
\mathcal{NIV} &= \left(D - \min\left(D, [(1-\varepsilon) V_D - C]^{+}\right)\right) \left[\frac{V}{V_D}\right]^{\gamma} - I \left(1-\left[\frac{V}{V_D}\right]^{\gamma}\right).
\end{aligned}
$$

Finally, under the mixed regime, when bail-in is feasible, the components are:

$$
\begin{aligned}
\mathcal{TS} &= \tau U \left(1-\left[\frac{V}{V_B}\right]^{\gamma}\right) + \tau \left(D+I+C\right) \left(1-\left(1-p_1\right)\left[\frac{V}{V_D}\right]^{\gamma} - p_1 \left[\frac{V}{V_B}\right]^{\gamma}\right), \\
\mathcal{BC} &= \left(1-p_1\right) \left(\varepsilon V_D \left[\frac{V}{V_D}\right]^{\gamma} + \xi V_B \left[\frac{V}{V_B}\right]^{\gamma}\right) + p_1 \varepsilon V_B \left[\frac{V}{V_B}\right]^{\gamma}, \\
\mathcal{GS} &= -\left(1-p_1\right)\left(1-p_2\right)\left(C-\mathcal{C}_D\right)\left[\frac{V}{V_D}\right]^{\gamma} - \left(1-p_1\right)\left(U-\mathcal{U}_B\right)\left[\frac{V}{V_B}\right]^{\gamma} \\
&\quad + \left(D+I+C+U\right)\left[\frac{V}{V_B}\right]^{\gamma} + \left(1-p_1\right)\tau\left(D+I+C\right)\left(\left[\frac{V}{V_D}\right]^{\gamma} - \left[\frac{V}{V_B}\right]^{\gamma}\right) \\
&\quad - \left(1-p_1\varepsilon\right) V_B \left[\frac{V}{V_B}\right]^{\gamma} + \left(1-p_1\right)\left(\varepsilon V_D \left[\frac{V}{V_D}\right]^{\gamma} + \xi V_B \left[\frac{V}{V_B}\right]^{\gamma}\right) \\
&\quad - \left(1-p_1\right)\left(D+I\right)\left[\frac{V}{V_D}\right]^{\gamma} - p_1\left(D+I\right)\left[\frac{V}{V_B}\right]^{\gamma} \\
&\quad - p_1 \left(\min\left(D, [(1-\varepsilon) V_D - C]^{+}\right)\left[\frac{V}{V_D}\right]^{\gamma} - \min\left(D, [(1-\varepsilon) V_B - C]^{+}\right)\left[\frac{V}{V_B}\right]^{\gamma}\right), \\
\mathcal{NIV} &= \left(1-p_1\right)\left(\left(D - \min\left(D, [(1-\varepsilon) V_D - C]^{+}\right)\right)\left[\frac{V}{V_D}\right]^{\gamma} - I\left(1-\left[\frac{V}{V_D}\right]^{\gamma}\right)\right) \\
&\quad + p_1 \left(\left(D - \min\left(D, [(1-\varepsilon) V_B - C]^{+}\right)\right)\left[\frac{V}{V_B}\right]^{\gamma} - I\left(1-\left[\frac{V}{V_B}\right]^{\gamma}\right)\right).
\end{aligned}
$$

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Table 1: Bank balance sheet

<table>
<tr><th>Assets</th><th>Liabilities</th></tr>
<tr><td rowspan="2">Asset value V</td><td>Covered bonds $\mathcal{C}$
(tax advantage)
(bankruptcy costs)
(not bail-inable)

Deposits $\mathcal{D}$
(tax advantage)
(insurance premium cost)

Uncovered bonds $\mathcal{U}$
(tax advantage)
(bail-in costs)
(bail-inable)</td></tr>
<tr><td rowspan="2">Equity $\mathcal{S}$</td></tr>
<tr><td>Charter value $(\mathcal{BV} - V)$</td></tr>
<tr><td colspan="2">Bank value $\mathcal{BV} = \mathcal{D} + \mathcal{C} + \mathcal{U} + \mathcal{S}$</td></tr>
</table>

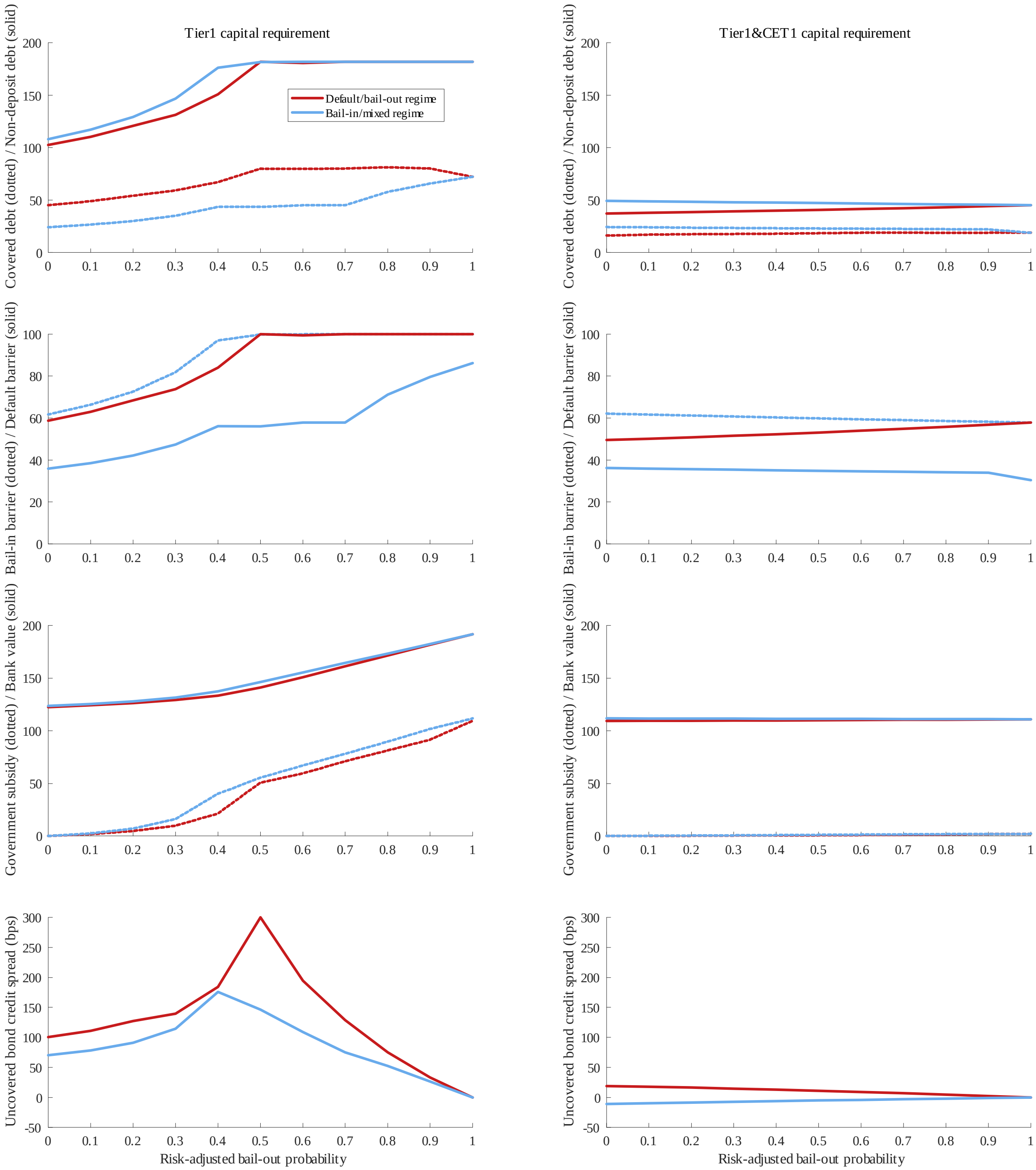
The table shows the asset and liability sides of the balance sheet of the bank considered in the paper. The bank value $\mathcal{BV}$ is given by the sum of the market values of the liabilities.

Table 2: Parameter values

Parameter	Symbol	Base case	Comparative statics
Cash-flow growth prospects	α	4%	$2\%, 4\%, 6\%$
Cash-flow volatility	σ	8%	$6\%, 8\%, 10\%$
Market price of risk	λ	0.5	
Risk-free interest rate	r	3%	$1\%, 3\%, 5\%$
Insurance premium	φ	0.15%	
Corporate tax rate	τ	28%	
Bankruptcy costs	ε	20%	
Bail-in costs	ξ	10%	
Minimum Tier1 capital ratio	β	6%	
Minimum CET1 capital ratio	ψ	4.5%	
Risk-adjusted probability of bail-out	p, p_1, p_2	30%	$10\%, 30\%, 50\%$
Insured deposits amount	D	10 (IB), 40 (CB)	
Initial asset value	V_0	100	

