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The impact of the bail-in regulation on banks' capital structure and CDSs

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Stude, non ut plus aliquid scias, sed ut melius.

Cit. Seneca: "Lettere morali a Lucilio" 89 (xiv.2), 23.

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Co-Authorship Disclaimer

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The second chapter is based on my own work and a revised version of the working paper has been presented at the Catholic University of the Sacred Heart in Milan.

Introduction

The financial crisis, started in 2007, caused the failure of several global systemically important financial institutions, sending shocks through the financial system which, in turn, impacted also the real economy. At that time, supervisors and other relevant authorities decided that a massive public sector intervention was the unique solution at their disposal, charging both the financial and economic costs of this intervention on tax-payers. For this reason, it had become of crucial importance to put in place additional measures aimed at reducing the excessive involvement of the public support and at allowing to failing institutions to exit from the market, irrespective of their sizes and interconnectedness, without causing systemic disruption and financial instability.

In order to do so, the Bank Recovery and Resolution Directive (EU 2014/59/EU, BRRD) has been introduced in Europe. Its major novelty is represented by the new bail-in resolution regime. The aims of the resolution framework are numerous, including the ensuring of the continuity of critical functions, the avoiding of adverse effects on financial stability, the protection of public funds (by minimising reliance on extraordinary public financial support to failing institutions), and the protection of covered depositors, investors, client funds and client assets. To reach these objectives the authorities have decided to impose a prior participation of some categories of bank's debt holders in meeting the costs of bank resolution. Moreover, to reduce the likelihood of a bank becoming critically distressed, the Basel Committee on Banking Supervision has adopted a series of reforms aimed at improving the resilience of banks and banking systems. Among others, the most important regulatory standard introduced by Basel III, in 2010, concerned the increase in the quality and in the quantity of the capital required to banks, aimed at ensuring an adequate level of the loss absorbing capital relative to their own exposures expressed in terms of risk weighted assets (RWAs). Both these regulations have had important impacts on banks, especially on those considered systemically important on a global scale (G-SIBs) due to their complexity, interconnections and business models. In this thesis I try to capture the impact that the introduction of the new resolution framework had on the banks' capital structure and their CDSs.

In the first chapter 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.

In the second chapter of the dissertation, my current work-in-progress, I estimate the spillover effect of some bail-in related events on the European banking system. An event study methodology has been adopted on the CDS spreads written on senior unsecured and subordinated debt of 69 banks in 16 countries. The introduction of the new bank recovery and resolution framework (BRRD) has removed the government's implicit guarantee on banks' debt, causing the increase in the CDS spreads, especially for the banks considered systemically important on a global scale (G-SIBs). Moreover, given that the market beliefs concerning the probability of bailing-out the senior unsecured debt were relatively higher than the subordinated debt, the removal of the government's guarantee had a greater impact on the senior debt as it was suddenly perceived as riskier by the market than in the past.

Albeit a far from being extremely precise and completely exhaustive, this thesis highlights the important role played by the implicit government guarantee on bank debt, which distorted the incentive of bankers and managers for long time, especially those of largest banks considered "too-big-to-fail". The removal of the guarantee and the shift in the responsibility from public funds to some category of creditors was of extremely importance in order to restore market discipline, reduce their competitive advantages in the funding markets and align banks' funding costs more closely to the risk they are exposed.

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Chapter I

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, as the economic and social costs of bank failures and bail-outs were severe and the interventions of several national governments strongly divided the public opinion. In the U.S, the 2008 Troubled Asset Relief Program (TARP) lead to the injection of more than $200 billion of capital by the Treasury, mostly concentrated into the eight largest bank holding companies, considered to be *too-big-to-fail*. A similar phenomenon took place in Europe, where failed European banks that were state re-capitalized or nationalized had realized €535 billions of impairment losses (Conlon and Cotter, 2014). The recourse to these measures highlighted the necessity to change the banking regulatory frameworks, which in the U.S. were based on the 1988 Basel I capital standards, as well as the 1991 Prompt Corrective Action rules, recommending the actions to be undertaken by the regulators in case the standards were not met. In Europe, they were instead based on the Basel II capital standards initially published in 2004. These frameworks did not consider the going-concern loss-absorbing capacity of the required capital instruments.

The 2010 Basel III global regulatory standards introduced, among other measures, more stringent minimum capital requirements for financial institutions. In particular, institutions are required to obey, at all times, to the following minimum requirements: having a Common Equity Tier 1 (CET1) capital at least equal to 4.5% of the risk-weighted assets, having a Tier1 capital ratio at least equal to 6%, and a total capital ratio at least equal to 8%. These requirements have been imposed in the U.S. through the 2010 Dodd-Frank Act, which included also requirements that were modulated according to the size of the bank. The European Union, instead, adopted these requirements through the 2013 Capital Requirements Regulation (CRR) and the Capital Requirements Directive (CRD IV), imposing at first the same requirements for all financial institutions, and then imposing other bank-specific requirements through the 2014 Minimum Requirement for own funds and Eligible Liabilities (MREL) and 2015 Total Loss Absorbing Capacity (TLAC) standards.

The *ex-ante* capital requirements have been also complemented by new rules on bank resolution in case of financial distress. While previously most situations of potential insolvencies of systemic banks were dealt with by re-capitalizing and nationalizing the financial institutions (Dübel, 2013), the Orderly Liquidation provision of the Dodd-Frank Act for the U.S., and the 2014 Bank Recovery and Resolution Directive (BRRD) and Single Resolution Mechanism (SRM) for the European Union, introduced the bail-in tool, which is applicable in case of serious financial distress, as signaled by violations of the aforementioned regulatory requirements on the CET1 or Tier1 capital ratios. The bail-in is an ex-post resolution mechanism, implemented by a resolution authority and applicable to institutions which failure would have serious adverse consequences for the financial stability. In such a situation, the resolution authority can impose that the market value of equity is wiped out and trigger the conversion, in a pre-defined hierarchy, of unsecured debt into equity capital, in order to re-capitalize the bank. This resolution mechanism, together with the imposition of stringent minimum requirements on the presence of loss-absorbing capital, would allow to restore to health financial institutions without requiring for injections of public funds through bail-outs. These regulations are complemented by the existence of deposit insurance schemes, such as the Federal Deposit Insurance Corporation (FDIC) scheme in the U.S. and the European Deposit Insurance Scheme (EDIS), which in the future is supposed to replace national deposit-guarantee schemes.

Our paper analyzes the impact of the resolution regime and of regulatory capital requirements on the optimal bank liability structure. To do so, we develop a continuous-time EBIT-based structural model of endogenous default, aimed at modeling the capital structure of a bank. We derive closed-form pricing formulae for bank liabilities under four different resolution regimes: a *default* regime where there is no regulatory intervention, 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 can be wiped out and uncovered debt can be converted into equity to keep the bank operating as a going concern, and, finally, a *mixed* regime, representing a non-credible bail-in regime, where there is the possibility that bondholders are required to bail-in the bank, but the government may still have a positive probability of 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 a given amount of insured deposits accounts for a significant fraction of the liability structure, and of a pure investment bank, holding no deposits. 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, especially under the lighter Tier1 capital requirement, the resolution regime plays a crucial role in optimal debt structure decisions. When there is a market belief of a possible government bail-out, the optimal leverage significantly increases, while credit spreads decrease, making shareholders and debtholders more insensitive to bankruptcy risk. This is in line with the theoretical findings by DeYoung et al. (2013), who argued that government protection makes bank depositors and borrowers passive counterparties, reducing bank exposure to market discipline and encouraging bank shareholders to take greater insolvency risk. Indeed, the mechanism that links default risk and market value of debt breaks down, because the cost of default risk is shifted from shareholders and debtholders to the government, and ultimately to taxpayers.

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 market value of equity and of uncovered debt. This makes bond credit spreads to be consistent with the solvency risk of the financial institution and effectively reduces the *too-big-to-fail* incentives. We show that, for different market scenarios, the bail-in regime entails a longer expected time to default than under the default and bail-out regime. However, our mixed-regime analysis highlights the pivotal role of the resolution-scheme credibility, by showing that when there is a strictly positive 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.

Under a tighter 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 the bank type (identified in our model by the deposits-to-assets ratio), being very marked in adverse market scenarios, when the optimal non-deposit debt issuance is negligible. 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.

While there are numerous quantitative studies focused on the subsidies, provided by the governments, to the larger banks (Morgan and Stiroh, 2005; Ueda and Weder-Di Mauro, 2011; Li et al., 2013; Santos, 2014) and there is sufficient evidence that shows that too-big-to-fail banks are prone to have riskier capital structures than other banks (Gadanecz et al., 2008, Gropp et al., 2011; Brandao et al., 2013; Afonso et al., 2014), there are few contributions in the literature studying the structural effects of different resolution regimes on the optimal bank capital structure.

Our work contributes to the literature applying structural models of endogenous default, introduced in the seminal contributions of Black and Cox (1976), Fischer et al. (1989) and

Leland (1994), to the study of the optimal capital structure of a bank. Closely related to ours is the work by Helberg and Lindset (2014), who developed an endogenous-default structural model to analyze how the optimal bank capital structure and bond risk are influenced by asset encumbrance, depositor preferences and the presence of a government guarantee or a bail-in resolution regime. However, they did not consider the presence of regulatory capital requirements, nor the possibility of issuing covered debt. Hugonnier and Morellec (2015) developed a dynamic model of the bank capital structure aimed at assessing the effects of liquidity and Tier1 capital requirements. However, they did not consider different resolution frameworks (their analysis is centered on the default regime only) or tighter capital requirements. Sundaresan and Wang (2017) determined the optimal mixed financing strategy between insured deposits and nondeposit debt, for a value-maximizing bank that faces a regulatory Tier1 capital constraint. 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 bank structure 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 did not study the optimal mix between uncovered and covered non-deposit debt. Covered debt is senior even to deposits and 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 (Figure 2). 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:

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

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 the asset value. We show in Appendix A that V is proportional to the EBIT:

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

where r is the risk-free interest rate, τ is the tax-rate, λ is the market price of the cash-flow risk. 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 the analysis 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 of Helberg and Lindset (2014) and Sundaresan and Wang

(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 risk-weighted assets (RWAs). 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, representing thus a fixed fraction of the total assets. We consider deposits as being totally insured.[1] 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 $c_{dep} = rD$. This implies that the deposit book value D is equal to its market value $\mathcal{D}$. For what concerns the deposit-insurance, as in Helberg and Lindset (2014), the bank must pay a fixed premium, expressed as a fraction φ of the total deposit D, exogenously determined by national banking authorities. Therefore, the continuous payment to the deposit insurer is equal to $i = \varphi D$, while the value of this perpetuity is $I = \frac{i}{r}$. These payments to depositors and insurer are tax-deductible.

Covered bonds An important source of funding is represented by bonds. The nondeposit 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 bank

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

assets. If the issuer defaults on its outstanding covered bonds, the C-type 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 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, $V_D(1-\varepsilon)$, is lower than the book value C, C-bondholders are only partially reimbursed, otherwise they are entirely reimbursed. Eventually, the C-type bondholders receive $\mathcal{C}_D = \min\left[C, V_D(1-\varepsilon)\right]$ 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 cashflow-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 determining 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 convert their claims into equity and have to 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 equityholders of the bank, they can benefit from the tax shield generated by the other liabilities 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 $\tau\,[c_{dep} + i + c + u]$. 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: $(1-\tau)\,X - (1-\tau)\,[c_{dep} + i + c + u]$. We denote with $\mathcal{S}$ the 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, the flow of tax savings to the new equityholders becomes $\tau\,[c + c_{dep} + i]$. 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 the C-bondholders,[2] carry their claims to the restructured bank, whereas the ownership of the bank is given to the 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 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

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

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:

$$\begin{cases} \underbrace{V-[D+C+U]}_{CET1} \geq \underbrace{\psi}_{4.5\%} V \\ \underbrace{V-[D+C+U]}_{CET1} + \underbrace{U}_{AT1} \geq \underbrace{\beta}_{6\%} V \end{cases}, \tag{1}$$

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

$$V_{RB} = \max\left(\frac{D+C+U}{1-\psi}, \frac{D+C}{1-\beta}\right). \tag{2}$$

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:

$$\underbrace{V - [D + C]}_{CET1} \geq \underbrace{\psi}_{4.5\%} V,$$

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

$$V_{RD} = \frac{D + C}{1 - \psi}. \tag{3}$$

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:

$$\underbrace{V - [D + C + U]}_{CET1} + \underbrace{U}_{AT1} \geq \beta V, \tag{4}$$

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

$$V_{RB} = \frac{D + C}{1 - \beta}. \tag{5}$$

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 (3). The conditions for the applicability of the bail-in tool are the same as for the Tier1&CET1 capital requirement.

Absent 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. Since bail-in and default are triggered as soon as one of the two barriers 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 under the bail-in regime.

Theorem 1 *Given the liability structure* (D, C, U)*, the regulatory bail-in boundary* V_{RB} *either in (2) or in (5) and the regulatory default boundary* V_{RD} *in (3), 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 $V_{EB} = \frac{\gamma}{\gamma-1}(D + I + C + U)(1-\tau)$ *and* $V_{ED} = \frac{\gamma}{\gamma-1}(D + I + C)(1-\tau)$*. The market values of the deposits* $\mathcal{D}$*, the 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:*

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

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:*

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

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

2.2 Bail-out regime

In this framework, rather than considering the re-capitalization of the bank by some debtholders, we take into account the possiblity 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 (Dübel, 2013) 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 (1). In the bail-out regime, this means that $V \geq V_{RD}$, where:

$$V_{RD} = \max\left(\frac{D+C+U}{1-\psi}, \frac{D+C}{1-\beta}\right). \tag{6}$$

Tier1 capital requirement This requirement is less stringent and imposes the same condition on the asset value as in (4). This entails that $V \geq V_{RD}$, where:

$$V_{RD} = \frac{D+C}{1-\beta}. \tag{7}$$

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 there could be two possible scenarios: i) the government bails out the bank and, even if the post-bankruptcy asset value ($V_D^*(1-\varepsilon)$) 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 ($\mathcal{U}_D = \min\left[U, \left[V_D(1-\varepsilon) - C - D\right]^+\right]$).

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

Theorem 2 *For $0 \leq p \leq 1$, given the liability structure (D, C, U) and the regulatory default boundary V_{RD} either in (6) or in (7), the default boundary in the bail-out regime is:*

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

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

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

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:

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

2.3 Mixed regime

This regime is a mix of the previous two. 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, there could be a government intervention avoiding the bond 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 amount of equity held by shareholders is totally wiped out and the bank is restructured, with U-bondholders becoming the new shareholders. If instead the government intervention prevails, only debtholders will be reimbursed after bank liquidation.

Moreover, this regime takes into account the possibility of a government intervention also at the default trigger. In this case, if at bail-in there has not been a government intervention, only the C-bond will be entirely reimbursed because the U-bond has already been bailed-in. Therefore, 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 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 (2) or in (5) and the regulatory default boundary V_{RD} in (3), the bail-in and default boundaries in the mixed regime are:*

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

where $V_{EB} = \frac{\gamma}{\gamma-1}\left(D + I + C + U\right)(1-\tau)$ and $V_{ED} = \frac{\gamma}{\gamma-1}\left(D + I + C\right)(1-\tau)$. 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:*

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

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 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 35 for a commercial bank and 0 for an investment bank. We assume a constant default-free interest rate $r = 3\%$. For what concerns the EBIT process, in the base case we set the growth prospects α at 5%, their volatility σ at 8% and the market price of the cash-flow risk λ at 0.6. The bankruptcy costs are defined as a fraction ε of the asset value, which we set to be equal to 40%, while the proportional bail-in costs ξ are chosen, as in Helberg and Lindset (2014), to be half of the bankruptcy costs, being thus equal to 20%. We choose a tax rate $\tau = 35\%$ and an insurance premium rate φ at $0,10\%$, close to the average value, observed by Demirgüç-Kunt et al. (2005) for the majority of relevant countries and employed also by Helberg and Lindset (2014). For the bail-out and mixed regimes, we set the risk-adjusted probability of government intervention to 30%, 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. The base case parameter values are summarized in Table 1.

We calculate 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 ($\mathcal{BV}$). In Table 3, we compare the results for the two types of bank considering four different regulatory regimes: default, bail-out, bail-in and the mixed framework already introduced. The difference between the two panels is the regulatory capital requirement that the bank must meet. In Panel (a), the regulator monitors only a Tier1 capital requirement, imposing that the sum of CET1 capital ($V - D - C - U$) and the book value of the U-bond (U), that represents the AT1 capital, must be 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 Panel (b), the more stringent Tier1&CET1 capital requirement is imposed, requiring also a minimum 4.5% CET1 capital ratio. For what concerns the market conditions, we consider three different scenarios for the interest rate r, the growth prosepcts α and the EBIT volatility σ. For the standard (STD) scenario, we consider the base case values, that is $r = 3\%$, $\alpha = 5\%$ and $\sigma = 8\%$. The favorable scenario (FAV) corresponds to $r = 5\%$, $\alpha = 8\%$ and $\sigma = 6\%$, the adverse scenario (ADV) to $r = 1\%$, $\alpha = 2\%$ and $\sigma = 10\%$. Tables 4-7 respectively report the static comparative analyses when only one parameter at a time is varied, respectively r, σ, α and the probability of bail-out p.

3.1 Impact of the resolution regime

Focusing on Panel (a) of Table 3, where the less stringent Tier1 capital requirement is imposed, it can be noticed that, when the bail-in is not applicable (default and bail-out regimes) for the commercial bank ($D = 35$) the optimal issuance policy of C and U can be determined, but for the investment bank ($D = 0$) only the total amount of debt, $C + U$, is defined. This is because, in the absence of deposits, the two types of bonds have contiguous seniorities and are subject to default or bail-out contemporaneously.[3] Only an upper bound to C is imposed by the minimum Tier1 capital requirement. For the bail-in and mixed regimes it is instead possible to determine an optimal debt structure. Furthermore, 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. 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 claimants' perspective, insured deposits and C-bonds are equivalent, as the first are insured by an external entity and the second are backed by bank assets. A substitution effect between the two instruments instead takes place in the optimal liability structure, as their presence entails incentives for other claimants. In fact, as the amount of insured deposits increases, the optimal amount of C-bond reduces, and the total insurance premium paid by the bank increases. The investment bank ($D = 0$) typically issues a higher amount of C-bond than the commercial bank ($D = 35$). In general, the amount of U-bond issued represents a significant portion of the total outstanding debt, especially in the ADV scenario, as it provides loss-absortion capacity

[3] The indeterminacy of the bond mix, in the bail-out regime, does not necessarily mean that an optimal mixed financing strategy does not exist for reasons that are exogenous to our model, but it implies that the bail-out resolution framework itself does not provide incentives to for the shareholders to choose between different categories of bond financing.

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 default barrier. Furthermore, in the bail-in and mixed regimes, it is converted into equity when bail-in is applicable, postponing the bankruptcy of the bank.

Comparing the the four resolution regimes, as can be noticed, the bail-out regime incentivizes the shareholders to significantly increase the leverage with respect to the default regime, where the implicit government guarantee is not present. In the STD scenario, for a commercial bank the leverage increases from 82.7% to 92.2%, and for an investment bank from 76.1% to 85.0%. The situation is more extreme in the ADV scenario, where for a commercial bank the leverage skyrockets from 76.4% to 98.0%, and for an investment bank from 57.4% to 97.7%. The same conclusion can be drawn observing the CET1 and Tier1 capital ratios, that significantly decrease when the government guarantee is introduced. The value added by the implicit guarantee makes the shareholder choose a very risky debt structure, increasing the level of the default barrier and thus reducing the time-to-default. The bank values in this last case are incredibly high (249.4 for the commercial bank and 233.8 for the investment bank), but these values are ultimately reached through an extraction of value from the government in case of bail-out. As can be noticed respectively in Tables 5a and 6a, the leverage is increasing in the cash-flow volatility σ and decreasing in the growth prospects α, which are the directions of variation that entail an increase of the value of the bail-out option implicitly held by the bank at government expenses.

The bail-in regime, instead, achieves a significant risk-mitigation effect with respect to the bail-out regime. In the STD scenario, for both banks the shareholders incentives to increase leverage are significantly reduced, leading to an optimal leverage close to that obtained in the default regime and to higher Tier1 and CET1 capital ratios. The same happens in the ADV scenario: for the investment bank, the bail-in is applicable and the leverage reduces from 97.7% in the bail-out regime to 67.5%, while for the commercial bank the bail-in tool is not applicable, as the value of the equity after conversion of the U-bonds would be lower than the bail-in costs, and thus the optimal debt structure is the same as in the default case. The regulatory capital ratios correspondingly increase and, in addition to this, also the debt composition significantly changes, as the optimal debt composition, especially in the less favorable scenarios, requires a significantly higher fraction of bail-inable debt (U-bond) as opposed to non-bail-inable debt (C-bond). It is also interesting to notice that the bail-in barrier, when applicable ($\max[V_{EB}, V_{RB}]$), is close and slightly above the 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. Additionally, the bank value is always higher in the bail-in than in the default regime. Furthermore, differing from the other regimes, where, as in Sundaresan and Wang (2017), the presence of a considerable amount of deposits makes the commercial bank have a higher total market value than the investment bank, when the bail-in regime is in place, the higher flexibility of the debt structure of the investment bank makes the market value of the investment bank higher than that of the commercial bank.

However, when the bail-in regime is not credible, which corresponds to the mixed regime in Table 3, the optimal leverage becomes similar to that in the bail-out regime and the levels of CET1 and Tier1 regulatory capital decrease. This is because, although combined with the bail-in tool, the implicit guarantee given by the possibility of a bail-out incentivizes the shareholder to implement a riskier capital structure. Interestingly, in the ADV scenario and for a commercial bank, even a rather low risk-adjusted probability of government intervention ($p_1 = p_2 = p = 30\%$) entails a significant reduction of the U-bond credit spreads with respect to the case where the implicit guarantee is not present. This happens when comparing the bail-out and mixed regimes respectively with the default and bail-in regimes.

Table 7a shows the impact of variations of the risk-adjusted probability of government intervention p, which crucially intervenes 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, which for the commercial bank skyrockets to even more than 99% in both regimes when $p = 50\%$. The results obtained for the mixed regime highlights 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 probability of government intervention ($p = 10\%$), it turns out that the optimal leverage in the mixed regime is significantly 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 the minimum 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 3-7.

Comparing Panel (b) of Table 3 to Panel (a), the most evident effect is a very strong reduction of the leverage ratios in all resolution regimes and market scenarios. Furthermore, while in most cases under the Tier1 requirement the amount of U-bonds issued has a dominant role within the debt structure, under the Tier1&CET1 requirement the optimal amount of U-bond issued is mostly marginal. Especially in the ADV scenario, for all resolution regimes there is almost no incentive to issue debt and the leverage ratios are very close to the minimum possible value (35%) for the commercial bank, and lower than 10% for the investment bank. This makes the differences among resolution regimes very marginal. Due to the low tax shield effect, the bank values are 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 STD and ADV scenarios when a government intervention is plausible (bail-out and mixed regimes) and for the investment bank. As an extreme example, in the ADV scenario in the bail-out regime, the leverage ratio for an investment bank drops from 97.7% to 2.6% and the default barrier drops from 72.0 in Panel (a) to 3.0 in Panel (b). This allows to significantly reduce the likelihood of bail-out and the consequent extraction of value from the government. These effect are present even when the market belief of government intervention p is increased, as can be noticed in Table 7b. Overall, a strict obligation of having more equity capital, through a constant combined monitoring of both the Tier1 and CET1 capital ratios, entails a significant risk-mitigation effect. Furthermore, even under the bail-out regime, corresponding to more adverse market conditions, the optimal leverage is decreasing, rather than increasing as in Table 3a. This is evident also in Tables 5b and 6b, where in all resolution regimes the leverage respectively is decreasing in σ and increasing in α.

The further risk-mitigation effect entailed by the bail-in regime under a Tier1&CET1 requirement is milder than under the Tier1 requirement also in STD and FAV scenarios. It consists of a lowering of the default barrier, which increases the time-to-default, rather than of a reduction of the leverage ratios. A minimum CET1 requirement entails 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 111 and 114 in the STD scenario in Panel (b), as opposed to between 128 and 140 in Panel (a). Under the FAV scenario, for both the commercial and the investment bank, a surprising result shows up: under the bail-in and mixed regimes, the market values of U-bonds is 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 bonds do not have. This fact tends to increase the bank value even above the levels obtainable under the default and bail-out regimes, and is mostly caused by the reduced level of volatility and the increased growth prospects, as can be noticed looking at the effects of independent variations of σ and α in Tables 5b and 6b.

4 Conclusions

We shed light on the effects of the regulations in the banking industry, in particular with respect to the resolution regime in place and to the capital requirements, on the optimal bank liability structure. We consider banks with different amounts of deposits, modeling thus a typical commercial bank and a typical investment bank, and identify the optimal issuance policies of covered and uncovered debt under different market scenarios.

Our analytically-tractable bank liability structure model captures several important issues: the high incentives of banks to increase leverage and to reduce own capital resources, the investor insensitivity toward insolvency risk, the excessive market confidence on implicit government guarantees. Our results highlight a significant moral hazard issue: even a small market belief of government bail-out is sufficient to induce shareholders to increase the level of bank indebtedness. The presence of an implicit government guarantee on bank debt distorts bond prices by means of a reduction of market credit spreads, which leads to creditor inertia.

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 bond prices are sensitive to bank risk. This allows to restore market discipline, by more closely aligning bank funding costs with risks.

By considering also a mixed regime, in which the government can still bail-out the bank 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, the incentives for shareholders to raise leverage and to take advantage of the implicit government guarantee significantly affect the optimal debt structure.

Additionally to the study of the resolution regime, 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 debtholders more risk-sensitive. Stringent capital requirements force shareholders to add more *skin in the game*, leading to markedly polar situations with a nearly-zero optimal non-deposit leverage. Hence, our analysis importantly contributes to the debate on the incentives generated by tight ex-ante capital requirements versus credible ex-post resolution mechanisms.

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Table 1: Bank balance sheet

Assets	**Liabilities**
Asset value V	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) (restructuring costs) (bail-inable)
Charter value $(\mathcal{BV} - V)$	Equity $\mathcal{S}$
Bank value $\mathcal{BV} = \mathcal{S} + \mathcal{D} + \mathcal{C} + \mathcal{U}$	

Table 2: Parameter values

Parameter	Symbol	Base case value	Comparative statics values
Cashflow growth prospects	α	5%	$2.5\%, 5\%, 7.5\%$
Cashflow volatility	σ	8%	$6\%, 8\%, 10\%$
Market price of risk	λ	0.6	
Risk-free interest rate	r	3%	$1\%, 3\%, 5\%$
Insurance premium	φ	0.10%	
Corporate tax rate	τ	35%	
Bankruptcy costs	ε	40%	
Bail-in costs	ξ	20%	
Minimum Tier1 capital ratio	β	6%	
Minimum CET1 capital ratio	ψ	4.5%	
Market beliefs of bail-out	p, p_1, p_2	30%	$10\%, 30\%, 50\%$
Insured deposits amount	D	$0, 35$	
Initial asset value	V_0	100	

Table 3: Optimal liability structure for different capital requirements and market conditions