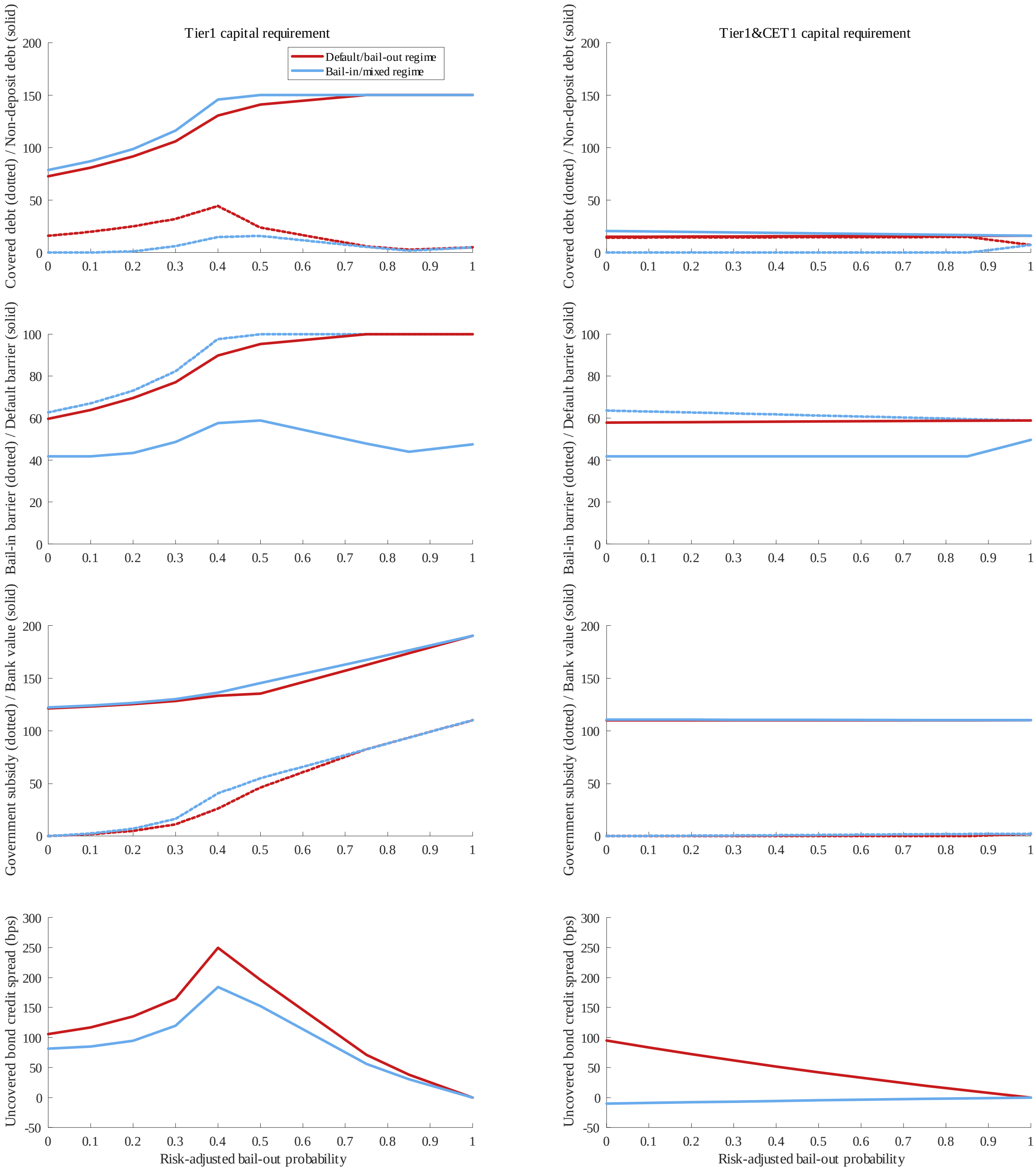
The table shows the base case parameter values, as well as the values of the parameters used for the comparative static analyses. IB stands for investment bank, CB for commercial bank.

Figure 1: Key aspects of an investment bank's optimal capital structure as a function of the risk-adjusted bail-out probability (p)



The level of deposits is $D = 10$. The initial asset value is $V_0 = 100$. Covered and total non-deposit debt are expressed in terms of book value. The expected present value of the government subsidy and the total bank value are market values.

Figure 2: Key aspects of a commercial bank's optimal capital structure as a function of the risk-adjusted bail-out probability (p)



The level of deposits is $D = 40$. The initial asset value is $V_0 = 100$. Covered and total non-deposit debt are expressed in terms of book value. The expected present value of the government subsidy and the total bank value are market values.

Table 3: Optimal liability structure for different growth prospects (α)

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Growth prospects α	2%	4%	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%
Commercial bank ($D = 40$)												
C-bond book value (C)	6.5	16.1	28.3	52.2	32.4	19.7	0.0	0.0	12.6	4.6	6.5	17.1
U-bond book value (U)	81.5	56.6	45.8	163.6	73.6	58.3	95.5	78.6	66.3	216.3	109.7	72.2
Total bond book value ($C + U$)	88.0	72.7	74.1	215.8	106.0	78.0	95.5	78.6	79.0	220.9	116.2	89.3
CET1 capital ratio (%)	-28.0	-12.7	-14.1	-155.8	-46.0	-18.0	-35.5	-18.6	-19.0	-160.9	-56.2	-29.3
Tier1 capital ratio (%)	53.5	43.9	31.7	7.8	27.6	40.3	60.0	60.0	47.4	55.4	53.5	42.9
C-bond market value ($\mathcal{C}$)	6.5	16.1	28.3	52.2	32.4	19.7	0.0	0.0	12.6	4.6	6.5	17.1
U-bond market value ($\mathcal{U}$)	44.5	41.9	40.3	51.6	47.5	52.3	53.1	61.8	60.2	100.5	78.5	64.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	51.0	57.9	68.6	103.7	79.9	72.0	53.1	61.8	72.8	105.1	85.0	81.2
Equity market value ($\mathcal{S}$)	26.5	23.4	17.7	0.0	8.4	15.3	23.6	20.3	14.7	0.0	5.1	8.8
Total bank value ($\mathcal{BV}$)	117.4	121.3	126.3	143.8	128.3	127.2	116.6	122.2	127.5	145.1	130.1	130.0
Total leverage (%)	77.5	80.7	86.0	100.0	93.4	88.0	79.8	83.4	88.5	100.0	96.1	93.2
Tax shield	19.9	23.7	28.6	1.6	20.5	28.6	21.1	26.0	30.7	5.2	21.9	29.6
Bail-in and bankruptcy costs	4.5	3.1	1.7	19.2	7.8	2.2	5.7	2.7	1.4	15.8	7.5	3.2
Government bail-out subsidy	0.0	0.0	0.0	48.0	11.2	2.6	0.0	0.0	0.0	54.3	16.3	5.2
Net insurance value	2.1	0.7	-0.5	13.4	4.5	-1.7	1.2	-1.1	-1.8	1.4	-0.6	-1.6
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	52.3	62.7	75.7	100.0	82.3	82.2
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	42.6	42.6	56.0	47.4	49.5	60.7
Endogenous default barrier (V_{ED})	49.4	59.6	72.7	98.0	77.0	75.1	16.0	21.8	34.2	17.7	25.2	37.0
Regulatory default barrier (V_{RD})	49.4	59.6	72.7	98.0	77.0	63.5	41.9	41.9	55.1	46.7	48.7	59.8
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	249.8	105.7	40.7	651.6	164.7	34.7	240.2	81.4	30.9	345.6	119.4	38.0
Investment bank ($D = 10$)												
C-bond book value (C)	35.0	45.3	57.6	48.4	59.2	61.8	11.4	24.2	42.1	33.0	35.3	46.5
U-bond book value (U)	80.4	57.3	46.9	180.6	72.1	51.1	107.2	83.9	68.1	219.4	111.4	74.0
Total bond book value ($C + U$)	115.4	102.5	104.5	229.0	131.4	112.9	118.6	108.2	110.2	252.4	146.7	120.4
CET1 capital ratio (%)	-25.4	-12.5	-14.5	-139.0	-41.4	-22.9	-28.6	-18.2	-20.2	-162.4	-56.7	-30.4
Tier1 capital ratio (%)	55.0	44.7	32.4	41.6	30.8	28.2	78.6	65.8	47.9	57.0	54.7	43.5
C-bond market value ($\mathcal{C}$)	35.0	45.3	57.6	48.4	59.2	61.8	11.4	24.2	42.1	33.0	35.3	46.5
U-bond market value ($\mathcal{U}$)	45.1	42.9	41.7	75.8	49.2	44.7	70.4	68.0	62.0	103.0	80.6	65.9
Total bond market value ($\mathcal{C} + \mathcal{U}$)	80.2	88.1	99.3	124.2	108.4	106.5	81.8	92.2	104.0	136.0	115.9	112.4
Equity market value ($\mathcal{S}$)	28.1	24.3	18.4	0.8	10.7	13.2	26.8	21.3	14.9	0.0	5.4	9.0
Total bank value ($\mathcal{BV}$)	118.3	122.4	127.7	135.1	129.1	129.7	118.7	123.5	128.9	146.0	131.3	131.4
Total leverage (%)	76.2	80.2	85.6	99.4	91.7	89.8	77.4	82.7	88.5	100.0	95.9	93.1
Tax shield	19.8	23.7	28.6	6.6	21.7	28.4	21.5	25.9	30.6	5.0	22.0	29.5
Bail-in and bankruptcy costs	4.2	2.9	1.6	16.4	6.7	2.8	3.1	2.3	1.4	15.6	7.2	3.1
Government bail-out subsidy	0.0	0.0	0.0	44.9	9.8	2.8	0.0	0.0	0.0	54.7	16.2	5.2
Net insurance value	2.7	1.7	0.7	0.0	4.3	1.4	0.2	-0.1	-0.3	1.8	0.4	-0.3
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	49.1	61.7	75.5	100.0	81.8	82.0
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	22.7	36.4	55.4	45.8	48.1	60.1
Endogenous default barrier (V_{ED})	47.9	58.8	72.0	91.1	73.8	77.3	8.3	18.1	32.9	16.6	23.8	35.7
Regulatory default barrier (V_{RD})	47.9	58.8	71.9	62.1	73.7	76.4	22.4	35.9	54.5	45.0	47.4	59.1
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	234.1	100.4	37.9	414.4	139.5	43.1	156.5	70.5	29.8	339.2	114.6	36.7