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Market scenario	FAV	STD	ADV	FAV	STD	ADV	FAV	STD	ADV	FAV	STD	ADV
Commercial bank ($D = 35$)												
C-bond book value (C)	46.2	22.5	1.1	47.5	34.8	33.2	36.9	0.4	1.1	38.2	8.0	33.2
U-Bond book value (U)	57.0	68.1	263.1	58.0	83.0	499.6	67.8	90.2	263.1	69.1	110.3	499.6
Total bond book value ($C + U$)	103.2	90.6	264.2	105.6	117.8	532.8	104.7	90.6	264.2	107.3	118.3	532.8
CET1 capital ratio (%)	-38.2	-25.6	-199.2	-40.6	-52.8	-467.8	-39.7	-25.6	-199.2	-42.3	-53.3	-467.8
Tier1 capital ratio (%)	18.8	42.5	63.9	17.5	30.2	31.8	28.1	64.6	63.9	26.8	57.0	31.8
CET1 ratio at B-in (%)	-	-	-	-	-	-	17.6	42.1	-	17.6	42.2	-
C-Bond market value ($\mathcal{C}$)	46.2	22.5	1.1	47.5	34.8	33.2	36.9	0.4	1.1	38.2	8.0	33.2
U-Bond market value ($\mathcal{U}$)	54.8	51.6	54.5	55.7	58.3	176.1	65.5	73.6	54.5	66.6	85.3	176.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	100.9	74.1	55.6	103.2	93.1	209.3	102.4	74.1	55.6	104.8	93.3	209.3
Equity market value ($\mathcal{S}$)	9.9	22.8	28.8	8.4	10.9	5.1	8.9	22.7	28.8	7.4	10.7	5.1
Total bank value ($\mathcal{BV}$)	145.8	131.8	119.4	146.6	139.0	249.4	146.3	131.8	119.4	147.2	139.0	249.4
Total leverage (%)	93.2	82.7	75.6	94.3	92.2	98.0	93.9	82.7	75.6	95.0	92.3	98.0
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	87.3	61.2	-	88.9	74.5	-
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	76.5	37.7	-	77.9	45.8	-
Endogenous def. barrier (V_{ED})	86.3	61.2	38.4	87.8	74.3	72.5	45.1	17.7	38.4	45.9	21.3	72.5
Regulatory def. barrier (V_{RD})	86.3	61.2	38.4	87.8	74.3	72.5	75.3	37.1	38.4	76.7	45.1	72.5
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.21	0.96	3.83	0.21	1.27	1.84	0.18	0.67	3.83	0.19	0.88	1.84
Investment bank ($D = 0$)												
C-bond book value (C)	≤79.5*	≤50.4*	≤22.0*	≤81.3*	≤59.9*	≤67.7*	69.6	27.3	0.5	≤81.3*	35.1	38.0
U-Bond book value (U)	≥56.6*	≥60.7*	≥162.2*	≥57.8*	≥72.2*	≥499.6*	70.6	97.4	241.1	≥57.8*	116.9	500.0
Total bond book value ($C + U$)	136.1	111.1	184.2	139.1	132.1	567.3	140.3	124.7	241.5	139.1	152.0	538.0
CET1 capital ratio (%)	-36.1	-11.1	-84.2	-39.1	-32.1	-467.3	-40.3	-24.7	-141.5	-39.1	-52.0	-438.0
Tier1 capital ratio (%)	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	30.4	72.7	99.5	≥6.0*	64.9	62.0
CET1 ratio at B-in (%)	-	-	-	-	-	-	20.1	54.6	98.5	-	52.1	44.3
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	69.6	27.0	0.4	*	34.8	32.5
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	68.3	81.6	78.2	*	93.1	191.6
Total bond market value ($\mathcal{C} + \mathcal{U}$)	133.9	98.0	64.6	136.8	114.2	228.5	137.9	108.6	78.7	136.8	127.9	224.1
Equity market value ($\mathcal{S}$)	11.6	30.9	48.0	9.7	20.2	5.3	9.0	23.8	37.8	9.7	11.6	6.8
Total bank value ($\mathcal{BV}$)	145.6	128.9	112.6	146.6	134.3	233.8	147.0	132.4	116.5	146.6	139.5	230.9
Total leverage (%)	92.0	76.1	57.4	93.4	85.0	97.7	93.9	82.0	67.5	93.4	91.7	97.0
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	87.2	60.2	30.7	-	73.3	68.3
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	74.1	29.0	0.5	-	37.4	40.4
Endogenous def. barrier (V_{ED})	84.6	53.6	23.4	86.5	63.8	72.0	43.3	13.2	0.1	86.5	17.0	4.8
Regulatory def. barrier (V_{RD})	≤84.6*	≤53.6*	≤23.4*	≤86.5*	≤63.8*	≤72.0*	72.9	28.6	0.5	≤86.5*	36.8	39.8
C-bond credit spread (%)	0.08*	0.40*	1.85*	0.08*	0.47*	1.48*	0.00	0.03	0.11	0.08*	0.03	0.17
U-bond credit spread (%)	0.08*	0.40*	1.85*	0.08*	0.47*	1.48*	0.17	0.58	2.08	0.08*	0.77	1.61

* Any combination of C- and U-bond is optimal, subject to the condition that $V_{RD} \leq V_{ED}$. Only the total amount $C + U$ is determined. The Tier1 ratio is at least equal to 6% and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

In the favorable scenario (FAV), $r = 5\%, \alpha = 7.5\%, \sigma = 6\%$ In the standard scenario (STD), $r = 3\%, \alpha = 5\%, \sigma = 8\%$. In the adverse scenario (ADV), $r = 1\%, \alpha = 2.5\%, \sigma = 10\%$

Table 3 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Market scenario	FAV	STD	ADV	FAV	STD	ADV	FAV	STD	ADV	FAV	STD	ADV
Commercial bank ($D = 35$)												
C-bond book value (C)	45.9	21.0	0.0	46.0	21.2	0.1	37.2	0.0	0.0	36.8	0.0	0.1
U-Bond book value (U)	1.3	0.9	0.6	1.3	0.9	0.6	11.5	22.0	0.6	11.4	22.1	0.6
Total bond book value ($C+U$)	47.2	21.8	0.6	47.3	22.1	0.7	48.8	22.0	0.6	48.3	22.1	0.7
CET1 capital ratio (%)	17.8	43.2	64.4	17.7	42.9	64.3	16.2	43.0	64.4	16.7	42.9	64.3
Tier1 capital ratio (%)	19.1	44.0	65.0	19.0	43.8	64.9	27.8	65.0	65.0	28.2	65.0	64.9
CET1 ratio at B-in (%)	-	-	-	-	-	-	17.6	41.3	-	17.6	41.5	-
C-Bond market value ($\mathcal{C}$)	45.9	21.0	0.0	46.0	21.2	0.1	37.2	0.0	0.0	36.8	0.0	0.1
U-Bond market value ($\mathcal{U}$)	1.2	0.7	0.1	1.3	0.8	0.3	12.1	21.7	0.1	11.8	22.0	0.3
Total bond market value ($\mathcal{C}+\mathcal{U}$)	47.2	21.6	0.1	47.2	21.9	0.4	49.3	21.7	0.1	48.6	22.0	0.4
Equity market value ($\mathcal{S}$)	44.9	57.4	65.3	44.9	57.2	65.2	43.2	57.3	65.3	43.8	57.1	65.2
Total bank value ($\mathcal{BV}$)	127.1	114.0	100.4	127.1	114.1	100.5	127.6	114.0	100.4	127.4	114.1	100.5
Total leverage (%)	64.7	49.7	35.0	64.7	49.9	35.2	66.1	49.8	35.0	65.6	49.9	35.2
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	52.5	28.0	-	52.2	28.1	-
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	87.7	59.6	-	87.2	59.8	-
Endogenous def. barrier (V_{ED})	51.5	28.0	5.0	51.6	28.1	5.0	45.3	17.4	5.0	45.1	17.4	5.0
Regulatory def. barrier (V_{RD})	86.1	59.5	37.2	86.1	59.8	37.3	75.7	36.6	37.2	75.2	36.6	37.3
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.19	0.87	3.69	0.14	0.57	1.23	-0.24	0.03	3.69	-0.15	0.02	1.23
Investment bank ($D = 0$)												
C-bond book value (C)	*	*	*	*	*	*	70.0	26.3	0.1	70.1	28.1	0.3
U-Bond book value (U)	*	*	*	*	*	*	13.7	29.0	5.6	13.1	27.9	8.1
Total bond book value ($C+U$)	79.9	45.4	1.5	80.4	47.9	2.9	83.6	55.3	5.7	83.2	56.0	8.3
CET1 capital ratio (%)	20.1	54.6	98.5	19.6	52.1	97.1	16.4	44.7	94.3	16.8	44.0	91.7
Tier1 capital ratio (%)	≥20.1*	≥54.6*	≥98.5*	≥19.6*	≥52.1*	≥97.1*	30.0	73.7	99.9	29.9	71.9	99.7
CET1 ratio at B-in (%)	-	-	-	-	-	-	20.1	54.6	98.5	19.6	52.1	97.1
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	69.9	26.0	0.1	70.1	28.0	0.2
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	14.3	28.8	5.1	13.5	27.8	7.6
Total bond market value ($\mathcal{C}+\mathcal{U}$)	79.3	43.4	1.3	80.0	46.2	2.6	84.2	54.8	5.2	83.5	55.7	7.8
Equity market value ($\mathcal{S}$)	47.5	68.4	98.8	47.0	66.2	97.6	43.8	59.5	95.2	44.3	58.8	92.8
Total bank value ($\mathcal{BV}$)	126.7	111.8	100.1	126.9	112.4	100.2	128.0	114.4	100.4	127.9	114.6	100.6
Total leverage (%)	62.6	38.8	1.3	63.0	41.1	2.6	65.8	47.9	5.2	65.3	48.7	7.8
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	52.0	26.7	0.7	51.7	27.0	1.1
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	87.6	57.9	6.0	87.1	58.6	8.7
Endogenous def. barrier (V_{ED})	49.7	21.9	0.2	50.0	23.1	0.4	43.5	12.7	0.0	43.6	13.6	0.0
Regulatory def. barrier (V_{RD})	83.6	47.5	1.6	84.2	50.2	3.0	73.3	27.5	0.1	73.4	29.4	0.3
C-bond credit spread (%)	0.04*	0.14*	0.16*	0.03*	0.11*	0.13*	0.00	0.03	0.07	0.00	0.02	0.05
U-bond credit spread (%)	0.04*	0.14*	0.16*	0.03*	0.11*	0.13*	-0.20	0.02	0.09	-0.13	0.01	0.07

* Any combination of C- and U-bond is optimal, only the total amount $C+U$ is determined. The Tier1 ratio is at least equal to the CET1 ratio and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

In the favorable scenario (FAV), $r = 5\%, \alpha = 7.5\%, \sigma = 6\%$ In the standard scenario (STD), $r = 3\%, \alpha = 5\%, \sigma = 8\%$. In the adverse scenario (ADV), $r = 1\%, \alpha = 2.5\%, \sigma = 10\%$

Table 4: Optimal liability structure for different capital requirements and risk-free rates

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Interest rate r	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%
Commercial bank ($D = 35$)												
C-bond book value (C)	16.0	22.5	25.9	43.2	34.8	34.9	16.0	0.4	5.1	6.1	8.0	11.2
U-Bond book value (U)	81.5	68.1	64.5	126.7	83.0	74.1	81.5	90.2	86.4	156.2	110.3	99.7
Total bond book value ($C + U$)	97.5	90.6	90.4	169.9	117.8	109.0	97.5	90.6	91.6	162.3	118.3	110.8
CET1 capital ratio (%)	-32.5	-25.6	-25.4	-104.9	-52.8	-44.0	-32.5	-25.6	-26.6	-97.3	-53.3	-45.8
Tier1 capital ratio (%)	49.0	42.5	39.1	21.8	30.2	30.1	49.0	64.6	59.9	58.9	57.0	53.8
CET1 ratio at B-in (%)	-	-	-	-	-	-	-	42.1	38.6	48.7	42.2	38.7
C-Bond market value ($\mathcal{C}$)	16.0	22.5	25.9	43.2	34.8	34.9	16.0	0.4	5.1	6.1	8.0	11.2
U-Bond market value ($\mathcal{U}$)	50.7	51.6	52.0	60.6	58.3	57.2	50.7	73.6	73.6	94.0	85.3	82.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	66.7	74.1	77.9	103.7	93.1	92.1	66.7	74.1	78.8	100.1	93.3	93.2
Equity market value ($\mathcal{S}$)	24.5	22.8	21.4	3.5	10.9	12.4	24.5	22.7	20.8	4.9	10.7	11.6
Total bank value ($\mathcal{BV}$)	126.2	131.8	134.2	142.3	139.0	139.4	126.2	131.8	134.5	140.0	139.0	139.8
Total leverage (%)	80.6	82.7	84.1	97.5	92.2	91.1	80.6	82.7	84.6	96.5	92.3	91.7
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	-	61.2	65.4	80.1	74.5	75.3
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	-	37.7	42.7	43.7	45.8	49.1
Endogenous def. barrier (V_{ED})	54.3	61.2	64.8	83.2	74.3	74.4	54.3	17.7	21.0	17.8	21.3	24.1
Regulatory def. barrier (V_{RD})	54.3	61.2	64.8	83.2	74.3	74.4	54.3	37.1	42.0	43.0	45.1	48.3
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.61	0.96	1.21	1.09	1.27	1.49	0.61	0.67	0.87	0.66	0.88	1.07
Investment bank ($D = 0$)												
C-bond book value (C)	≤40.8*	≤50.4*	≤54.9*	≤59.3*	≤59.9*	≤62.2*	16.1	27.3	33.1	27.2	35.1	39.8
U-Bond book value (U)	≥68.0*	≥60.7*	≥58.8*	≥98.7*	≥72.2*	≥66.6*	110.1	97.4	92.7	166.0	116.9	105.2
Total bond book value ($C + U$)	108.7	111.1	113.8	158.0	132.1	128.8	126.2	124.7	125.8	193.2	152.0	145.0
CET1 capital ratio (%)	-8.7	-11.1	-13.8	-58.0	-32.1	-28.8	-26.2	-24.7	-25.8	-93.2	-52.0	-45.0
Tier1 capital ratio (%)	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	83.9	72.7	66.9	72.8	64.9	60.2
CET1 ratio at B-in (%)	-	-	-	-	-	-	68.0	54.6	48.8	64.7	52.1	46.6
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	15.8	27.0	32.9	26.5	34.8	39.5
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	82.7	81.6	80.4	108.5	93.1	88.3
Total bond market value ($\mathcal{C} + \mathcal{U}$)	86.8	98.0	103.4	117.6	114.2	115.7	98.5	108.6	113.3	135.0	127.9	127.8
Equity market value ($\mathcal{S}$)	36.5	30.9	28.1	16.4	20.2	20.0	28.6	23.8	21.5	6.5	11.6	12.3
Total bank value ($\mathcal{BV}$)	123.4	128.9	131.5	133.9	134.3	135.6	127.1	132.4	134.8	141.5	139.5	140.1
Total leverage (%)	70.4	76.1	78.6	87.8	85.0	85.3	77.5	82.0	84.0	95.4	91.7	91.2
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	50.3	60.2	64.6	77.1	73.3	74.5
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	17.1	29.0	35.2	29.0	37.4	42.3
Endogenous def. barrier (V_{ED})	43.4	53.6	58.5	63.0	63.8	66.2	6.4	13.2	17.0	10.9	17.0	20.4
Regulatory def. barrier (V_{RD})	≤43.4*	≤53.6*	≤58.5*	≤63.0*	≤63.8*	≤66.2*	16.9	28.6	34.7	28.5	36.8	41.6
C-bond credit spread (%)	0.25*	0.40*	0.50*	0.34*	0.47*	0.57*	0.02	0.03	0.03	0.03	0.03	0.03
U-bond credit spread (%)	0.25*	0.40*	0.50*	0.34*	0.47*	0.57*	0.33	0.58	0.77	0.53	0.77	0.96

* Any combination of C- and U-bond is optimal, subject to the condition that $V_{RD} \leq V_{ED}$. Only the total amount $C + U$ is determined. The Tier1 ratio is at least equal to 6% and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 4 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Interest rate r	1%	3%	5%	1%	3%	5%	1%	3%	5%	1%	3%	5%
Commercial bank ($D = 35$)												
C-bond book value (C)	13.7	21.0	24.7	14.1	21.2	24.9	0.0	0.0	24.7	14.1	0.0	4.6
U-Bond book value (U)	0.8	0.9	1.0	0.8	0.9	1.0	13.0	22.0	1.0	0.8	22.1	22.0
Total bond book value ($C+U$)	14.5	21.8	25.7	14.8	22.1	25.8	13.0	22.0	25.7	14.8	22.1	26.5
CET1 capital ratio (%)	50.5	43.2	39.3	50.2	42.9	39.2	52.0	43.0	39.3	50.2	42.9	38.5
Tier1 capital ratio (%)	51.3	44.0	40.3	50.9	43.8	40.1	65.0	65.0	40.3	50.9	65.0	60.4
CET1 ratio at B-in (%)	-	-	-	-	-	-	30.4	41.3	-	-	41.5	38.6
C-Bond market value ($\mathcal{C}$)	13.7	21.0	24.7	14.1	21.2	24.9	0.0	0.0	24.7	14.1	0.0	4.6
U-Bond market value ($\mathcal{U}$)	0.5	0.7	0.8	0.6	0.8	0.8	11.4	21.7	0.8	0.6	22.0	22.0
Total bond market value ($\mathcal{C}+\mathcal{U}$)	14.2	21.6	25.5	14.6	21.9	25.7	11.4	21.7	25.5	14.6	22.0	26.6
Equity market value ($\mathcal{S}$)	59.5	57.4	55.8	59.1	57.2	55.7	60.9	57.3	55.8	59.1	57.1	55.0
Total bank value ($\mathcal{BV}$)	108.7	114.0	116.3	108.7	114.1	116.4	107.3	114.0	116.3	108.7	114.1	116.6
Total leverage (%)	45.3	49.7	52.0	45.7	49.9	52.2	43.3	49.8	52.0	45.7	49.9	52.9
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	20.6	28.0	-	-	28.1	32.0
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	50.3	59.6	-	-	59.8	64.4
Endogenous def. barrier (V_{ED})	21.1	28.0	31.5	21.3	28.1	31.6	15.4	17.4	31.5	21.3	17.4	20.7
Regulatory def. barrier (V_{RD})	51.8	59.5	63.5	52.2	59.8	63.7	36.6	36.6	63.5	52.2	36.6	41.4
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.54	0.87	1.10	0.33	0.57	0.73	0.14	0.03	1.10	0.33	0.02	-0.02
Investment bank ($D = 0$)												
C-bond book value (C)	*	*	*	*	*	*	14.3	26.3	32.4	16.5	28.1	34.0
U-Bond book value (U)	*	*	*	*	*	*	28.3	29.0	28.0	28.0	27.9	26.8
Total bond book value ($C+U$)	51.2	45.4	32.0	35.3	47.9	53.4	42.6	55.3	60.5	44.5	56.0	60.8
CET1 capital ratio (%)	48.8	54.6	68.0	64.7	52.1	46.6	57.4	44.7	39.5	55.5	44.0	39.2
Tier1 capital ratio (%)	≥48.8*	≥54.6*	≥68.0*	≥64.7*	≥52.1*	≥46.6*	85.7	73.7	67.6	83.5	71.9	66.0
CET1 ratio at B-in (%)	-	-	-	-	-	-	68.0	54.6	48.8	64.7	52.1	46.6
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	14.0	26.0	32.2	16.3	28.0	33.9
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	27.5	28.8	28.1	27.5	27.8	26.9
Total bond market value ($\mathcal{C}+\mathcal{U}$)	49.4	43.4	29.9	33.4	46.2	51.8	41.6	54.8	60.3	43.7	55.7	60.7
Equity market value ($\mathcal{S}$)	64.8	68.4	77.0	74.2	66.2	62.9	67.6	59.5	56.4	65.8	58.8	56.1
Total bank value ($\mathcal{BV}$)	114.2	111.8	106.9	107.6	112.4	114.8	109.2	114.4	116.7	109.6	114.6	116.8
Total leverage (%)	43.3	38.8	28.0	31.1	41.1	45.2	38.1	47.9	51.7	39.9	48.7	52.0
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	17.0	26.7	31.1	17.8	27.0	31.2
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	44.6	57.9	63.3	46.6	58.6	63.7
Endogenous def. barrier (V_{ED})	26.3	21.9	12.8	14.1	23.1	27.4	5.7	12.7	16.7	6.6	13.6	17.5
Regulatory def. barrier (V_{RD})	53.6	47.5	33.5	37.0	50.2	55.9	15.0	27.5	33.9	17.2	29.4	35.6
C-bond credit spread (%)	0.18*	0.14*	0.07*	0.06*	0.11*	0.15*	0.02	0.03	0.03	0.01	0.02	0.02
U-bond credit spread (%)	0.18*	0.14*	0.07*	0.06*	0.11*	0.15*	0.03	0.02	-0.01	0.02	0.01	-0.01

* Any combination of C- and U-bond is optimal, only the total amount $C+U$ is determined. The Tier1 ratio is at least equal to the CET1 ratio and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 5: Optimal liability structure for different capital requirements and volatility rates

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 ($D = 35$)												
C-bond book value (C)	36.7	22.5	13.5	40.6	34.8	46.6	21.4	0.4	0.0	24.3	8.0	4.5
U-Bond book value (U)	58.0	68.1	87.5	61.2	83.0	148.2	75.4	90.2	99.6	79.5	110.3	181.0
Total bond book value ($C+U$)	94.8	90.6	101.0	101.8	117.8	194.8	96.8	90.6	99.6	103.8	118.3	185.5
CET1 capital ratio (%)	-29.8	-25.6	-36.0	-36.8	-52.8	-129.8	-31.8	-25.6	-34.6	-38.8	-53.3	-120.5
Tier1 capital ratio (%)	28.3	42.5	51.5	24.4	30.2	18.4	43.6	64.6	65.0	40.7	57.0	60.5
CET1 ratio at B-in (%)	-	-	-	-	-	-	27.3	42.1	31.4	27.3	42.2	52.6
C-Bond market value ($\mathcal{C}$)	36.7	22.5	13.5	40.6	34.8	46.6	21.4	0.4	0.0	24.3	8.0	4.5
U-Bond market value ($\mathcal{U}$)	52.5	51.6	52.2	54.8	58.3	62.7	69.6	73.6	63.6	72.8	85.3	101.2
Total bond market value ($\mathcal{C}+\mathcal{U}$)	89.2	74.1	65.7	95.3	93.1	109.3	91.0	74.1	63.6	97.2	93.3	105.7
Equity market value ($\mathcal{S}$)	15.7	22.8	26.0	11.7	10.9	2.0	14.5	22.7	26.5	10.6	10.7	3.2
Total bank value ($\mathcal{BV}$)	140.0	131.8	126.7	142.1	139.0	146.4	140.6	131.8	125.1	142.8	139.0	143.9
Total leverage (%)	88.8	82.7	79.5	91.7	92.2	98.6	89.7	82.7	78.8	92.6	92.3	97.8
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	77.5	61.2	51.0	81.6	74.5	83.3
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	60.0	37.7	37.2	63.1	45.8	42.0
Endogenous def. barrier (V_{ED})	76.3	61.2	51.6	80.4	74.3	86.8	33.5	17.7	13.6	35.3	21.3	15.3
Regulatory def. barrier (V_{RD})	76.3	61.2	51.6	80.4	74.3	86.8	59.0	37.1	36.6	62.1	45.1	41.4
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.32	0.96	2.03	0.35	1.27	4.09	0.25	0.67	1.70	0.27	0.88	2.37
Investment bank ($D = 0$)												
C-bond book value (C)	≤68.3*	≤50.4*	≤38.6*	≤71.5*	≤59.9*	≤60.8*	51.8	27.3	13.8	55.6	35.1	32.2
U-Bond book value (U)	≥56.3*	≥60.7*	≥70.6*	≥59.0*	≥72.2*	≥111.3*	80.5	97.4	114.0	83.8	116.9	233.8
Total bond book value ($C+U$)	124.6	111.1	109.2	130.5	132.1	172.1	132.4	124.7	127.8	139.4	152.0	266.0
CET1 capital ratio (%)	-24.6	-11.1	-9.2	-30.5	-32.1	-72.1	-32.4	-24.7	-27.8	-39.4	-52.0	-166.0
Tier1 capital ratio (%)	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	48.2	72.7	86.2	44.4	64.9	67.8
CET1 ratio at B-in (%)	-	-	-	-	-	-	32.8	54.6	71.3	31.6	52.1	67.9
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	51.7	27.0	13.4	55.5	34.8	30.8
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	74.9	81.6	82.7	77.3	93.1	109.5
Total bond market value ($\mathcal{C}+\mathcal{U}$)	119.6	98.0	84.3	125.0	114.2	120.8	126.7	108.6	96.1	132.9	127.9	140.3
Equity market value ($\mathcal{S}$)	19.5	30.9	37.8	16.0	20.2	14.1	14.9	23.8	29.7	10.9	11.6	0.0
Total bank value ($\mathcal{BV}$)	139.1	128.9	122.1	141.0	134.3	134.8	141.6	132.4	125.9	143.8	139.5	140.3
Total leverage (%)	85.9	76.1	69.0	88.7	85.0	89.6	89.5	82.0	76.4	92.4	91.7	100.0
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	77.2	60.2	48.1	81.3	73.3	100.0
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	55.2	29.0	14.7	59.1	37.4	34.2
Endogenous def. barrier (V_{ED})	72.6	53.6	41.1	76.1	63.8	64.7	30.2	13.2	5.2	32.4	17.0	12.1
Regulatory def. barrier (V_{RD})	≤72.6*	≤53.6*	≤41.1*	≤76.1*	≤63.8*	≤64.7*	54.3	28.6	14.4	58.2	36.8	33.7
C-bond credit spread (%)	0.13	0.40	0.89	0.13	0.47	1.28	0.01	0.03	0.08	0.00	0.03	0.13
U-bond credit spread (%)	0.13	0.40	0.89	0.13	0.47	1.28	0.22	0.58	1.14	0.25	0.77	3.41

* Any combination of C- and U-bond is optimal, subject to the condition that $V_{RD} \leq V_{ED}$. Only the total amount $C + U$ is determined. The Tier1 ratio is at least equal to 6% and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 5 (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 ($D = 35$)												
C-bond book value (C)	36.2	21.0	10.4	36.3	21.2	10.7	21.6	0.0	10.4	21.2	0.0	10.7
U-Bond book value (U)	1.1	0.9	0.7	1.1	0.9	0.7	17.7	22.0	0.7	17.6	22.1	0.7
Total bond book value ($C+U$)	37.4	21.8	11.1	37.5	22.1	11.5	39.3	22.0	11.1	38.8	22.1	11.5
CET1 capital ratio (%)	27.6	43.2	53.9	27.5	42.9	53.5	25.7	43.0	53.9	26.2	42.9	53.5
Tier1 capital ratio (%)	28.8	44.0	54.6	28.7	43.8	54.3	43.4	65.0	54.6	43.8	65.0	54.3
CET1 ratio at B-in (%)	-	-	-	-	-	-	27.3	41.3	-	27.3	41.5	-
C-Bond market value ($\mathcal{C}$)	36.2	21.0	10.4	36.3	21.2	10.7	21.6	0.0	10.4	21.2	0.0	10.7
U-Bond market value ($\mathcal{U}$)	1.0	0.7	0.5	1.1	0.8	0.5	18.3	21.7	0.5	17.9	22.0	0.5
Total bond market value ($\mathcal{C}+\mathcal{U}$)	37.3	21.6	10.8	37.4	21.9	11.3	39.9	21.7	10.8	39.1	22.0	11.3
Equity market value ($\mathcal{S}$)	49.7	57.4	62.8	49.6	57.2	62.5	47.7	57.3	62.8	48.3	57.1	62.5
Total bank value ($\mathcal{BV}$)	122.0	114.0	108.7	122.0	114.1	108.7	122.6	114.0	108.7	122.4	114.1	108.7
Total leverage (%)	59.3	49.7	42.2	59.3	49.9	42.6	61.1	49.8	42.2	60.6	49.9	42.6
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	44.0	28.0	-	43.7	28.1	-
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	77.8	59.6	-	77.2	59.8	-
Endogenous def. barrier (V_{ED})	42.9	28.0	17.8	42.9	28.1	17.9	33.7	17.4	17.8	33.4	17.4	17.9
Regulatory def. barrier (V_{RD})	75.8	59.5	48.3	75.9	59.8	48.7	59.3	36.6	48.3	58.8	36.6	48.7
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.30	0.87	1.75	0.20	0.57	1.06	-0.09	0.03	1.75	-0.06	0.02	1.06
Investment bank ($D = 0$)												
C-bond book value (C)	*	*	*	*	*	*	51.9	26.3	11.8	52.6	28.1	14.0
U-Bond book value (U)	*	*	*	*	*	*	21.9	29.0	27.5	20.8	27.9	27.5
Total bond book value ($C+U$)	67.2	45.4	28.7	68.4	47.9	32.1	73.8	55.3	39.3	73.5	56.0	41.5
CET1 capital ratio (%)	32.8	54.6	71.3	31.6	52.1	67.9	26.2	44.7	60.7	26.5	44.0	58.5
Tier1 capital ratio (%)	≥32.8*	≥54.6*	≥71.3*	≥31.6*	≥52.1*	≥67.9*	48.1	73.7	88.2	47.4	71.9	86.0
CET1 ratio at B-in (%)	-	-	-	-	-	-	32.8	54.6	71.3	31.6	52.1	67.9
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	51.8	26.0	11.6	52.6	28.0	13.8
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	22.4	28.8	26.6	21.2	27.8	26.8
Total bond market value ($\mathcal{C}+\mathcal{U}$)	66.0	43.4	26.6	67.4	46.2	30.3	74.3	54.8	38.1	73.8	55.7	40.6
Equity market value ($\mathcal{S}$)	55.1	68.4	79.2	54.0	66.2	76.2	48.9	59.5	69.8	49.3	58.8	67.8
Total bank value ($\mathcal{BV}$)	121.1	111.8	105.8	121.5	112.4	106.5	123.2	114.4	108.0	123.1	114.6	108.4
Total leverage (%)	54.5	38.8	25.2	55.5	41.1	28.4	60.3	47.9	35.3	60.0	48.7	37.5
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	43.0	26.7	14.8	42.8	27.0	15.6
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	77.3	57.9	41.2	76.9	58.6	43.5
Endogenous def. barrier (V_{ED})	39.2	21.9	10.8	39.9	23.1	12.1	30.3	12.7	4.4	30.7	13.6	5.3
Regulatory def. barrier (V_{RD})	70.3	47.5	30.0	71.6	50.2	33.7	54.4	27.5	12.4	55.1	29.4	14.6
C-bond credit spread (%)	0.05*	0.14*	0.23*	0.04*	0.11*	0.19*	0.01	0.03	0.06	0.00	0.02	0.04
U-bond credit spread (%)	0.05*	0.14*	0.23*	0.04*	0.11*	0.19*	-0.07	0.02	0.11	-0.05	0.01	0.08