Table 3 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Growth prospects α	2%	4%	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%
Commercial bank ($D = 40$)												
C-bond book value (C)	2.3	14.4	11.0	2.6	14.7	11.5	0.0	0.0	13.5	0.0	0.0	12.5
U-bond book value (U)	0.7	0.9	14.0	0.7	0.9	14.6	10.8	20.8	20.0	9.1	19.4	19.6
Total bond book value ($C + U$)	3.0	15.2	25.1	3.3	15.5	26.1	10.8	20.8	33.6	9.1	19.4	32.1
CET1 capital ratio (%)	57.0	44.8	34.9	56.7	44.5	33.9	49.2	39.2	26.4	50.9	40.6	27.9
Tier1 capital ratio (%)	57.7	45.6	49.0	57.4	45.3	48.5	60.0	60.0	46.5	60.0	60.0	47.5
C-bond market value ($\mathcal{C}$)	2.3	14.4	11.0	2.6	14.7	11.5	0.0	0.0	13.5	0.0	0.0	12.5
U-bond market value ($\mathcal{U}$)	0.4	0.7	13.2	0.5	0.7	14.0	9.7	21.5	21.3	8.3	19.9	20.4
Total bond market value ($\mathcal{C} + \mathcal{U}$)	2.7	15.0	24.3	3.1	15.4	25.5	9.7	21.5	34.9	8.3	19.9	32.8
Equity market value ($\mathcal{S}$)	62.5	54.8	50.2	62.2	54.5	49.2	54.6	49.1	41.6	56.3	50.5	43.3
Total bank value ($\mathcal{BV}$)	105.2	109.8	114.4	105.2	109.9	114.7	104.3	110.6	116.5	104.6	110.4	116.1
Total leverage (%)	40.6	50.1	56.2	40.9	50.4	57.1	47.7	55.6	64.3	46.2	54.2	62.7
Tax shield	7.4	12.2	17.3	7.5	12.2	17.4	8.9	14.6	19.8	8.3	13.7	19.0
Bail-in and bankruptcy costs	3.7	2.8	1.1	3.7	2.8	1.2	5.8	2.8	1.6	5.4	3.0	1.6
Government bail-out subsidy	0.0	0.0	0.0	0.1	0.1	0.3	0.0	0.0	0.0	1.1	0.8	0.5
Net insurance value	1.4	0.4	-1.8	1.4	0.5	-1.8	1.2	-1.1	-1.8	0.5	-1.2	-1.8
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	20.1	32.7	47.3	19.4	32.0	46.4
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	53.1	63.7	77.0	51.4	62.2	75.5
Endogenous default barrier (V_{ED})	17.1	29.8	42.0	17.2	29.9	42.7	16.0	21.8	34.8	16.0	21.8	34.1
Regulatory default barrier (V_{RD})	45.0	57.8	68.1	45.3	58.2	69.3	41.9	41.9	56.1	41.9	41.9	54.9
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	207.3	95.1	18.7	121.6	61.8	14.0	31.6	-10.1	-18.3	27.9	-6.7	-11.4
Investment bank ($D = 10$)												
C-bond book value (C)	9.6	16.4	22.1	11.2	18.0	22.2	10.0	24.5	43.0	9.9	23.7	41.8
U-bond book value (U)	10.4	20.9	32.7	11.8	21.3	33.6	23.7	24.9	20.5	23.6	24.3	20.0
Total bond book value ($C + U$)	20.0	37.3	54.8	22.9	39.3	55.8	33.7	49.4	63.5	33.5	48.1	61.8
CET1 capital ratio (%)	70.0	52.7	35.2	67.1	50.7	34.2	56.3	40.6	26.5	56.5	41.9	28.2
Tier1 capital ratio (%)	80.4	73.6	67.9	78.8	72.0	67.8	80.0	65.5	47.0	80.1	66.3	48.2
C-bond market value ($\mathcal{C}$)	9.6	16.4	22.1	11.2	18.0	22.2	10.0	24.5	43.0	9.9	23.7	41.8
U-bond market value ($\mathcal{U}$)	9.1	19.6	31.9	10.6	20.3	33.0	23.8	25.8	21.9	23.7	24.9	20.9
Total bond market value ($\mathcal{C} + \mathcal{U}$)	18.7	36.1	54.0	21.8	38.3	55.2	33.7	50.4	65.0	33.5	48.7	62.7
Equity market value ($\mathcal{S}$)	75.5	63.2	51.4	72.8	61.4	50.5	62.4	51.3	42.6	62.6	52.7	44.4
Total bank value ($\mathcal{BV}$)	104.1	109.2	115.4	104.6	109.6	115.7	106.1	111.7	117.5	106.1	111.4	117.1
Total leverage (%)	27.5	42.2	55.4	30.4	44.0	56.4	41.2	54.1	63.8	41.0	52.7	62.1
Tax shield	6.2	11.2	16.9	6.5	11.4	17.0	8.6	14.1	19.4	8.2	13.3	18.6
Bail-in and bankruptcy costs	1.7	1.6	1.0	2.1	1.8	1.2	2.6	2.3	1.6	3.0	2.5	1.6
Government bail-out subsidy	0.0	0.0	0.0	0.5	0.4	0.3	0.0	0.0	0.0	0.9	0.8	0.5
Net insurance value	-0.4	-0.4	-0.5	-0.3	-0.4	-0.5	0.1	-0.1	-0.3	0.0	-0.2	-0.4
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	16.8	31.2	46.3	16.7	30.5	45.3
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	45.7	62.2	77.0	45.5	60.8	75.2
Endogenous default barrier (V_{ED})	11.6	24.9	40.9	12.7	25.9	41.5	7.8	18.2	33.5	7.7	17.8	32.8
Regulatory default barrier (V_{RD})	31.4	49.5	67.8	34.5	51.6	68.9	20.9	36.1	55.5	20.8	35.3	54.3
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	44.1	18.8	7.5	32.1	14.8	5.7	-0.8	-10.9	-19.9	-0.5	-7.3	-12.3

The table reports the optimal liability structure of the bank corresponding to different values of the growth prospects α in (1). In Panel (a) only a Tier1 capital requirement is imposed, in Panel (b) also a CET1 capital requirement is imposed. The top section refers to a commercial bank (deposits $D = 40$), the bottom section to an investment bank (deposits $D = 10$). In the bail-out and mixed regimes, the risk-adjusted probability of bail-out is $p = 30\%$. The initial asset value is $V_0 = 100$.

Table 4: Optimal liability structure for different EBIT volatilities (σ)