* Any combination of C- and U-bond is optimal, only the total amount $C+U$ is determined. The Tier1 ratio is at least equal to the CET1 ratio and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 6: Optimal liability structure for different capital requirements and growth prospects

Panel (a): Tier1 capital requirement

	Default regime			**Bail-out regime**			**Bail-in regime**			**Mixed regime**		
Growth prospects α	2.5%	5%	7.5%	2.5%	5%	7.5%	2.5%	5%	7.5%	2.5%	5%	7.5%
Commercial bank ($D = 35$)												
C-bond book value (C)	10.4	22.5	36.5	57.1	34.8	40.2	0.0	0.4	21.0	7.6	8.0	24.0
U-Bond book value (U)	100.8	68.1	58.1	205.5	83.0	61.2	108.2	90.2	75.6	256.3	110.3	79.8
Total bond book value ($C+U$)	111.2	90.6	94.6	262.6	117.8	101.4	108.2	90.6	96.6	263.9	118.3	103.8
CET1 capital ratio (%)	-46.2	-25.6	-29.6	-197.6	-52.8	-36.4	-43.2	-25.6	-31.6	-198.9	-53.3	-38.8
Tier1 capital ratio (%)	54.6	42.5	28.5	7.9	30.2	24.8	65.0	64.6	44.0	57.4	57.0	41.0
CET1 ratio at B-in (%)	-	-	-	-	-	-	26.1	42.1	27.5	56.7	42.2	27.5
C-Bond market value ($\mathcal{C}$)	10.4	22.5	36.5	57.1	34.8	40.2	0.0	0.4	21.0	7.6	8.0	24.0
U-Bond market value ($\mathcal{U}$)	52.7	51.6	52.4	64.6	58.3	54.8	59.6	73.6	69.7	109.4	85.3	73.0
Total bond market value ($\mathcal{C}+\mathcal{U}$)	63.1	74.1	89.0	121.7	93.1	95.0	59.6	74.1	90.8	117.0	93.3	97.0
Equity market value ($\mathcal{S}$)	26.8	22.8	15.8	0.0	10.9	12.0	27.9	22.7	14.7	0.0	10.7	10.7
Total bank value ($\mathcal{BV}$)	125.0	131.8	139.8	156.7	139.0	142.0	122.5	131.8	140.4	152.1	139.0	142.7
Total leverage (%)	78.5	82.7	88.7	100.0	92.2	91.6	77.2	82.7	89.6	100.0	92.3	92.5
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	47.3	61.2	77.3	98.4	74.5	81.4
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	37.2	37.7	59.6	45.3	45.8	62.8
Endogenous def. barrier (V_{ED})	48.3	61.2	76.1	98.0	74.3	80.0	11.9	17.7	33.3	14.4	21.3	35.0
Regulatory def. barrier (V_{RD})	48.3	61.2	76.1	98.0	74.3	80.0	36.6	37.1	58.7	44.6	45.1	61.8
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	2.74	0.96	0.32	6.54	1.27	0.35	2.44	0.67	0.25	4.02	0.88	0.28
Investment bank ($D = 0$)												
C-bond book value (C)	≤34.5*	≤50.4*	≤68.0*	≤68.3*	≤59.9*	≤71.3*	9.7	27.3	51.4	24.4	35.1	55.2
U-Bond book value (U)	≥77.4*	≥60.7*	≥56.3*	≥153.2*	≥72.2*	≥59.1*	123.6	97.4	80.8	263.5	116.9	84.2
Total bond book value ($C+U$)	111.9	111.1	124.3	221.4	132.1	130.4	133.3	124.7	132.2	287.9	152.0	139.4
CET1 capital ratio (%)	-11.9	-11.1	-24.3	-121.4	-32.1	-30.4	-33.3	-24.7	-32.2	-187.9	-52.0	-39.4
Tier1 capital ratio (%)	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	90.3	72.7	48.6	75.6	64.9	44.8
CET1 ratio at B-in (%)	-	-	-	-	-	-	77.9	54.6	33.1	74.2	52.1	31.9
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	9.3	27.0	51.3	23.3	34.8	55.2
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	82.4	81.6	75.1	127.3	93.1	77.6
Total bond market value ($\mathcal{C}+\mathcal{U}$)	79.5	98.0	119.2	131.5	114.2	124.8	91.7	108.6	126.4	150.5	127.9	132.7
Equity market value ($\mathcal{S}$)	40.2	30.9	19.7	7.6	20.2	16.1	31.8	23.8	15.0	0.3	11.6	11.0
Total bank value ($\mathcal{BV}$)	119.8	128.9	138.9	139.1	134.3	140.9	123.5	132.4	141.4	150.8	139.5	143.7
Total leverage (%)	66.4	76.1	85.8	94.6	85.0	88.6	74.2	82.0	89.4	99.8	91.7	92.4
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	43.7	60.2	76.9	94.4	73.3	81.1
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	10.3	29.0	54.7	25.9	37.4	58.8
Endogenous def. barrier (V_{ED})	36.7	53.6	72.3	72.6	63.8	75.9	3.2	13.2	29.9	8.0	17.0	32.1
Regulatory def. barrier (V_{RD})	≤36.7*	≤53.6*	≤72.3*	≤72.6*	≤63.8*	≤75.9*	10.1	28.6	53.9	25.5	36.8	57.8
C-bond credit spread (%)	1.22*	0.40*	0.13*	2.05*	0.47*	0.14*	0.11	0.03	0.01	0.14	0.03	0.01
U-bond credit spread (%)	1.22*	0.40*	0.13*	2.05*	0.47*	0.14*	1.50	0.58	0.23	3.21	0.77	0.26

* Any combination of C- and U-bond is optimal, subject to the condition that $V_{RD} \leq V_{ED}$. Only the total amount $C+U$ is determined. The Tier1 ratio is at least equal to 6% and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 6 (continued)

Panel (b): Tier1 & CET1 capital requirement

	Default regime			Bail-out regime			Bail-in regime			Mixed regime		
Growth prospects α	2.5%	5%	7.5%	2.5%	5%	7.5%	2.5%	5%	7.5%	2.5%	5%	7.5%
Commercial bank ($D = 35$)												
C-bond book value (C)	6.1	21.0	36.0	6.5	21.2	36.1	6.1	0.0	21.2	6.5	0.0	20.8
U-Bond book value (U)	0.7	0.9	1.1	0.7	0.9	1.1	0.7	22.0	17.8	0.7	22.1	17.7
Total bond book value ($C + U$)	6.7	21.8	37.1	7.1	22.1	37.2	6.7	22.0	39.1	7.1	22.1	38.5
CET1 capital ratio (%)	58.3	43.2	27.9	57.9	42.9	27.8	58.3	43.0	25.9	57.9	42.9	26.5
Tier1 capital ratio (%)	58.9	44.0	29.0	58.5	43.8	28.9	58.9	65.0	43.8	58.5	65.0	44.2
CET1 ratio at B-in (%)	-	-	-	-	-	-	-	41.3	27.5	-	41.5	27.5
C-Bond market value ($\mathcal{C}$)	6.1	21.0	36.0	6.5	21.2	36.1	6.1	0.0	21.2	6.5	0.0	20.8
U-Bond market value ($\mathcal{U}$)	0.4	0.7	1.0	0.5	0.8	1.1	0.4	21.7	18.4	0.5	22.0	18.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	6.5	21.6	37.0	6.9	21.9	37.1	6.5	21.7	39.6	6.9	22.0	38.9
Equity market value ($\mathcal{S}$)	65.3	57.4	49.8	64.9	57.2	49.7	65.3	57.3	47.8	64.9	57.1	48.4
Total bank value ($\mathcal{BV}$)	106.8	114.0	121.8	106.8	114.1	121.9	106.8	114.0	122.4	106.8	114.1	122.3
Total leverage (%)	38.8	49.7	59.1	39.2	49.9	59.2	38.8	49.8	60.9	39.2	49.9	60.4
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	-	28.0	43.8	-	28.1	43.5
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	-	59.6	77.5	-	59.8	77.0
Endogenous def. barrier (V_{ED})	14.1	28.0	42.6	14.2	28.1	42.7	14.1	17.4	33.4	14.2	17.4	33.2
Regulatory def. barrier (V_{RD})	43.7	59.5	75.5	44.1	59.8	75.6	43.7	36.6	58.9	44.1	36.6	58.5
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	2.27	0.87	0.30	1.31	0.57	0.21	2.27	0.03	-0.09	1.31	0.02	-0.06
Investment bank ($D = 0$)												
C-bond book value (C)	*	*	*	*	*	*	7.5	26.3	51.5	9.5	28.1	52.2
U-Bond book value (U)	*	*	*	*	*	*	25.0	29.0	22.1	25.8	27.9	21.0
Total bond book value ($C + U$)	22.1	45.4	66.9	25.8	47.9	68.1	32.6	55.3	73.6	35.3	56.0	73.2
CET1 capital ratio (%)	77.9	54.6	33.1	74.2	52.1	31.9	67.4	44.7	26.4	64.7	44.0	26.8
Tier1 capital ratio (%)	≥77.9*	≥54.6*	≥33.1*	≥74.2*	≥52.1*	≥31.9*	92.5	73.7	48.5	90.5	71.9	47.8
CET1 ratio at B-in (%)	-	-	-	-	-	-	77.9	54.6	33.1	74.2	52.1	31.9
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	7.3	26.0	51.4	9.4	28.0	52.2
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	23.9	28.8	22.6	24.9	27.8	21.4
Total bond market value ($\mathcal{C} + \mathcal{U}$)	20.3	43.4	65.7	24.0	46.2	67.1	31.3	54.8	74.0	34.3	55.7	73.5
Equity market value ($\mathcal{S}$)	83.6	68.4	55.3	80.5	66.2	54.2	74.5	59.5	49.0	71.9	58.8	49.4
Total bank value ($\mathcal{BV}$)	103.9	111.8	120.9	104.6	112.4	121.3	105.8	114.4	123.1	106.2	114.6	122.9
Total leverage (%)	19.5	38.8	54.3	23.0	41.1	55.3	29.6	47.9	60.2	32.3	48.7	59.8
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	10.7	26.7	42.8	11.6	27.0	42.6
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	34.1	57.9	77.0	37.0	58.6	76.7
Endogenous def. barrier (V_{ED})	7.3	21.9	38.9	8.5	23.1	39.6	2.5	12.7	30.0	3.1	13.6	30.4
Regulatory def. barrier (V_{RD})	23.2	47.5	70.0	27.0	50.2	71.3	7.9	27.5	53.9	10.0	29.4	54.7
C-bond credit spread (%)	0.27*	0.14*	0.05*	0.22*	0.11*	0.04*	0.09	0.03	0.01	0.05	0.02	0.00
U-bond credit spread (%)	0.27*	0.14*	0.05*	0.22*	0.11*	0.04*	0.14	0.02	-0.07	0.10	0.01	-0.05

* Any combination of C- and U-bond is optimal, only the total amount $C + U$ is determined. The Tier1 ratio is at least equal to the CET1 ratio and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 7: Optimal liability structure for different capital requirements and market beliefs

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 ($D = 35$)												
C-bond book value (C)	22.5	22.5	22.5	25.7	34.8	53.9	0.4	0.4	0.4	2.4	8.0	20.1
U-Bond book value (U)	68.1	68.1	68.1	71.9	83.0	105.9	90.2	90.2	90.2	95.3	110.3	141.9
Total bond book value ($C + U$)	90.6	90.6	90.6	97.6	117.8	159.8	90.6	90.6	90.6	97.7	118.3	162.0
CET1 capital ratio (%)	-25.6	-25.6	-25.6	-32.6	-52.8	-94.8	-25.6	-25.6	-25.6	-32.7	-53.3	-97.0
Tier1 capital ratio (%)	42.5	42.5	42.5	39.3	30.2	11.1	64.6	64.6	64.6	62.6	57.0	44.9
CET1 ratio at B-in (%)	-	-	-	-	-	-	42.1	42.1	42.1	42.1	42.2	42.4
C-Bond market value ($\mathcal{C}$)	22.5	22.5	22.5	25.7	34.8	53.9	0.4	0.4	0.4	2.4	8.0	20.1
U-Bond market value ($\mathcal{U}$)	51.6	51.6	51.6	53.6	58.3	60.9	73.6	73.6	73.6	76.9	85.3	94.9
Total bond market value ($\mathcal{C} + \mathcal{U}$)	74.1	74.1	74.1	79.2	93.1	114.7	74.1	74.1	74.1	79.3	93.3	115.0
Equity market value ($\mathcal{S}$)	22.8	22.8	22.8	19.4	10.9	0.6	22.7	22.7	22.7	19.4	10.7	0.4
Total bank value ($\mathcal{BV}$)	131.8	131.8	131.8	133.7	139.0	150.3	131.8	131.8	131.8	133.6	139.0	150.4
Total leverage (%)	82.7	82.7	82.7	85.5	92.2	99.6	82.7	82.7	82.7	85.5	92.3	99.8
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	61.2	61.2	61.2	64.6	74.5	95.6
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	37.7	37.7	37.7	39.7	45.8	58.6
Endogenous def. barrier (V_{ED})	61.2	61.2	61.2	64.5	74.3	94.6	17.7	17.7	17.7	18.6	21.3	27.1
Regulatory def. barrier (V_{RD})	61.2	61.2	61.2	64.5	74.3	94.6	37.1	37.1	37.1	39.1	45.1	57.7
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.96	0.96	0.96	1.03	1.27	2.22	0.67	0.67	0.67	0.72	0.88	1.48
Investment bank ($D = 0$)												
C-bond book value (C)	≤50.4*	≤50.4*	≤50.4*	≤52.9*	≤59.9*	≤72.9*	27.3	27.3	27.3	29.3	35.1	46.9
U-Bond book value (U)	≥60.7*	≥60.7*	≥60.7*	≥63.8*	≥72.2*	≥87.8*	97.4	97.4	97.4	102.4	116.9	147.7
Total bond book value ($C + U$)	111.1	111.1	111.1	116.7	132.1	160.7	124.7	124.7	124.7	131.7	152.0	194.6
CET1 capital ratio (%)	-11.1	-11.1	-11.1	-16.7	-32.1	-60.7	-24.7	-24.7	-24.7	-31.7	-52.0	-94.6
Tier1 capital ratio (%)	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	≥6.0*	72.7	72.7	72.7	70.7	64.9	53.1
CET1 ratio at B-in (%)	-	-	-	-	-	-	54.6	54.6	54.6	53.8	52.1	50.0
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	27.0	27.0	27.0	29.0	34.8	46.3
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	81.6	81.6	81.6	84.8	93.1	103.5
Total bond market value ($\mathcal{C} + \mathcal{U}$)	98.0	98.0	98.0	102.4	114.2	133.3	108.6	108.6	108.6	113.8	127.9	149.9
Equity market value ($\mathcal{S}$)	30.9	30.9	30.9	27.9	20.2	8.5	23.8	23.8	23.8	20.4	11.6	0.7
Total bank value ($\mathcal{BV}$)	128.9	128.9	128.9	130.3	134.3	141.7	132.4	132.4	132.4	134.2	139.5	150.6
Total leverage (%)	76.1	76.1	76.1	78.6	85.0	94.0	82.0	82.0	82.0	84.8	91.7	99.5
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	60.2	60.2	60.2	63.5	73.3	93.9
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	29.0	29.0	29.0	31.2	37.4	49.9
Endogenous def. barrier (V_{ED})	53.6	53.6	53.6	56.3	63.8	77.5	13.2	13.2	13.2	14.2	17.0	22.6
Regulatory def. barrier (V_{RD})	≤53.6*	≤53.6*	≤53.6*	≤56.3*	≤63.8*	≤77.5*	28.6	28.6	28.6	30.7	36.8	49.1
C-bond credit spread (%)	0.40*	0.40*	0.40*	0.42*	0.47*	0.62*	0.03	0.03	0.03	0.03	0.03	0.04
U-bond credit spread (%)	0.40*	0.40*	0.40*	0.42*	0.47*	0.62*	0.58	0.58	0.58	0.62	0.77	1.28

* Any combination of C- and U-bond is optimal, subject to the condition that $V_{RD} \leq V_{ED}$. Only the total amount $C + U$ is determined. The Tier1 ratio is at least equal to 6% and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

Table 7 (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 ($D = 35$)												
C-bond book value (C)	21.0	21.0	21.0	21.0	21.2	21.3	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	22.0	22.0	22.0	22.0	22.1	22.2
Total bond book value ($C + U$)	21.8	21.8	21.8	21.9	22.1	22.2	22.0	22.0	22.0	22.0	22.1	22.2
CET1 capital ratio (%)	43.2	43.2	43.2	43.1	42.9	42.8	43.0	43.0	43.0	43.0	42.9	42.8
Tier1 capital ratio (%)	44.0	44.0	44.0	44.0	43.8	43.7	65.0	65.0	65.0	65.0	65.0	65.0
CET1 ratio at B-in (%)	-	-	-	-	-	-	41.3	41.3	41.3	41.4	41.5	41.6
C-Bond market value ($\mathcal{C}$)	21.0	21.0	21.0	21.0	21.2	21.3	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	0.8	0.8	21.7	21.7	21.7	21.8	22.0	22.1
Total bond market value ($\mathcal{C} + \mathcal{U}$)	21.6	21.6	21.6	21.7	21.9	22.1	21.7	21.7	21.7	21.8	22.0	22.1
Equity market value ($\mathcal{S}$)	57.4	57.4	57.4	57.3	57.2	57.0	57.3	57.3	57.3	57.2	57.1	57.0
Total bank value ($\mathcal{BV}$)	114.0	114.0	114.0	114.1	114.1	114.1	114.0	114.0	114.0	114.0	114.1	114.1
Total leverage (%)	49.7	49.7	49.7	49.7	49.9	50.0	49.8	49.8	49.8	49.8	49.9	50.1
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	28.0	28.0	28.0	28.1	28.1	28.2
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	59.6	59.6	59.6	59.7	59.8	59.9
Endogenous def. barrier (V_{ED})	28.0	28.0	28.0	28.0	28.1	28.2	17.4	17.4	17.4	17.4	17.4	17.4
Regulatory def. barrier (V_{RD})	59.5	59.5	59.5	59.6	59.8	59.9	36.6	36.6	36.6	36.6	36.6	36.6
C-bond credit spread (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U-bond credit spread (%)	0.87	0.87	0.87	0.76	0.57	0.39	0.03	0.03	0.03	0.03	0.02	0.02
Investment bank ($D = 0$)												
C-bond book value (C)	*	*	*	*	*	*	26.3	26.3	26.3	26.8	28.1	29.5
U-Bond book value (U)	*	*	*	*	*	*	29.0	29.0	29.0	28.7	27.9	26.9
Total bond book value ($C + U$)	45.4	45.4	45.4	46.2	47.9	50.0	55.3	55.3	55.3	55.5	56.0	56.4
CET1 capital ratio (%)	54.6	54.6	54.6	53.8	52.1	50.0	44.7	44.7	44.7	44.5	44.0	43.6
Tier1 capital ratio (%)	≥54.6*	≥54.6*	≥54.6*	≥53.8*	≥52.1*	≥50.0*	73.7	73.7	73.7	73.2	71.9	70.5
CET1 ratio at B-in (%)	-	-	-	-	-	-	54.6	54.6	54.6	53.8	52.1	50.0
C-Bond market value ($\mathcal{C}$)	*	*	*	*	*	*	26.0	26.0	26.0	26.6	28.0	29.4
U-Bond market value ($\mathcal{U}$)	*	*	*	*	*	*	28.8	28.8	28.8	28.5	27.8	26.8
Total bond market value ($\mathcal{C} + \mathcal{U}$)	43.4	43.4	43.4	44.3	46.2	48.5	54.8	54.8	54.8	55.1	55.7	56.3
Equity market value ($\mathcal{S}$)	68.4	68.4	68.4	67.7	66.2	64.5	59.5	59.5	59.5	59.3	58.8	58.4
Total bank value ($\mathcal{BV}$)	111.8	111.8	111.8	112.0	112.4	113.0	114.4	114.4	114.4	114.4	114.6	114.7
Total leverage (%)	38.8	38.8	38.8	39.5	41.1	42.9	47.9	47.9	47.9	48.2	48.7	49.1
Endogenous b-in barrier (V_{EB})	-	-	-	-	-	-	26.7	26.7	26.7	26.8	27.0	27.2
Regulatory b-in barrier (V_{RB})	-	-	-	-	-	-	57.9	57.9	57.9	58.1	58.6	59.1
Endogenous def. barrier (V_{ED})	21.9	21.9	21.9	22.3	23.1	24.1	12.7	12.7	12.7	13.0	13.6	14.2
Regulatory def. barrier (V_{RD})	47.5	47.5	47.5	48.3	50.2	52.3	27.5	27.5	27.5	28.1	29.4	30.9
C-bond credit spread (%)	0.14*	0.14*	0.14*	0.13*	0.11*	0.09*	0.03	0.03	0.03	0.02	0.02	0.01
U-bond credit spread (%)	0.14*	0.14*	0.14*	0.13*	0.11*	0.09*	0.02	0.02	0.02	0.02	0.01	0.01

* Any combination of C- and U-bond is optimal, only the total amount $C + U$ is determined. The Tier1 ratio is at least equal to the CET1 ratio and depends on the actual debt structure implemented. The credit spreads are referred to the total amount of debt issued.

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 $\mathbb{P}$:

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

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

$$\frac{dX}{X} = (\alpha - \sigma\lambda)\, dt + \sigma dW^{\mathbb{Q}}.$$

We interpret the after-tax claim over the EBIT process as the asset value V:

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

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:

$$\frac{dV}{V} = \alpha dt + \sigma dW, \tag{8}$$

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

$$\frac{dV}{V} = (\alpha - \sigma\lambda)\, dt + \sigma dW^{\mathbb{Q}}. \tag{9}$$

B Perpetual bond valuation

Denote the coupon payment of a generic perpetual debt contract with b, the book value of the contract 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 (9). Applying Itô's lemma to the market value $\mathcal{B}$ and imposing no-arbitrage restrictions, the following equation is obtained:

$$\frac{1}{2}\sigma^2 V^2 \mathcal{B}_{VV} + (\alpha - \sigma\lambda) V \mathcal{B}_V + b = r\mathcal{B}. \tag{10}$$

Two boundary conditions can be imposed. The first is evaluated at the asset value V_T[4], corresponding to which the firm fails to serve debt obligations and the recovery value of debt, $\mathcal{B}_T$, is paid to the claimants:

$$\mathcal{B}(V = V_T) = \mathcal{B}_T. \tag{11}$$

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

$$\lim_{V\to\infty} \mathcal{B} = \frac{b}{r} = B. \tag{12}$$

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

$$\mathcal{B} = B - (B - \mathcal{B}_T) \left[\frac{V}{V_T}\right]^{\gamma}, \tag{13}$$

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 (13) solves (10) and satisfies the boundary conditions (11) and (12) when:

$$\gamma = -\left(\frac{\alpha - \sigma\lambda}{\sigma^2} - \frac{1}{2}\right) - \sqrt{\left(\frac{\alpha - \sigma\lambda}{\sigma^2} - \frac{1}{2}\right)^2 + 2\frac{r}{\sigma^2}}. \tag{14}$$

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 (9). 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, generating 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:

$$\frac{1}{2}\sigma^2 V^2 \mathcal{S}_{VV} + (\alpha - \sigma\lambda) V \mathcal{S}_V + (r + \sigma\lambda - \alpha) V - b(1-\tau) = r\mathcal{S}. \tag{15}$$

[4] According to the resolution framework under analysis, T represents the first hitting time of the asset value process at the bail-in/default boundary.

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[5]:

$$\mathcal{S}(V = V_T) = 0. \tag{16}$$

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 $V - B(1-\tau)$:

$$\lim_{V \longrightarrow +\infty} \frac{\mathcal{S}}{V - B(1-\tau)} = 1. \tag{17}$$

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

$$\mathcal{S} = V - V_T \left[\frac{V}{V_T}\right]^{\gamma} - B(1-\tau)\left(1 - \left[\frac{V}{V_T}\right]^{\gamma}\right), \tag{18}$$

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 (15) solves (10) and satisfies the boundary conditions (16) and (17) when γ is equal to the value in (14).

D Proof of Theorem 1 (bail-in regime)

Before bail-in is triggered at an asset level V_B[6], the equityholders must obey a continuous payment of the interests on deposits 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 (15), together with the bail-in trigger level V_B to obtain the equity value before bail-in:

$$\mathcal{S} = V - V_B \left[\frac{V}{V_B}\right]^{\gamma} - (D + I + C + U)(1-\tau)\left(1 - \left[\frac{V}{V_B}\right]^{\gamma}\right). \tag{19}$$

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

[5] It happens the first time the asset value process hits the bail-in/default boundary.

[6] The V_T boundary, used in the generic perpetual bond valuation formula presented before, represents the bail-in boundary V_B in this regime.

by invoking the smooth-pasting condition $\frac{\vartheta \mathcal{S}}{\vartheta V}\Big|_{V=V_B^*} = 0$:

$$V_{EB} = V_B^* = \frac{\gamma}{\gamma - 1}\left(D + I + C + U\right)\left(1 - \tau\right). \tag{20}$$

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

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[7], determined as $\max\left[V_{ED}, V_{RD}\right]$, 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 (15), together with the default trigger level V_D to obtain the equity value after bail-in:

$$\widehat{\mathcal{S}} = V - V_D\left[\frac{V}{V_D}\right]^{\gamma} - \left(D + I + C\right)\left(1 - \tau\right)\left(1 - \left[\frac{V}{V_D}\right]^{\gamma}\right). \tag{21}$$

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

$$V_{ED} = V_D^* = \frac{\gamma}{\gamma - 1}\left(D + I + C\right)\left(1 - \tau\right). \tag{22}$$

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 $\widehat{\mathcal{S}}\left(V = V_B\right)$. 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 $\widehat{\mathcal{S}}\left(V = V_B\right) - \xi V_B$. 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 $\left[V_B\left(1 - \varepsilon\right) - C - D\right]^+$. This means that the value of the U-bond at V_B is equal to:

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

The bail-in is applicable if $\widehat{\mathcal{S}}\left(V = V_B\right) - \xi V_B > 0$ (limited liability of U-bondholders) and $V_{RB} - \left[D + C\right] \geq \psi V_{RB}$ (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

[7] After bail-in, the V_T boundary, used in the generic perpetual bond valuation formula presented before, becomes the default boundary V_D.

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 (13) 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, when 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 (13):

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

E Proof of Theorem 2 (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[8]:

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

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

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

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 $p = 1$,

[8] Therefore, the V_T boundary, used in the generic perpetual bond valuation formula presented before, represents only the default boundary V_D in this regime.

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:

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

The market values of U- and C-bonds are given by a weighted average of the equivalent risk-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:

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

F Proof of Theorem 3 (mixed regime)

The equity value $\mathcal{S}$ is the same as in (19), 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 (21), where $V_D = \max\left[V_{ED}, V_{RD}\right]$. The endogenous barriers V_{EB} and V_{ED} are respectively given in (20) and (22).

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 risk-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:

$$\mathcal{C} = C - (1 - p_1)(1 - p_2)(C - \mathcal{C}_D)\left[\frac{V}{V_D}\right]^\gamma,$$

$$\mathcal{U} = U - (1 - p_1)(U - \mathcal{U}_B)\left[\frac{V}{V_B}\right]^\gamma.$$

Chapter II

Bail-in related events and bank CDSs

Luca Leanza*

Abstract

This paper aims to estimate the spillover effect of some bail-in related events on the European banking system. An event study methodology has been adopted on the CDS spreads written on senior unsecured and subordinated debt of 69 banks in 16 countries. The introduction of the new bank recovery and resolution framework (BRRD) has removed the government's implicit guarantee on banks' debt, causing the increase in the CDS spreads, especially for the banks considered systemically important on a global scale (G-SIBs). Moreover, given that the market beliefs concerning the probability of bailing-out the senior unsecured debt were relatively higher than the subordinated debt, the removal of the government's guarantee had a greater impact on the senior debt as it was suddenly perceived as riskier by the market than in the past.

JEL classification: G01, G14, G18, G21.

Keywords: Bail-in, Event study, CDS, BRRD.

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1 Introduction

The financial crisis of 2007/2008 showed major weaknesses on the global financial system and some systemic financial institutions were saved through public tax payers' support. As a response to avoid an excessive involvement of subjects not directly related to banks, European policymakers introduced new rules aimed to supersede the way by which distressed financial institutions and their resolutions were treated in the past. According to regulators, in order to avoid moral hazard, any failing institution should be able to exit the market, irrespective of its size and interconnectedness, without causing systemic disruption and financial instability.