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Cash-flow volatility σ	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%
Commercial bank ($D = 40$)												
C-bond book value (C)	28.9	16.1	8.5	19.8	32.4	48.5	13.4	0.0	0.0	17.7	6.5	7.9
U-bond book value (U)	45.5	56.6	73.4	58.3	73.6	135.6	65.8	78.6	89.4	71.3	109.7	189.8
Total bond book value ($C + U$)	74.4	72.7	81.8	78.1	106.0	184.1	79.2	78.6	89.4	89.0	116.2	197.6
CET1 capital ratio (%)	-14.4	-12.7	-21.8	-18.1	-46.0	-124.1	-19.2	-18.6	-29.4	-29.0	-56.2	-137.6
Tier1 capital ratio (%)	31.1	43.9	51.5	40.2	27.6	11.5	46.6	60.0	60.0	42.3	53.5	52.1
C-bond market value ($\mathcal{C}$)	28.9	16.1	8.5	19.8	32.4	48.5	13.4	0.0	0.0	17.7	6.5	7.9
U-bond market value ($\mathcal{U}$)	40.3	41.9	43.8	52.5	47.5	48.2	59.8	61.8	55.1	63.6	78.5	91.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	69.2	57.9	52.3	72.3	79.9	96.7	73.3	61.8	55.1	81.3	85.0	98.9
Equity market value ($\mathcal{S}$)	17.4	23.4	26.0	15.1	8.4	0.4	14.4	20.3	22.8	8.8	5.1	0.0
Total bank value ($\mathcal{BV}$)	126.6	121.3	118.3	127.4	128.3	137.1	127.7	122.2	117.9	130.1	130.1	138.9
Total leverage (%)	86.2	80.7	78.0	88.1	93.4	99.7	88.7	83.4	80.6	93.2	96.1	100.0
Tax shield	28.8	23.7	20.7	28.8	20.5	5.0	30.9	26.0	22.3	29.8	21.9	6.1
Bail-in and bankruptcy costs	1.7	3.1	4.2	2.2	7.8	17.3	1.4	2.7	4.9	3.1	7.5	15.7
Government bail-out subsidy	0.0	0.0	0.0	2.5	11.2	37.5	0.0	0.0	0.0	4.9	16.3	47.2
Net insurance value	-0.6	0.7	1.7	-1.7	4.5	12.0	-1.8	-1.1	0.6	-1.6	-0.6	1.2
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	76.3	62.7	54.7	82.4	82.3	99.8
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	56.9	42.6	42.6	61.4	49.5	50.9
Endogenous default barrier (V_{ED})	73.3	59.6	51.6	75.6	77.0	94.2	34.9	21.8	17.5	37.6	25.2	20.8
Regulatory default barrier (V_{RD})	73.3	59.6	51.6	63.6	77.0	94.2	56.0	41.9	41.9	60.4	48.7	50.1
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	39.0	105.7	202.6	32.9	164.7	544.2	29.7	81.4	186.8	36.3	119.4	325.1
Investment bank ($D = 10$)												
C-bond book value (C)	58.2	45.3	37.3	62.1	59.2	47.1	42.9	24.2	14.1	47.1	35.3	35.9
U-bond book value (U)	46.6	57.3	73.0	50.7	72.1	132.9	67.5	83.9	100.2	73.0	111.4	193.2
Total bond book value ($C + U$)	104.8	102.5	110.4	112.8	131.4	180.0	110.4	108.2	114.3	120.1	146.7	229.1
CET1 capital ratio (%)	-14.8	-12.5	-20.4	-22.8	-41.4	-90.0	-20.4	-18.2	-24.3	-30.1	-56.7	-139.1
Tier1 capital ratio (%)	31.8	44.7	52.7	27.9	30.8	42.9	47.1	65.8	75.9	42.9	54.7	54.1
C-bond market value ($\mathcal{C}$)	58.2	45.3	37.3	62.1	59.2	47.1	42.9	24.2	14.1	47.1	35.3	35.9
U-bond market value ($\mathcal{U}$)	41.6	42.9	44.6	44.6	49.2	68.4	61.6	68.0	70.1	65.4	80.6	94.0
Total bond market value ($\mathcal{C} + \mathcal{U}$)	99.8	88.1	81.9	106.7	108.4	115.5	104.5	92.2	84.2	112.5	115.9	129.9
Equity market value ($\mathcal{S}$)	18.1	24.3	27.3	13.1	10.7	4.9	14.6	21.3	25.6	9.0	5.4	0.0
Total bank value ($\mathcal{BV}$)	127.9	122.4	119.2	129.8	129.1	130.5	129.1	123.5	119.8	131.5	131.3	139.9
Total leverage (%)	85.9	80.2	77.1	89.9	91.7	96.2	88.7	82.7	78.6	93.2	95.9	100.0
Tax shield	28.8	23.7	20.6	28.6	21.7	14.5	30.8	25.9	22.5	29.8	22.0	5.9
Bail-in and bankruptcy costs	1.6	2.9	3.9	2.7	6.7	11.5	1.3	2.3	2.9	3.0	7.2	15.4
Government bail-out subsidy	0.0	0.0	0.0	2.6	9.8	27.6	0.0	0.0	0.0	4.9	16.2	47.6
Net insurance value	0.6	1.7	2.4	1.3	4.3	-0.1	-0.4	-0.1	0.2	-0.3	0.4	1.7
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	76.1	61.7	52.0	82.2	81.8	99.8
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	56.3	36.4	25.6	60.8	48.1	48.8
Endogenous default barrier (V_{ED})	72.6	58.8	50.3	77.6	73.8	79.3	33.6	18.1	10.2	36.3	23.8	19.3
Regulatory default barrier (V_{RD})	72.6	58.8	50.3	76.7	73.7	60.7	55.4	35.9	25.2	59.8	47.4	48.0
C-bond credit spread (bps)	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	36.3	100.4	191.7	41.0	139.5	282.4	28.7	70.5	128.9	35.0	114.6	316.5

Table 4 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Cash-flow volatility σ	6%	8%	10%	6%	8%	10%	6%	8%	10%	6%	8%	10%
Commercial bank ($D = 40$)												
C-bond book value (C)	11.6	14.4	5.4	11.6	14.7	5.5	14.4	0.0	0.0	13.3	0.0	0.0
U-bond book value (U)	14.1	0.9	0.7	15.2	0.9	0.7	19.8	20.8	13.3	19.3	19.4	11.6
Total bond book value ($C+U$)	25.8	15.2	6.1	26.8	15.5	6.2	34.1	20.8	13.3	32.6	19.4	11.6
CET1 capital ratio (%)	34.2	44.8	53.9	33.2	44.5	53.8	25.9	39.2	46.7	27.4	40.6	48.4
Tier1 capital ratio (%)	48.4	45.6	54.6	48.4	45.3	54.5	45.6	60.0	60.0	46.7	60.0	60.0
C-bond market value ($\mathcal{C}$)	11.6	14.4	5.4	11.6	14.7	5.5	14.4	0.0	0.0	13.3	0.0	0.0
U-bond market value ($\mathcal{U}$)	13.3	0.7	0.5	14.6	0.7	0.5	21.1	21.5	12.7	20.1	19.9	11.2
Total bond market value ($\mathcal{C}+\mathcal{U}$)	25.0	15.0	5.8	26.2	15.4	6.0	35.4	21.5	12.7	33.4	19.9	11.2
Equity market value ($\mathcal{S}$)	49.7	54.8	60.4	48.7	54.5	60.2	41.3	49.1	53.0	43.0	50.5	54.8
Total bank value ($\mathcal{BV}$)	114.7	109.8	106.2	114.9	109.9	106.3	116.7	110.6	105.8	116.3	110.4	105.9
Total leverage (%)	56.7	50.1	43.1	57.6	50.4	43.3	64.6	55.6	49.9	63.1	54.2	48.3
Tax shield	17.6	12.2	8.5	17.7	12.2	8.5	20.0	14.6	10.2	19.2	13.7	9.6
Bail-in and bankruptcy costs	1.0	2.8	3.5	1.2	2.8	3.6	1.6	2.8	5.0	1.6	3.0	4.8
Government bail-out subsidy	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.0	0.0	0.5	0.8	1.1
Net insurance value	-1.9	0.4	1.2	-1.8	0.5	1.2	-1.8	-1.1	0.6	-1.8	-1.2	0.1
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	47.9	32.7	23.0	47.0	32.0	22.3
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	77.6	63.7	55.8	76.0	62.2	54.0
Endogenous default barrier (V_{ED})	42.7	29.8	20.0	43.3	29.9	20.1	35.5	21.8	17.5	34.8	21.8	17.5
Regulatory default barrier (V_{RD})	68.9	57.8	48.2	70.0	58.2	48.4	56.9	41.9	41.9	55.8	41.9	41.9
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	18.0	95.1	174.6	13.0	61.8	104.7	-18.6	-10.1	12.4	-11.6	-6.7	11.5
Investment bank ($D = 10$)												
C-bond book value (C)	22.1	16.4	11.5	22.5	18.0	12.5	43.9	24.5	13.2	42.7	23.7	12.9
U-bond book value (U)	33.4	20.9	12.7	34.0	21.3	14.4	20.2	24.9	24.5	19.7	24.3	24.2
Total bond book value ($C+U$)	55.5	37.3	24.2	56.5	39.3	26.9	64.0	49.4	37.7	62.4	48.1	37.1
CET1 capital ratio (%)	34.5	52.7	65.8	33.5	50.7	63.1	26.0	40.6	52.3	27.6	41.9	52.9
Tier1 capital ratio (%)	67.9	73.6	78.5	67.5	72.0	77.5	46.1	65.5	76.8	47.3	66.3	77.1
C-bond market value ($\mathcal{C}$)	22.1	16.4	11.5	22.5	18.0	12.5	43.9	24.5	13.2	42.7	23.7	12.9
U-bond market value ($\mathcal{U}$)	32.6	19.6	11.3	33.4	20.3	13.3	21.6	25.8	24.8	20.6	24.9	24.4
Total bond market value ($\mathcal{C}+\mathcal{U}$)	54.7	36.1	22.8	55.9	38.3	25.8	65.5	50.4	38.0	63.3	48.7	37.3
Equity market value ($\mathcal{S}$)	51.0	63.2	72.4	50.0	61.4	69.9	42.3	51.3	59.4	44.1	52.7	60.0
Total bank value ($\mathcal{BV}$)	115.7	109.2	105.2	115.9	109.6	105.7	117.8	111.7	107.4	117.4	111.4	107.3
Total leverage (%)	56.0	42.2	31.2	56.8	44.0	33.9	64.1	54.1	44.7	62.4	52.7	44.1
Tax shield	17.1	11.2	7.3	17.2	11.4	7.6	19.6	14.1	9.9	18.8	13.3	9.4
Bail-in and bankruptcy costs	1.0	1.6	1.7	1.1	1.8	2.1	1.5	2.3	2.6	1.6	2.5	2.9
Government bail-out subsidy	0.0	0.0	0.0	0.3	0.4	0.5	0.0	0.0	0.0	0.5	0.8	0.9
Net insurance value	-0.5	-0.4	-0.4	-0.5	-0.4	-0.4	-0.3	-0.1	0.1	-0.4	-0.2	0.0
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	46.9	31.2	20.1	45.9	30.5	19.8
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	77.5	62.2	49.9	75.8	60.8	49.4
Endogenous default barrier (V_{ED})	41.5	24.9	14.4	42.2	25.9	15.6	34.2	18.2	9.9	33.5	17.8	9.7
Regulatory default barrier (V_{RD})	68.6	49.5	35.8	69.6	51.6	38.6	56.4	36.1	24.2	55.2	35.3	24.0
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	7.1	18.8	35.8	5.5	14.8	25.7	-20.3	-10.9	-3.3	-12.5	-7.3	-2.2

The table reports the optimal liability structure of the bank corresponding to different values of the EBIT volatility σ in (1). In Panel (a) only a Tier1 capital requirement is imposed, in Panel (b) also a CET1 capital requirement is imposed. The top section refers to a commercial bank (deposits $D = 40$), the bottom section to an investment bank (deposits $D = 10$). In the bail-out and mixed regimes, the risk-adjusted probability of bail-out is $p = 30\%$. The initial asset value is $V_0 = 100$.