In order to do so, the Bank Recovery and Resolution Directive (BRRD)[1] has been introduced in Europe. Its major novelty is represented by the new bail-in resolution regime. The aims of the resolution framework are numerous, including the ensuring of the continuity of critical functions, the avoiding of adverse effects on financial stability, the protection of public funds (by minimising reliance on extraordinary public support to failing institutions), and the protection of covered depositors, investors, client funds and client assets.

The objectives above may come into being thanks to the prior participation of some categories of bank's debt holders in meeting the resolution costs. Indeed, Article n. 48 of the BRRD establishes the sequence the resolution authorities should follow in applying the power to write-down or convert obligations (the bail-in power) of an entity under resolution. Bank's losses should be firstly absorbed by regulatory capital instruments. Then, they should be allocated to shareholders either through the cancellation or transfer of shares. Alternatively, shareholders could be severely diluted. Subordinated debt could be written down or converted into equity only if the actions mentioned above are not sufficient. Eventually, senior unsecured debt and deposits over the EUR 100.000[2] could be involved in the procedure only when subordinated debt is not sufficient. Therefore, in order to definitively eliminate the public subsidy, the directive establishes that taxpayers will be the last in line

[1] Directive 2014/59/EU.

[2] The legal limit provided by deposit guarantee schemes in EU.

to pay the bills of a failing bank. Other creditors will forfeit some or all of their holdings to keep the bank alive according to Article 48 and the "No Creditor Worse Off" (NCWO) principle[3]. However, not all the bank's capital instruments are bail-inable. Article 44 (point 2) of BRRD expressly excludes the possibility for the resolution authorities to exercise the write-down or conversion powers to some categories of debt instruments as covered deposits, covered bonds, employee remuneration, etcetera. Moreover, to ensure restructuring as a going-concern, each bank needs to prepare a full recovery plan that sets out the measures it will take in distinct scenarios where it is at risk.

According to Rutledge et al. (2012), the new resolution regime should be able to remove the distortive incentive of bankers and managers, generated by the "too-big-to-fail" status of a bank. The wished outcome would be to restore market discipline[4] and align banks' funding costs more closely to the risk they are exposed. Indeed, the transition from the bail-out to the bail-in resolution regime, introduced by the BRRD, has been complemented with a specification of the loss-absorption priorities and the bail-in hierarchy of the various financial instruments, which has modified the priority to bank creditors.

According to Danisewicz et al., (2018), conferring priority to depositors implies subordinating nondepositors' claims. As a consequence, they (especially senior unsecured creditors) might be induced to exert more monitoring than before affecting bank behaviour by means of reducing the level of risk taken in the long run. However, Belkhir (2013) shows that the impact of a high amount of subordinated debt on risk management decisions depends upon whether the debt is held by outside investors or by investors who also hold the bank's equity (the parent holding company). The additional subordinated debt leads to risk management decisions in line with the market discipline hypothesis in the second case, while it leads to

[3] The application of the NCWO principle is carried out under Article 74 of Directive 2014/59/EU (BRRD). According to the principle no creditor or shareholder shall incur greater losses than they would have incurred if the institution had been wound up under normal insolvency proceedings.

[4] Market discipline can be divided in two distinct components: market monitoring and market influence (Bliss and Flannery, 2002). Market monitoring refers to the ability of investors in detecting variations in the bank's risk and in incorporating them into the price of the bank's securities. Instead, market influence refers to the ability of both the investors and the regulators to influence the behaviour of the banks in terms of risk taking.

risk management decisions in line with the moral hazard behaviour in the first one. However, his analysis also reveals that the presence of such a "too-big-to-fail" status leads managers to adopt a moral hazard behaviour as the subordinated debt ratio increases. In this case, the increase occurs even when the debt is held by equity owners, who have access to a whole set of information and greater capability to influence a bank's decisions.

As far as incentives are concerned, the presence of an implicit government guarantee on bank bonds made the bank's debtholders less risk-sensitive. As argued by DeYoung et al. (2013), the presence of passive counterparties reduces banks' exposure to market discipline and encourages banks' managers to take greater insolvency risk. However, one can claim that the removal of the government implicit guarantee on bank debt produced some negative effects.

Citing again Rutledge et al. (2012), *"To the extent that bail-in reduces or even eliminates the implicit too-big-to-fail subsidy to SIFIs, it would, by design, have an impact on banks' funding costs."*. Baglioni (2016) also argued that the main drawback of the bail-in principle is that it might increase the cost of funding, thus making instable the market of bank liabilities due to the more relevant costs shifted from tax payers to creditors in case of bank distress. Therefore, up to the introduction of the new resolution regime, implicit government guarantees made banks' debt rating artificially high. Consequently, the removal of the protection may cause an average downgrade of the unsecured debt[5], along with an increase in the bank' s cost of funding. This effect should be reflected in a positive variation in the spread of the bank-related credit default swap, due to the increase in the default risk.

The main hypotheses of the paper are twofold. As for the first, given that banks generally suffer from the removal of the government guarantee in case of bank distress, deeper analysis is needed on banks whose failure might trigger a financial crisis. These types of banks are defined systemically important (G-SIBs)[6], and market beliefs of a public bail-out, before

[5] In Europe, JP Morgan estimates the percentage of EU banks shifting to non-investment grade would increase from 2 percent to 33 percent (Henriques, 2011)).

[6] The Financial Stability Board (FSB), in consultation with Basel Committee on Banking Supervision (BCBS) and national authorities, identified every year a list of global systemically important banks. These

the introduction of the new resolution regime, were higher than those related to medium or small banks. Therefore, a change in the CDS spreads for G-SIBs is expected to be greater than those of non-G-SIBs.

As for the second hypothesis of this paper, different debt instruments issued by the same banks are thought to be reacting differently. Therefore, the CDSs written on the senior unsecured debt are expected to show spread variations relatively higher than the spread of the CDSs written on the subordinated debt. The reason is the same: market beliefs concerning the probability of a government intervention aimed at bailing-out the senior unsecured debt were relatively higher than those related to the subordinated one in case of bank distress. Therefore, the removal of the government protection should mostly have a negative impact on the senior debt category. To better clarify the reasons behind these hypotheses, the differences in the treatment received by the two types of banks and the two categories of debt in case of bank distress, in both the bail-out and bail-in regime, are presented in section 3 and are summarized in tables 1 and 2.

To test the two hypotheses, an event study methodology has been adopted on the CDSs written on both senior unsecured and subordinated debt of 69 European Banks in 16 countries, also taking into account the rating groups to which banks belong in each event. To estimate the CDSs' expected variation the CDS factors model introduced by Andres et al. (2016) has been employed. The model, also used by Bruno et al. (2018), is considered the reference to predict expected variation in the CDS spreads in the literature.

The analysis has been carried out on two dimensions. At an aggregate level, the impact of the bail-in related events on European banking system has been evaluated using both market CDS indices and other ones developed by the author of this paper. At an individual level, the impact of the same events on a bank-to-bank basis has been evaluated. Then, bank-related cumulative abnormal spreads have been used as dependent variables of a cross-sectional analysis aimed at identifying their most important bank- and country-specific

are banks, insurance company, or other financial institution whose failure might trigger a financial crisis. They are colloquially referred to as "too-big-to-fail ".

determinants. Finally, as a robustness check, the event study analysis on the CDS written on the European countries' sovereign senior debt has been repeated. In order to verify the presence of an endogeneity problem between bank and sovereign risk, the sovereign CDS abnormal variations obtained in the event study analysis has been considered in the main cross-sectional regression.

This paper finds evidence on positive CDS spreads variations triggered by bail-in related events rather than other confounding factors as confirmed by the robustness check. Moreover, both hypotheses of the paper have been confirmed, highlighting the important role played by the implicit government guarantee in the past. Indeed, it distorted the incentive of bankers and managers of banks considered "too-big-to-fail" for long time. Finally, the cross-sectional analysis confirmed the main result obtained by Schäfer et al. (2016), namely that belonging to the G-SIBs category is an important determinant in explaining CDS abnormal variations. However, the robustness check shows the expected correlation between bank and sovereign risk, documented in De Bruyckere et al (2013) but not discussed in the paper by Schäfer et al. (2016), which generates endogeneity problems. Solving the endogeneity problem goes beyond the goal of this paper, which simply aims to highlight its presence which makes their results not robust. Nevertheless, it could represent an interesting issue for future research.

In the rest of the paper I outline: in section 2 an overview of the main literature concerning the studies on credit default swap and the introduction of the BRRD; in section 3 the research hypothesis, methodology, data and events specification; in section 4 the discussion on the empirical results and on the robustness checks; in section 5 the conclusions.

2 Literature review

The use of CDS to detect the impact of a credit event[7] is increasing. One of the first event study based on CDSs spread was performed by Hull et al. (2004). They examined the theoretical relationship between CDS spreads and bond yields in order to estimate the five-year risk-free rate benchmark used by the CDS market participants. Moreover, they performed a series of analysis aimed at testing how the Moody's credit rating announcements were anticipated by investors. After some years, Andres et al. (2016), in the spirit of Brown and Warner (1985) and Bessembinder et al. (2008), examined the size and the power of test statistics designed to capture abnormal variation in the CDS spreads. To do so, they used daily observations and a simulation approach. Moreover, they completed the analysis introducing the so called "CDS Factor Model" in the literature. The model uses the most important factors identified by the empirical literature on CDS in order to predict the expected variation of the CDS spreads.

Among the other, the most important authors who contributed to the empirical literature on CDS are: Collin-Dufresne et al. (2001), who investigated the relation between the determinants of credit risk, coming from the structural model of default, and the bond spread changes; Ericsson et al. (2009), who identified the best determinants of credit spread variation, namely the level of leverage, the equity implied volatility and the level of the Treasury yield curve; Alexander and Kaeck (2008), who documented the statistically significant relation between the slope of the risk-free yield curve and spread variation.

More recent contribution to the use of CDS in an event study methodology has been provided by Georgescu et al. (2017) and Bruno et al. (2018). The first authors used the event study approach, based on CDS spreads and stock prices, to explore how market participants reacted to the 2014 Comprehensive Assessment and the 2016 stress test in Europe. They found that both the CDS spreads and the stock prices reacted more for the

[7] A default, bankruptcy or other situation which is recognized as affecting the creditworthiness of a country or organization and which may trigger insurance payment as defined in a CDS.

weaker performing banks in the stress test. In a similar way, Bruno et al. (2018) measured the market reactions to announcements concerning one of the most important innovation introduced by Basel III framework, the liquidity regulation.

Concerning the Bank Recovery and Resolution Directive (BRRD), its most discussed provision is the bail-in tool, which represents an important innovation in the way the European countries must deal with bank resolution. The most important novelty is represented by the transfer of responsibility in bearing the cost of bank losses from the taxpayers to the debtholders of the bank. Pamela Lintner, the Senior Financial Sector Specialist at the World Bank[8], with the outstanding assistance of many other authors, in 2016 analyzed a series of selected cases related to the resolution of several failing European banks from a theoretical point of view. She analyzed resolution cases occurred both in the period pre- and post-BRRD introduction, focusing on the application of the bail-in tool.

From an empirical point of view, Schäfer et al. (2016) was the main reference point for this paper. They studied the response to a selection of bail-in related events analysing the market reaction of both the stock prices and the CDS spreads of 64 European banks. They found evidence of decreased stock prices and increasing CDS spreads especially after the bail-in happened in Cyprus in 2013, stated that a concrete bail-in application generated a stronger market reaction than the legal implementation of the resolution regimes: "actions speak louder than rules and good intentions". Another result they found was that the effect of the bail-in expectations on the market reaction of both the stock price and the CDS spread depended on the sovereign's fiscal strength. Indeed, they showed that the spillover effect of a bail-in event was stronger for banks headquartered in countries with limited fiscal space for a public bail-out (GIIPS countries[9]) than for banks headquartered in other countries (No-GIIPS).

[8] Financial sector advisory center (FinSAC): "Bank Resolution and Bail-in in the EU: Selected case studies pre and post BRRD", World Bank Group (2016).

[9] Banks from Greece, Ireland, Italy, Portugal, and Spain (GIIPS). These were the countries strongly affected by the European sovereign debt crises.

With this paper I contributed both to the literature related to the use of CDS in the event study methodology, started by Hull et al. (2004) and followed by Andres et al. (2016), Georgescu et al. (2017) and Bruno et al. (2018), and to the series of empirical researches that tried to identify a measurable effect to the introduction of the new European banks resolution framework and bail-in provision, as the ones performed by Schäfer et al. (2016) and Giuliana (2017). Indeed, as in Schäfer et al. (2016), the aim of the paper was to estimate the spillover effect of bail-in related events on the European banking system, however important modifications both in the research hypotheses and in the methodology has been introduced with respect their study. Indeed, they focused only on the CDS written on the banks' senior unsecured bond, employing a standard constant return model for an equally-weighted CDS index created by the authors. Doing so, the small banks present in the sample received the same weights of largest banks. For this reason, the estimates they obtained on the CDS abnormal variation were not only less accurate, due to the use of an unsophisticated model, but also biased, because mostly driven by the CDS spread variations on small banks, less affected by the new regulation. I corrected the bias creating three different asset-weighted CDS indices, two of them made grouping the banks according to whether they belong or not to the group of G-SIBs, and four CDS indices based on the median spread variation of banks grouped by similar credit ratings. Moreover, instead of performing a standard constant return model, I implemented a CDS four-factor model that, according to Galil et al. (2014), is considered the reference model to detect expected CDS variations.

Focusing on the cross-sectional analysis, they did not consider the relevant role of the existent link, especially for the banks headquartered in the GIIPS countries, between bank and sovereign risk, which should determine endogeneity problem. I show the presence of this relation including in the analysis the CDS abnormal variations obtained repeating the events study analysis at sovereign level. Solving the endogeneity problem goes beyond the goal of this paper, which simply aims to highlight its presence which makes their results not robust. Indeed, the major novelty of this paper is to highlight the heterogeneity of the reactions that the bail-in related events had not only among banks (G-SIBs Vs No-G-SIBs) but also among different debt instruments issued by the same bank. To do so, a focus on the CDSs written on the subordinated debt has been provided, discussing the economic reasons behind the different reactions obtained on CDSs written on the two types of bond.

Albeit a far from being extremely precise and completely exhaustive, the empirical analysis highlights the important role played by the implicit government guarantee on bank debt, which distorted the incentive of bankers and managers for long time, especially those of largest banks considered "too-big-to-fail". The removal of the guarantee and the shift in the responsibility from public funds (at tax-payers expense) to some category of creditors was of extremely importance in order to restore market discipline and align banks' funding costs more closely to the risk they are exposed.