Table 5: Optimal liability structure for different risk-free rates (r)

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Interest rate r	2%	3%	4%	2%	3%	4%	2%	3%	4%	2%	3%	4%
Commercial bank ($D = 40$)												
C-bond book value (C)	13.5	16.1	18.0	36.5	32.4	31.3	0.0	0.0	0.0	6.9	6.5	7.3
U-bond book value (U)	61.2	56.6	54.1	88.7	73.6	66.9	80.7	78.6	77.8	129.7	109.7	100.0
Total bond book value ($C + U$)	74.7	72.7	72.1	125.2	106.0	98.2	80.7	78.6	77.8	136.6	116.2	107.2
CET1 capital ratio (%)	-14.7	-12.7	-12.1	-65.2	-46.0	-38.2	-20.7	-18.6	-17.8	-76.6	-56.2	-47.2
Tier1 capital ratio (%)	46.5	43.9	42.0	23.5	27.6	28.7	60.0	60.0	60.0	53.1	53.5	52.7
C-bond market value ($\mathcal{C}$)	13.5	16.1	18.0	36.5	32.4	31.3	0.0	0.0	0.0	6.9	6.5	7.3
U-bond market value ($\mathcal{U}$)	41.9	41.9	41.8	48.0	47.5	46.8	58.7	61.8	63.9	81.7	78.5	76.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	55.4	57.9	59.8	84.5	79.9	78.1	58.7	61.8	63.9	88.6	85.0	83.4
Equity market value ($\mathcal{S}$)	24.0	23.4	22.8	4.9	8.4	10.0	21.1	20.3	19.7	2.5	5.1	6.6
Total bank value ($\mathcal{BV}$)	119.4	121.3	122.6	129.4	128.3	128.1	119.8	122.2	123.6	131.1	130.1	130.0
Total leverage (%)	79.9	80.7	81.4	96.2	93.4	92.2	82.3	83.4	84.1	98.1	96.1	94.9
Tax shield	22.6	23.7	24.6	16.2	20.5	22.4	24.7	26.0	26.9	17.6	21.9	23.9
Bail-in and bankruptcy costs	3.6	3.1	2.8	10.7	7.8	6.5	3.5	2.7	2.3	10.1	7.5	6.2
Government bail-out subsidy	0.0	0.0	0.0	17.4	11.2	8.6	0.0	0.0	0.0	24.1	16.3	12.9
Net insurance value	0.5	0.7	0.8	6.4	4.5	3.7	-1.4	-1.1	-0.9	-0.6	-0.6	-0.5
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	59.8	62.7	64.8	86.9	82.3	80.8
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	42.6	42.6	42.6	49.9	49.5	50.3
Endogenous default barrier (V_{ED})	57.0	59.6	61.7	81.4	77.0	75.9	20.8	21.8	22.5	24.1	25.2	26.5
Regulatory default barrier (V_{RD})	57.0	59.6	61.7	81.4	77.0	75.9	41.9	41.9	41.9	49.1	48.7	49.5
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	92.2	105.7	117.5	169.6	164.7	171.3	75.0	81.4	86.6	117.6	119.4	125.2
Investment bank ($D = 10$)												
C-bond book value (C)	27.9	45.3	47.4	33.6	59.2	58.9	20.4	24.2	47.4	34.7	35.3	58.9
U-bond book value (U)	65.8	57.3	54.7	100.4	72.1	65.8	88.9	83.9	54.7	132.1	111.4	65.8
Total bond book value ($C + U$)	93.7	102.5	102.1	134.0	131.4	124.6	109.3	108.2	102.1	166.8	146.7	124.6
CET1 capital ratio (%)	-3.7	-12.5	-12.1	-44.0	-41.4	-34.6	-19.3	-18.2	-12.1	-76.8	-56.7	-34.6
Tier1 capital ratio (%)	62.1	44.7	42.6	56.4	30.8	31.1	69.6	65.8	42.6	55.3	54.7	31.1
C-bond market value ($\mathcal{C}$)	27.9	45.3	47.4	33.6	59.2	58.8	20.4	24.2	47.4	34.7	35.3	58.8
U-bond market value ($\mathcal{U}$)	50.2	42.9	42.6	70.7	49.2	48.0	68.6	68.0	42.6	85.2	80.6	48.0
Total bond market value ($\mathcal{C} + \mathcal{U}$)	78.1	88.1	90.1	104.3	108.4	106.8	89.0	92.2	90.1	119.8	115.9	106.8
Equity market value ($\mathcal{S}$)	30.9	24.3	23.4	12.3	10.7	12.0	22.9	21.3	23.4	2.9	5.4	12.0
Total bank value ($\mathcal{BV}$)	119.0	122.4	123.5	126.6	129.1	128.8	121.9	123.5	123.5	132.7	131.3	128.8
Total leverage (%)	74.0	80.2	81.1	90.3	91.7	90.7	81.2	82.7	81.1	97.8	95.9	90.7
Tax shield	22.0	23.7	24.6	21.0	21.7	23.2	24.6	25.9	24.6	17.9	22.0	23.2
Bail-in and bankruptcy costs	2.5	2.9	2.7	6.8	6.7	5.7	2.5	2.3	2.7	9.6	7.2	5.7
Government bail-out subsidy	0.0	0.0	0.0	12.7	9.8	7.6	0.0	0.0	0.0	23.8	16.2	7.6
Net insurance value	-0.6	1.7	1.6	-0.4	4.3	3.6	-0.2	-0.1	1.6	0.6	0.4	3.6
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	58.1	61.7	–	85.9	81.8	–
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	32.3	36.4	–	47.5	48.1	–
Endogenous default barrier (V_{ED})	50.5	58.8	61.1	70.0	73.8	73.3	15.1	18.1	61.1	22.0	23.8	73.3
Regulatory default barrier (V_{RD})	40.3	58.8	61.1	46.4	73.7	73.3	31.8	35.9	61.1	46.8	47.4	73.3
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.4
U-bond credit spread (bps)	62.2	100.4	113.0	84.0	139.5	147.9	59.1	70.5	113.0	110.3	114.6	147.9

Table 5 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Interest rate r	2%	3%	4%	2%	3%	4%	2%	3%	4%	2%	3%	4%
Commercial bank ($D = 40$)												
C-bond book value (C)	11.9	14.4	16.5	11.9	14.7	16.8	0.0	0.0	0.0	0.0	0.0	0.0
U-bond book value (U)	0.8	0.9	0.9	0.8	0.9	0.9	18.0	20.8	22.7	16.7	19.4	21.4
Total bond book value ($C + U$)	12.7	15.2	17.4	12.7	15.5	17.7	18.0	20.8	22.7	16.7	19.4	21.4
CET1 capital ratio (%)	47.3	44.8	42.6	47.3	44.5	42.3	42.0	39.2	37.3	43.3	40.6	38.6
Tier1 capital ratio (%)	48.1	45.6	43.5	48.1	45.3	43.2	60.0	60.0	60.0	60.0	60.0	60.0
C-bond market value ($\mathcal{C}$)	11.9	14.4	16.5	11.9	14.7	16.8	0.0	0.0	0.0	0.0	0.0	0.0
U-bond market value ($\mathcal{U}$)	0.6	0.7	0.7	0.7	0.7	0.8	18.2	21.5	23.7	16.8	19.9	22.0
Total bond market value ($\mathcal{C} + \mathcal{U}$)	12.5	15.0	17.2	12.5	15.4	17.6	18.2	21.5	23.7	16.8	19.9	22.0
Equity market value ($\mathcal{S}$)	55.4	54.8	53.9	55.4	54.5	53.6	50.0	49.1	48.4	51.3	50.5	49.8
Total bank value ($\mathcal{BV}$)	107.9	109.8	111.1	108.0	109.9	111.2	108.2	110.6	112.1	108.2	110.4	111.8
Total leverage (%)	48.6	50.1	51.5	48.7	50.4	51.8	53.8	55.6	56.8	52.5	54.2	55.4
Tax shield	11.0	12.2	13.0	11.0	12.2	13.0	13.2	14.6	15.4	12.5	13.7	14.6
Bail-in and bankruptcy costs	3.3	2.8	2.5	3.3	2.8	2.6	3.6	2.8	2.4	3.6	3.0	2.6
Government bail-out subsidy	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	1.0	0.8	0.8
Net insurance value	0.2	0.4	0.6	0.2	0.5	0.6	-1.4	-1.1	-0.9	-1.6	-1.2	-1.0
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	29.5	32.7	34.9	28.9	32.0	34.2
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	60.8	63.7	65.7	59.4	62.2	64.3
Endogenous default barrier (V_{ED})	27.0	29.8	32.0	27.0	29.9	32.1	20.8	21.8	22.5	20.8	21.8	22.5
Regulatory default barrier (V_{RD})	55.2	57.8	60.1	55.2	58.2	60.4	41.9	41.9	41.9	41.9	41.9	41.9
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	84.1	95.1	106.2	52.2	61.8	70.0	-2.4	-10.1	-16.2	-1.2	-6.7	-11.0
Investment bank ($D = 10$)												
C-bond book value (C)	15.4	16.4	19.3	16.3	18.0	20.3	20.3	24.5	27.6	19.7	23.7	26.7
U-bond book value (U)	17.2	20.9	21.2	18.5	21.3	22.0	25.0	24.9	24.6	24.5	24.3	24.0
Total bond book value ($C + U$)	32.6	37.3	40.5	34.8	39.3	42.3	45.3	49.4	52.2	44.2	48.1	50.7
CET1 capital ratio (%)	57.4	52.7	49.5	55.2	50.7	47.7	44.7	40.6	37.8	45.8	41.9	39.3
Tier1 capital ratio (%)	74.6	73.6	70.7	73.7	72.0	69.7	69.7	65.5	62.4	70.3	66.3	63.3
C-bond market value ($\mathcal{C}$)	15.4	16.4	19.3	16.3	18.0	20.3	20.3	24.5	27.6	19.7	23.7	26.7
U-bond market value ($\mathcal{U}$)	15.9	19.6	20.0	17.4	20.3	21.1	25.7	25.8	25.7	24.9	24.9	24.7
Total bond market value ($\mathcal{C} + \mathcal{U}$)	31.3	36.1	39.4	33.7	38.3	41.4	45.9	50.4	53.3	44.6	48.7	51.4
Equity market value ($\mathcal{S}$)	66.3	63.2	61.0	64.2	61.4	59.4	53.9	51.3	49.6	55.1	52.7	51.2
Total bank value ($\mathcal{BV}$)	107.5	109.2	110.4	107.9	109.6	110.8	109.9	111.7	112.9	109.7	111.4	112.6
Total leverage (%)	38.4	42.2	44.7	40.5	44.0	46.4	50.9	54.1	56.1	49.8	52.7	54.5
Tax shield	9.8	11.2	12.2	10.1	11.4	12.4	12.6	14.1	15.1	11.9	13.3	14.3
Bail-in and bankruptcy costs	1.7	1.6	1.5	2.0	1.8	1.7	2.5	2.3	2.2	2.7	2.5	2.3
Government bail-out subsidy	0.0	0.0	0.0	0.5	0.4	0.4	0.0	0.0	0.0	0.8	0.8	0.7
Net insurance value	-0.6	-0.4	-0.3	-0.6	-0.4	-0.3	-0.2	-0.1	0.0	-0.3	-0.2	-0.1
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	27.1	31.2	34.0	26.6	30.5	33.2
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	57.9	62.2	65.1	56.7	60.8	63.5
Endogenous default barrier (V_{ED})	21.0	24.9	27.7	22.1	25.9	28.6	15.0	18.2	20.6	14.7	17.8	20.1
Regulatory default barrier (V_{RD})	44.6	49.5	52.9	46.9	51.6	54.8	31.7	36.1	39.4	31.1	35.3	38.4
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	16.6	18.8	23.2	12.4	14.8	17.8	-5.2	-10.9	-17.2	-3.5	-7.3	-11.3

The table reports the optimal liability structure of the bank corresponding to different values of the risk-free interest rate r. In Panel (a) only a Tier1 capital requirement is imposed, in Panel (b) also a CET1 capital requirement is imposed. The top section refers to a commercial bank (deposits $D = 40$), the bottom section to an investment bank (deposits $D = 10$). In the bail-out and mixed regimes, the risk-adjusted probability of bail-out is $p = 30\%$. The initial asset value is $V_0 = 100$.

Table 6: Optimal liability structure for different probabilities of bail-out (p)

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Probability of bail-out $p = p_1 = p_2$	10%	30%	50%	10%	30%	50%	10%	30%	50%	10%	30%	50%
Commercial bank ($D = 40$)												
C-bond book value (C)	16.1	16.1	16.1	20.0	32.4	24.1	0.0	0.0	0.0	0.0	6.5	16.2
U-bond book value (U)	56.6	56.6	56.6	60.8	73.6	117.0	78.6	78.6	78.6	87.0	109.7	134.0
Total bond book value ($C + U$)	72.7	72.7	72.7	80.8	106.0	141.2	78.6	78.6	78.6	87.0	116.2	150.2
CET1 capital ratio (%)	-12.7	-12.7	-12.7	-20.8	-46.0	-81.2	-18.6	-18.6	-18.6	-27.0	-56.2	-90.2
Tier1 capital ratio (%)	43.9	43.9	43.9	40.0	27.6	35.9	60.0	60.0	60.0	60.0	53.5	43.8
C-bond market value ($\mathcal{C}$)	16.1	16.1	16.1	20.0	32.4	24.1	0.0	0.0	0.0	0.0	6.5	16.2
U-bond market value ($\mathcal{U}$)	41.9	41.9	41.9	43.7	47.5	70.8	61.8	61.8	61.8	67.8	78.5	88.9
Total bond market value ($\mathcal{C} + \mathcal{U}$)	57.9	57.9	57.9	63.8	79.9	94.9	61.8	61.8	61.8	67.8	85.0	105.1
Equity market value ($\mathcal{S}$)	23.4	23.4	23.4	19.2	8.4	0.4	20.3	20.3	20.3	16.2	5.1	0.0
Total bank value ($\mathcal{BV}$)	121.3	121.3	121.3	123.0	128.3	135.3	122.2	122.2	122.2	124.0	130.1	145.1
Total leverage (%)	80.7	80.7	80.7	84.4	93.4	99.7	83.4	83.4	83.4	86.9	96.1	100.0
Tax shield	23.7	23.7	23.7	23.7	20.5	6.1	26.0	26.0	26.0	26.0	21.9	6.1
Bail-in and bankruptcy costs	3.1	3.1	3.1	4.0	7.8	16.8	2.7	2.7	2.7	3.4	7.5	16.5
Government bail-out subsidy	0.0	0.0	0.0	1.9	11.2	46.3	0.0	0.0	0.0	2.6	16.3	55.1
Net insurance value	0.7	0.7	0.7	1.4	4.5	-0.2	-1.1	-1.1	-1.1	-1.1	-0.6	0.4
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	62.7	62.7	62.7	67.1	82.3	100.0
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	42.6	42.6	42.6	42.6	49.5	59.8
Endogenous default barrier (V_{ED})	59.6	59.6	59.6	63.9	77.0	95.3	21.8	21.8	21.8	21.8	25.2	30.3
Regulatory default barrier (V_{RD})	59.6	59.6	59.6	63.9	77.0	68.2	41.9	41.9	41.9	41.9	48.7	58.9
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	105.7	105.7	105.7	116.8	164.7	196.2	81.4	81.4	81.4	85.0	119.4	152.1
Investment bank ($D = 10$)												
C-bond book value (C)	45.3	45.3	45.3	49.1	59.2	80.0	24.2	24.2	24.2	26.8	35.3	43.6
U-bond book value (U)	57.3	57.3	57.3	61.3	72.1	101.7	83.9	83.9	83.9	90.3	111.4	137.9
Total bond book value ($C + U$)	102.5	102.5	102.5	110.5	131.4	181.7	108.2	108.2	108.2	117.2	146.7	181.5
CET1 capital ratio (%)	-12.5	-12.5	-12.5	-20.5	-41.4	-91.7	-18.2	-18.2	-18.2	-27.2	-56.7	-91.5
Tier1 capital ratio (%)	44.7	44.7	44.7	40.9	30.8	10.0	65.8	65.8	65.8	63.2	54.7	46.4
C-bond market value ($\mathcal{C}$)	45.3	45.3	45.3	49.1	59.2	80.0	24.2	24.2	24.2	26.8	35.3	43.6
U-bond market value ($\mathcal{U}$)	42.9	42.9	42.9	44.8	49.2	50.9	68.0	68.0	68.0	71.7	80.6	92.7
Total bond market value ($\mathcal{C} + \mathcal{U}$)	88.1	88.1	88.1	93.9	108.4	130.9	92.2	92.2	92.2	98.5	115.9	136.3
Equity market value ($\mathcal{S}$)	24.3	24.3	24.3	20.1	10.7	0.0	21.3	21.3	21.3	16.9	5.4	0.0
Total bank value ($\mathcal{BV}$)	122.4	122.4	122.4	124.1	129.1	140.9	123.5	123.5	123.5	125.3	131.3	146.3
Total leverage (%)	80.2	80.2	80.2	83.8	91.7	100.0	82.7	82.7	82.7	86.5	95.9	100.0
Tax shield	23.7	23.7	23.7	23.7	21.7	0.0	25.9	25.9	25.9	25.9	22.0	6.1
Bail-in and bankruptcy costs	2.9	2.9	2.9	3.8	6.7	20.0	2.3	2.3	2.3	3.1	7.2	16.2
Government bail-out subsidy	0.0	0.0	0.0	1.8	9.8	50.9	0.0	0.0	0.0	2.6	16.2	55.6
Net insurance value	1.7	1.7	1.7	2.3	4.3	10.0	-0.1	-0.1	-0.1	0.0	0.4	0.8
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	61.7	61.7	61.7	66.4	81.8	99.9
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	36.4	36.4	36.4	39.2	48.1	57.0
Endogenous default barrier (V_{ED})	58.8	58.8	58.8	62.9	73.8	100.0	18.1	18.1	18.1	19.4	23.8	28.1
Regulatory default barrier (V_{RD})	58.8	58.8	58.8	62.9	73.7	95.7	35.9	35.9	35.9	38.5	47.4	56.1
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	100.4	100.4	100.4	110.7	139.5	299.9	70.5	70.5	70.5	78.3	114.6	146.4

Table 6 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Probability of bail-out $p = p_1 = p_2$	10%	30%	50%	10%	30%	50%	10%	30%	50%	10%	30%	50%
Commercial bank ($D = 40$)												
C-bond book value (C)	14.4	14.4	14.4	14.5	14.7	14.9	0.0	0.0	0.0	0.0	0.0	0.0
U-bond book value (U)	0.9	0.9	0.9	0.9	0.9	0.9	20.8	20.8	20.8	20.4	19.4	18.5
Total bond book value ($C + U$)	15.2	15.2	15.2	15.3	15.5	15.8	20.8	20.8	20.8	20.4	19.4	18.5
CET1 capital ratio (%)	44.8	44.8	44.8	44.7	44.5	44.2	39.2	39.2	39.2	39.6	40.6	41.5
Tier1 capital ratio (%)	45.6	45.6	45.6	45.5	45.3	45.1	60.0	60.0	60.0	60.0	60.0	60.0
C-bond market value ($\mathcal{C}$)	14.4	14.4	14.4	14.5	14.7	14.9	0.0	0.0	0.0	0.0	0.0	0.0
U-bond market value ($\mathcal{U}$)	0.7	0.7	0.7	0.7	0.7	0.8	21.5	21.5	21.5	21.0	19.9	18.8
Total bond market value ($\mathcal{C} + \mathcal{U}$)	15.0	15.0	15.0	15.2	15.4	15.6	21.5	21.5	21.5	21.0	19.9	18.8
Equity market value ($\mathcal{S}$)	54.8	54.8	54.8	54.7	54.5	54.3	49.1	49.1	49.1	49.6	50.5	51.5
Total bank value ($\mathcal{BV}$)	109.8	109.8	109.8	109.8	109.9	109.9	110.6	110.6	110.6	110.5	110.4	110.3
Total leverage (%)	50.1	50.1	50.1	50.2	50.4	50.6	55.6	55.6	55.6	55.2	54.2	53.3
Tax shield	12.2	12.2	12.2	12.2	12.2	12.2	14.6	14.6	14.6	14.3	13.7	13.2
Bail-in and bankruptcy costs	2.8	2.8	2.8	2.8	2.8	2.9	2.8	2.8	2.8	2.9	3.0	3.0
Government bail-out subsidy	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.3	0.8	1.3
Net insurance value	0.4	0.4	0.4	0.4	0.5	0.5	-1.1	-1.1	-1.1	-1.1	-1.2	-1.3
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	32.7	32.7	32.7	32.4	32.0	31.5
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	63.7	63.7	63.7	63.2	62.2	61.3
Endogenous default barrier (V_{ED})	29.8	29.8	29.8	29.8	29.9	30.0	21.8	21.8	21.8	21.8	21.8	21.8
Regulatory default barrier (V_{RD})	57.8	57.8	57.8	58.0	58.2	58.4	41.9	41.9	41.9	41.9	41.9	41.9
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	95.1	95.1	95.1	83.4	61.8	42.2	-10.1	-10.1	-10.1	-8.9	-6.7	-4.6
Investment bank ($D = 10$)												
C-bond book value (C)	16.4	16.4	16.4	17.3	18.0	18.6	24.5	24.5	24.5	24.2	23.7	23.2
U-bond book value (U)	20.9	20.9	20.9	20.6	21.3	22.1	24.9	24.9	24.9	24.7	24.3	24.0
Total bond book value ($C + U$)	37.3	37.3	37.3	37.9	39.3	40.7	49.4	49.4	49.4	49.0	48.1	47.2
CET1 capital ratio (%)	52.7	52.7	52.7	52.1	50.7	49.3	40.6	40.6	40.6	41.0	41.9	42.8
Tier1 capital ratio (%)	73.6	73.6	73.6	72.7	72.0	71.4	65.5	65.5	65.5	65.8	66.3	66.8
C-bond market value ($\mathcal{C}$)	16.4	16.4	16.4	17.3	18.0	18.6	24.5	24.5	24.5	24.2	23.7	23.2
U-bond market value ($\mathcal{U}$)	19.6	19.6	19.6	19.5	20.3	21.3	25.8	25.8	25.8	25.5	24.9	24.4
Total bond market value ($\mathcal{C} + \mathcal{U}$)	36.1	36.1	36.1	36.8	38.3	39.9	50.4	50.4	50.4	49.8	48.7	47.6
Equity market value ($\mathcal{S}$)	63.2	63.2	63.2	62.6	61.4	60.0	51.3	51.3	51.3	51.8	52.7	53.6
Total bank value ($\mathcal{BV}$)	109.2	109.2	109.2	109.3	109.6	109.9	111.7	111.7	111.7	111.6	111.4	111.2
Total leverage (%)	42.2	42.2	42.2	42.8	44.0	45.4	54.1	54.1	54.1	53.6	52.7	51.8
Tax shield	11.2	11.2	11.2	11.3	11.4	11.6	14.1	14.1	14.1	13.8	13.3	12.8
Bail-in and bankruptcy costs	1.6	1.6	1.6	1.7	1.8	2.0	2.3	2.3	2.3	2.4	2.5	2.6
Government bail-out subsidy	0.0	0.0	0.0	0.1	0.4	0.8	0.0	0.0	0.0	0.3	0.8	1.2
Net insurance value	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	31.2	31.2	31.2	30.9	30.5	30.0
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	62.2	62.2	62.2	61.7	60.8	59.9
Endogenous default barrier (V_{ED})	24.9	24.9	24.9	25.2	25.9	26.6	18.2	18.2	18.2	18.1	17.8	17.6
Regulatory default barrier (V_{RD})	49.5	49.5	49.5	50.2	51.6	53.1	36.1	36.1	36.1	35.9	35.3	34.8
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	18.8	18.8	18.8	17.9	14.8	11.2	-10.9	-10.9	-10.9	-9.6	-7.3	-5.0

The table reports the optimal liability structure of the bank corresponding to different values of the risk-adjusted probability of a government bail-out when, in the bail-out and mixed regimes, the default or bail-in is triggered. In Panel (a) only a Tier1 capital requirement is imposed, in Panel (b) also a CET1 capital requirement is imposed. The top section refers to a commercial bank (deposits $D = 40$), the bottom section to an investment bank (deposits $D = 10$). The initial asset value is $V_0 = 100$.

Table 7: Optimal liability structure for different growth prospects (α) when the deposit insurance premium (φ) is fairly determined

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Growth prospects α	2%	4%	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%
Commercial bank ($D = 40$)												
C-bond book value (C)	1.4	10.9	25.5	25.5	14.7	16.8	0.0	0.0	8.7	0.0	0.0	12.6
U-bond book value (U)	70.3	51.3	44.8	172.8	76.8	62.5	94.4	79.5	71.3	220.9	114.3	77.4
Total bond book value ($C + U$)	71.7	62.1	70.3	198.3	91.5	79.3	94.4	79.5	80.1	220.9	114.3	90.1
CET1 capital ratio (%)	-11.7	-2.1	-10.3	-138.3	-31.5	-19.3	-34.4	-19.5	-20.1	-160.9	-54.3	-30.1
Tier1 capital ratio (%)	58.6	49.1	34.5	34.5	45.3	43.2	60.0	60.0	51.3	60.0	60.0	47.4
C-bond market value ($\mathcal{C}$)	1.4	10.9	25.5	25.5	14.7	16.8	0.0	0.0	8.7	0.0	0.0	12.6
U-bond market value ($\mathcal{U}$)	42.2	40.9	40.8	68.8	56.8	56.6	52.2	62.7	65.3	104.4	85.0	69.7
Total bond market value ($\mathcal{C} + \mathcal{U}$)	43.7	51.8	66.3	94.3	71.5	73.3	52.2	62.7	74.1	104.4	85.0	82.3
Equity market value ($\mathcal{S}$)	32.3	29.3	20.8	0.9	15.1	15.7	23.3	20.5	15.2	0.0	6.1	9.4
Total bank value ($\mathcal{BV}$)	116.0	121.0	127.1	135.3	126.6	129.0	115.5	123.2	129.2	144.4	131.1	131.7
Total leverage (%)	72.1	75.8	83.6	99.3	88.1	87.8	79.8	83.4	88.2	100.0	95.3	92.9
Tax shield	19.5	23.2	28.4	6.9	23.1	28.6	21.2	25.9	30.5	5.4	22.4	29.6
Bail-in and bankruptcy costs	3.5	2.2	1.3	16.2	5.1	2.1	5.7	2.7	1.2	15.2	6.6	2.9
Government bail-out subsidy	0.0	0.0	0.0	44.6	8.6	2.6	0.0	0.0	0.0	54.3	15.4	5.0
Net insurance value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance fee (φ) (bps)	30.8	14.4	7.3	0.1	0.0	0.0	29.5	5.6	0.7	29.5	4.7	0.9
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	52.6	62.6	75.2	100.0	80.6	81.5
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	42.6	42.6	51.8	42.6	42.6	56.0
Endogenous default barrier (V_{ED})	44.1	54.1	69.7	90.6	68.4	74.7	16.7	21.2	30.6	16.7	21.1	33.0
Regulatory default barrier (V_{RD})	44.1	54.1	69.7	69.7	58.2	60.4	41.9	41.9	51.0	41.9	41.9	55.1
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	199.5	76.1	29.8	453.0	105.7	31.6	242.5	80.4	27.6	334.6	103.3	33.4
Investment bank ($D = 10$)												
C-bond book value (C)	28.5	24.8	29.9	24.5	41.4	31.7	4.6	18.9	38.7	18.1	27.2	42.6
U-bond book value (U)	66.7	69.3	71.4	203.8	80.1	77.6	111.2	88.1	71.3	234.2	116.3	77.4
Total bond book value ($C + U$)	95.2	94.1	101.3	228.3	121.5	109.3	115.8	107.0	110.1	252.3	143.5	120.1
CET1 capital ratio (%)	-5.2	-4.1	-11.3	-138.3	-31.5	-19.3	-25.8	-17.0	-20.1	-162.3	-53.5	-30.1
Tier1 capital ratio (%)	61.5	65.2	60.1	65.5	48.6	58.3	85.4	71.1	51.3	71.9	62.8	47.4
C-bond market value ($\mathcal{C}$)	28.5	24.8	29.9	24.5	41.4	31.7	4.6	18.9	38.7	18.1	27.2	42.6
U-bond market value ($\mathcal{U}$)	42.0	57.0	66.4	99.8	60.1	71.6	76.0	72.7	65.3	116.9	87.6	69.7
Total bond market value ($\mathcal{C} + \mathcal{U}$)	70.5	81.8	96.3	124.3	101.5	103.3	80.7	91.6	104.1	135.0	114.8	112.3
Equity market value ($\mathcal{S}$)	35.6	29.3	20.8	0.9	15.1	15.7	28.0	22.1	15.2	0.0	6.4	9.4
Total bank value ($\mathcal{BV}$)	116.0	121.0	127.1	135.3	126.6	129.0	118.6	123.7	129.2	145.0	131.2	131.7
Total leverage (%)	69.3	75.8	83.6	99.3	88.1	87.8	76.4	82.2	88.2	100.0	95.1	92.9
Tax shield	19.1	23.2	28.4	6.9	23.1	28.6	21.1	25.7	30.5	4.3	22.4	29.6
Bail-in and bankruptcy costs	3.1	2.2	1.3	16.2	5.1	2.1	2.5	2.0	1.2	14.0	6.3	2.9
Government bail-out subsidy	0.0	0.0	0.0	44.6	8.6	2.6	0.0	0.0	0.0	54.7	15.0	5.0
Net insurance value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance fee (φ) (bps)	97.4	0.0	0.0	0.1	0.0	0.0	9.9	6.6	2.7	46.5	14.1	3.7
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	48.0	61.0	75.2	100.0	80.1	81.5
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	15.5	30.8	51.8	29.9	39.5	56.0
Endogenous default barrier (V_{ED})	41.3	54.1	69.7	90.7	68.4	74.7	5.7	15.2	30.6	11.3	19.6	33.0
Regulatory default barrier (V_{RD})	41.0	37.0	42.5	36.7	54.7	44.4	15.3	30.3	51.0	29.4	38.9	55.1
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	176.9	64.7	22.7	312.6	99.8	25.0	138.8	63.4	27.6	301.0	98.4	33.4

Table 7 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Growth prospects α	2%	4%	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%
Commercial bank ($D = 40$)												
C-bond book value (C)	0.0	8.0	11.3	0.0	1.1	11.6	0.0	0.0	10.2	0.0	0.0	9.2
U-bond book value (U)	0.6	0.8	13.4	0.6	7.9	14.1	10.8	20.8	22.8	8.5	19.1	22.4
Total bond book value ($C + U$)	0.7	8.7	24.7	0.7	9.0	25.7	10.8	20.8	33.1	8.5	19.1	31.5
CET1 capital ratio (%)	59.3	51.3	35.3	59.3	51.0	34.3	49.2	39.2	26.9	51.5	40.9	28.5
Tier1 capital ratio (%)	60.0	52.0	48.7	60.0	58.9	48.4	60.0	60.0	49.8	60.0	60.0	50.8
C-bond market value ($\mathcal{C}$)	0.0	8.0	11.3	0.0	1.1	11.6	0.0	0.0	10.2	0.0	0.0	9.2
U-bond market value ($\mathcal{U}$)	0.4	0.6	12.6	0.5	6.9	13.5	9.6	21.7	24.3	7.7	19.6	23.2
Total bond market value ($\mathcal{C} + \mathcal{U}$)	0.4	8.6	23.9	0.5	8.1	25.1	9.6	21.7	34.5	7.7	19.6	32.4
Equity market value ($\mathcal{S}$)	64.0	61.3	51.8	64.0	61.8	50.9	53.8	49.7	43.3	56.5	51.7	45.0
Total bank value ($\mathcal{BV}$)	104.4	109.9	115.7	104.5	109.9	116.0	103.4	111.4	117.8	104.2	111.3	117.4
Total leverage (%)	38.7	44.2	55.2	38.8	43.7	56.1	47.9	55.4	63.2	45.7	53.6	61.6
Tax shield	7.7	11.6	16.8	7.7	11.3	16.9	9.2	14.3	19.2	8.4	13.4	18.4
Bail-in and bankruptcy costs	3.3	1.8	1.0	3.3	1.8	1.1	5.8	2.8	1.4	5.3	2.9	1.5
Government bail-out subsidy	0.0	0.0	0.0	0.1	0.4	0.3	0.0	0.0	0.0	1.1	0.8	0.5
Net insurance value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance fee (φ) (bps)	27.9	11.3	0.0	27.9	0.1	0.0	29.5	5.6	0.9	21.6	4.2	0.5
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	20.8	32.0	45.8	19.5	31.0	44.8
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	53.1	63.7	76.5	50.8	61.8	74.9
Endogenous default barrier (V_{ED})	16.9	26.1	40.5	16.9	25.5	41.1	16.7	21.2	31.5	16.3	21.1	30.8
Regulatory default barrier (V_{RD})	42.6	51.0	67.7	42.6	51.4	68.8	41.9	41.9	52.6	41.9	41.9	51.5
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	187.1	63.0	18.6	110.4	42.3	13.8	37.2	-12.5	-17.5	32.5	-8.6	-10.9
Investment bank ($D = 10$)												
C-bond book value (C)	9.5	16.3	21.9	11.0	17.9	22.2	4.1	19.8	40.2	4.2	19.3	39.2
U-bond book value (U)	10.2	20.8	32.8	11.5	21.1	33.5	27.5	28.4	22.8	27.7	27.9	22.4
Total bond book value ($C + U$)	19.7	37.1	54.7	22.6	39.0	55.7	31.6	48.3	63.1	31.9	47.2	61.5
CET1 capital ratio (%)	70.3	52.9	35.3	67.4	51.0	34.3	58.4	41.7	26.9	58.1	42.8	28.5
Tier1 capital ratio (%)	80.5	73.7	68.1	79.0	72.1	67.8	85.9	70.2	49.8	85.8	70.7	50.8
C-bond market value ($\mathcal{C}$)	9.5	16.3	21.9	11.0	17.9	22.2	4.1	19.8	40.2	4.2	19.3	39.2
U-bond market value ($\mathcal{U}$)	8.9	19.6	32.0	10.4	20.2	32.9	27.5	29.3	24.3	27.7	28.5	23.2
Total bond market value ($\mathcal{C} + \mathcal{U}$)	18.4	35.9	53.9	21.5	38.0	55.1	31.7	49.1	64.5	31.9	47.8	62.4
Equity market value ($\mathcal{S}$)	76.0	63.6	51.8	73.4	61.9	50.9	64.5	52.6	43.3	64.3	53.8	45.0
Total bank value ($\mathcal{BV}$)	104.4	109.5	115.7	104.8	109.9	116.0	106.2	111.8	117.8	106.2	111.6	117.4
Total leverage (%)	27.2	41.9	55.2	30.0	43.7	56.1	39.2	52.9	63.2	39.5	51.8	61.6
Tax shield	6.1	11.1	16.8	6.4	11.3	16.9	8.2	13.8	19.2	7.9	13.1	18.4
Bail-in and bankruptcy costs	1.7	1.6	1.0	2.0	1.8	1.1	2.1	2.0	1.4	2.5	2.3	1.5
Government bail-out subsidy	0.0	0.0	0.0	0.5	0.4	0.3	0.0	0.0	0.0	0.8	0.7	0.5
Net insurance value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance fee (φ) (bps)	0.0	0.0	0.0	0.0	0.0	0.0	9.1	7.4	3.4	7.2	5.2	2.1
Endogenous bail-in barrier (V_{EB})	–	–	–	–	–	–	16.0	30.4	45.8	16.0	29.8	44.8
Regulatory bail-in barrier (V_{RB})	–	–	–	–	–	–	43.6	61.0	76.5	43.9	59.9	74.9
Endogenous default barrier (V_{ED})	11.3	24.5	40.5	12.4	25.5	41.1	5.5	15.6	31.5	5.5	15.3	30.8
Regulatory default barrier (V_{RD})	31.1	49.3	67.7	34.1	51.3	68.8	14.8	31.2	52.6	14.9	30.7	51.5
C-bond credit spread (bps)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U-bond credit spread (bps)	44.0	18.6	7.4	31.9	14.6	5.7	-0.1	-8.9	-17.5	-0.2	-6.1	-10.9

The table reports the optimal liability structure of the bank corresponding to different values of the growth prospects α in (1). The insurance fee φ is numerically determined in order to make the net insurance value $\mathcal{NIV}$ in Appendix G to be equal to zero. In Panel (a) only a Tier1 capital requirement is imposed, in Panel (b) also a CET1 capital requirement is imposed. The top section refers to a commercial bank (deposits $D = 40$), the bottom section to an investment bank (deposits $D = 10$). In the bail-out and mixed regimes, the risk-adjusted probability of bail-out is $p = 30\%$. The initial asset value is $V_0 = 100$.