3 Events specification, research questions, data and methodology

3.1 Events specification

Concerning the selection of events, I relied on previous studies[10] that identified a series of main bail-in related events starting from 2011, the failure of Amagerbanken in Denmark, up to the first of January 2016, when the bail-in resolution regime becomes effective in Europe. To estimate the impact of the new regulation on the European banking system eight events has been selected. However, some events can be also considered as a great unique event and the results are also provided in cumulative terms.

[10]More details on the events are provided in Giuliana (2017), Schäfer et al. (2016) and on the book of the World Bank Group (2016), FinSAC.

Event 1: Amagerbanken bail-in of senior unsecured debt

The first event is the creditors bail-in of Amagerbanken, the small retail Danish bank, that were wound up on Sunday 6 February 2011, under the Danish national resolution procedure "Bank Package III"[11]. The case is interesting because the Danish authority decided to apply the new bail-in regime long before the creation of the single resolution mechanism (SRM). Moreover, for the first time in Europe, the bail-in procedure also involved the senior unsecured debt and larger deposits.

Event 2: Bankia and other small savings banks

The second event refers to the Spanish bank rescue plan occurred during the second half of the 2012, when Bankia and other small savings banks went in distress. The Spanish government applied for European Stability Mechanism (ESM) assistance in order to restructure and recapitalize the country's banks. The ESM made available to the Spanish government up to EUR 100 billion in assistance, although, in the end, it only needed EUR 41.3 billion[12]. The necessary condition for granting bank aid, contained in the Memorandum of Understanding (MoU), explicitly required the participation of junior creditors in bearing part of the losses of the Spanish institutes. However, it is important to underline that no ESM's cash was disbursed directly to the banks and that owners of senior unsecured debt as well as depositors have not been involved.

Event 3 and 4: Bail-in of Bank of Cyprus

In March 2013, after very intense discussions, the Troika (the International Monetary Fund [IMF], the European Central Bank [ECB] and the European Commission) and the Cypriot government (Cyprus MoU [2013]) agreed to an originally estimated EUR 7 billion

[11] See Dübel (2013b).

[12] European Stability Mechanism: Conclusion of ESM financial assistance programme for Spain: an overview. December (2013).

bail-in solution to recapitalize the largest systemic bank (Bank of Cyprus [BoC])[13]. For the first time in the euro area, also uninsured depositors (together with all non-secured debt) were called upon to recapitalize their banks. It was the necessary condition in order to receive public support by the Cypriot government.

To recapitalize BoC, an estimated 37.5% of BoC's uninsured deposits were converted into ordinary shares and, to prevent capital flight, the largest part of the remaining uninsured deposits was temporarily frozen.

The initial announcement, made on 18 of March, represents the event 3. At that time, the Cypriot government and the Eurozone Finance Ministers announced that all deposits, including those below EUR 100.000, would be facing losses. The initial proposal provided for a 6.75% levy on all deposits under EUR 100.000 and a 9.9% levy above this threshold. However, one week later, on 25 March 2013 (event 4), after tough negotiations, the final deal provided the bail-in of senior unsecured debt and large deposits, those above the legal level of the deposit guarantee scheme. The exact level of the bail-in ("haircut") was set at 47.5% and the government became the major shareholder of BoC due to the EUR 1.5 billion capital injection.

These two events have been also analysed in cumulative terms since they can be considered as a unique great event split in two dates. The Cyprus related events represent the turning point on the way ailing banks will be resolved in Europe. From that moment on, the European banking system realized that a new resolution regime would have replace the previous bail-out framework. For this reason, these two events are the most important in the analysis and, as obtained in Schäfer et al. 2016, the greatest impact in terms of CDS spread increase is expected with respect the other events, especially for the banks and the financial instruments that relied mostly on the implicit government guarantee in the past.

[13] While the second largest bank, Cyprus Popular Bank (Laik]), was subject to the "sale-of-business" tool merging it with BoC. World Bank Group (2016), FinSAC.

Event 5 and 6: Agreement on the SRM

Events 5 and 6 refer, respectively, to the provisional and the formal agreement on the single resolution mechanism (SRM), fixing bail-in rules within the European Banking Union. The purpose of the SRM is to ensure efficiency in the procedure to dealing with potential future bank failures in the euro area, reducing the burden for taxpayers and avoiding contagion to the real economy. The SRM has access to a European Single Resolution Fund (SRF), which is supposed to be financed from the banking sector instead of involving public funds.

The SRM applies the rules established under the BRRD, briefly summarized in the introduction of the paper. The main novelty introduced by the BRRD is that creditors, according to a well-defined hierarchy and the NCWO principle, are primarily supposed to bear the costs of the bank failure in order to minimise the burden for taxpayers. The EU Finance ministers agreed upon the BRRD in June 2013, but the milestone was passed on 20 of March 2014 (event 5), when the European Parliament and the Council reached the provisional agreement. On the 15 of April 2014 (event 6), the SRM was finally adopted by the European Parliament and one month later the directive 2014/59/EU has been published.

As for event 3 and 4, also these two events can be considered as a unique great event and results are also provided in cumulative terms.

Event 7: Bail-in of Andelskassen

Another relevant event is the bail-in of another Danish bank, Andelskassen. During the bail-in procedure, in order to help maintaining financial stability, the Danish government provided guarantees, capital injections and liquidity support to the distressed bank, charging the financial sector to pay for the implementation of these measures. The bail-in process included the write-down of uninsured depositors and the contributions of the deposit guarantee scheme (DGS). The event was considered one of the first bail-in case providing a concrete example of the NCWP principle application. Moreover, it represented the first case of a successful and smoother open bank bail-in process able to ensure uninterrupted access to the bank's deposits and critical functions.

Event 8: The formal transposition of the bail-in tool

Article 130 of the BRRD (Transposition), requires that: *"Member States shall apply provisions adopted in order to comply with Section 5 of Chapter IV of Title IV from 1 January 2016 at the latest."* Therefore, the First of January 2016 is the last event analysed.

The list of the events, as well as the expectations concerning their impact on the CDS spreads, are summarized in table 3.

Apart from the Cyprus events, the hypothesis is that none of the other events should be statistically significant. As far as the first two events concerns, the bail-in procedure took place long before with respect to the implementation of its regulation and would have been considerate as isolate cases of pure national resolution of non-systemically important banks.Concerning both the provisional and the formal agreement on the SRM there might have been a slow price incorporation due to the previous public discussion on the new regulation. In this way, the market had already incorporated the novelty introduced by the regulation at the time of the events. For the same reason, also the last two events, occurred after the introduction of the BRRD, are expected to generate not significant variation in the CDS of the European banks.

Moreover, it is also important to highlight that together with the BRRD the banks started to also comply with the more stringent capital requirements imposed by Basel III, that tended to progressively make the financial institution safer. Indeed, Berger et al. (2018) showed that shifting from the bail-out to the bail-in framework, the largest banks increased their capital ratios more than other banks, and with a rate of adjustment much faster. Therefore, any zero (or also negative) impact on the banks' CDS obtained for the events occurred either around the period of the BRRD introduction, or immediately after, could also be explained by their results.

3.2 Research questions

According to Rutledge et al. (2012), the removal of the implicit subsidy to G-SIBs would increase the banks' funding costs kept low in the past by the artificially high credit rating of these institutions. For this reason, the most important G-SIBs, considered too-big-to-fail in the past, should suffer most from the adoption of the new resolution regime, which eliminating the government guarantee should trigger the repricing of their bonds.

Therefore, the first research hypothesis of the paper is that a change in the CDS spreads for G-SIBs is expected to be greater than those of non-G-SIBs. Figures 1 and 2 show the average CDSs level and their variations, from 2010 to 2016, for the two groups (G-SIB and No-G-SIB). As expected, the average CDS level for G-SIB is lower than No-G-SIB as the first group is composed by largest banks, usually characterized by well-diversified asset and liability structures. Moreover, given the "too-big-to-fail" status, these banks benefitted from credit rating artificially high in the past. However, looking at the average spread variations, from 2012 onwards the changes in the CDSs for the group of G-SIBs became more consistent than the group of non-G-SIBs. The differences in the CDS spread variations could signal that something related to the stability of this type of institution was changing, and the introduction of new resolution regulation, principally applied to largest bank, could be one possible determinant. In table 1 the assumptions on the different reactions among the CDS of G-SIBs and non-G-SIBs, before and after the adoption of the new resolution regime, are briefly summarized.

At this point it is important to clarify that with this set up it is not possible to identify the difference in the reaction between treated and not treaded group due to the impossibility to construct a counterfactual group, not treated by the event, that can allow to run the classical difference in differences analysis[14]. At the same time, it is not possible to use different events to evaluate the before and after reaction of the same bank to the introduction of the bail-in

[14] For this type of analysis, performed on bank's bonds, see Giuliana (2017).

regime. The analysis simply captures the difference in the average reaction[15], at the same event, between the group of G-SIBs and the group of non-G-SIBs. The difference in the treatment received by the two group of banks, before and after the introduction of the bail-in resolution framework, might represents only the possible explanation of the differences in the reaction we should obtain from the analysis.

The heterogeneity of the reactions to the bail-in related events is expected to be present not only among banks but also among different debt instrument issued by the same banks, according to their seniority. Figures 3 and 4 show the Markit iTraxx CDSs[16] level and their variations from 2010 to 2016 and for the two key bank's unsecured financing source (Senior unsecured and Subordinated debt). As expected, the level of the CDS spreads on the senior unsecured debt is lower than the subordinated one due to the high priority of the first category of debt in case of bankruptcy or liquidation. Moreover, the presence of the implicit government guarantee on this category of debt kept its recovery value in case of default artificially high.

However, looking at the CDS variations of these indices during the 2013, the changes were more consistent for the CDS written on senior unsecured debt than on subordinated one. The differences in the CDS spread variations could signal that something related to the treatment received by this "privileged" category of debt in the past was changing and, again, the introduction of the new bail-in resolution framework could be one possible determinant. Indeed, under the bail-out regime the owners of senior unsecured debt were relatively safe in case of bank distress due to the high probability of a public bail-out aimed at reimbursing the face value of their credit. Unfortunately, the same could not be affirmed for the owners of subordinated debt, characterized by a high loss given default (LGD). For this reason, before the introduction of the bail-in framework, in case of bank distress the increase in the CDS spreads for this category of debt was expected to be greater than the senior unsecured one.

[15] Of the different indices used in the analysis.

[16] The list of banks, which CDSs were included in the Index at September 2018, is provided in appendix A, table A.1.

Under the bail-in regime, the removal of the implicit government guarantees should affect all the financing instruments owned by the banks, increasing the CDS spreads required by the market to provide protection against the failure of all the outstanding bank debt instruments. However, looking at the average amount (among banks) of the total outstanding senior unsecured debt (figure 5) from 2010 to 2016, it is possible to notice that it decreased more than the average amount of outstanding subordinated debt.

The reduction in the volume of this type of funding instruments can be interpreted in two ways: it could be a signal of a bank funding strategies aimed at reducing the amount of senior unsecured debt in the capital structure due to the increase of its cost with respect the past or, it could be a signal of some bank difficult in rolling over the senior unsecured debt in market[17]. Regardless of what the real explanation behind this effect was, the marked decline in the amount of senior unsecured debt, relatively higher than subordinated one, suggests that this debt category may have suffered most from the introduction of the new regulation.Therefore, the second main hypothesis of the paper is that an abnormal reaction for the CDS written on senior unsecured debt is expected to be greater than the abnormal reaction of the CDS written on the subordinated one.

Another reason in favour of this hypothesis is that the introduction of the new resolution framework, removing the protection provided by the government on the senior unsecured debt, could have suddenly increased the risk perceived by the market on this type of security more than the already high risk perceived on the subordinated debt. Moreover, it is also important to take into account other two factors that could have mitigated the increase in the spread of the CDS on subordinated debt. First, thanks to the early intervention established by the regulation, once the viability of the distressed financial institution is restored, the first in line bailed-in bondholders (the owners of the subordinated debt) might benefit from future revaluation of the shares received as new shareholders of the bank. Second, in case of

[17] Indeed, such a decline began before 2013 and, over the same period, European banks increased the volume of other debt instruments such as covered bonds, which mostly replaced senior unsecured bonds and not the subordinated ones.

bank restructuring, the restructuring costs afforded by this category of bondholders should be lower than the bankruptcy cost afforded in case of disorderly liquidation of the bank (Helberg and Lindset 2014).

So, to recap, the lower costs in case of bank restructuring and the positive probability of getting future higher return, as new shareholders of the bank, are two possible mitigation effects that may strengths the second research hypothesis of the paper. To better understand the arguments behind the second research question, in table 2 are briefly summarized the assumptions on the CDS spread reaction, before and after the adoption of the new resolution regime, for the two types of CDSs.

As done for the first hypothesis, it is important to clarify that the analysis captures the difference in the average reaction[18], at the same event, between the two types of CDS indices. And again, the different treatment received by the two types of underlying debt instruments, before and after the introduction of the bail-in resolution framework, represents only the possible explanation of the differences in the reaction we should obtain from the events study analysis. Indeed, also in this case it is not possible to evaluate the differences in the impact that a specific event should have on the same banks before and after the introduction of the new resolution regime.

3.3 Data specification

The event study methodology performed in this paper is based on a CDS dataset building via a combined research on Bloomberg and Thomson Reuters Datastream. The daily 5-year CDS[19] mid spreads were collected, from January 2010 to January 2016, for 69 European banks in 16 countries. The sample size reduces to 58 banks for the CDS written on subordinated debt. A sample composition by country is shown in table 4.1[20]. It presents a

[18]Using both the equally-weighted and the asset-weighted indices in addition to the Markit iTraxx CDS indices for financial.

[19]The most actively traded category according to Andres et al. (2016) and Hull et al. (2004).

[20]Summary statistics, including the banks national placement, the mean, minimum and maximum CDS spread and the belonging to the G-SIB and GIIPS categories, for both senior unsecured and subordinated

dominance of banks coming from Germany, Italy, United Kingdom and Spain. On average, for each event in which the CDSs on senior unsecured debt are involved, the sample is composed by 17 G-SIBs and 46 non-G-SIBs, while for the analysis on the subordinated CDS the number of non-G-SIBs reduces to 32.

In order to build the largest sample as possible, the sample considered for each event may slightly change due to the exclusion of all the banks for which data were not available from a day on (since some banks failed or had been acquired by other banks, or simply because data were missing) and the inclusion of banks for which data became available only from a specific day on. Therefore, the sample composition has been dynamically managed such that, for each event, the largest number of banks with available data were included. Table 4.2 reports, for each specific event, the number of banks considered and the number of G-SIBs and non-G-SIB composing the sample.

Most of the CDS are Euro denominated and have restructuring clause of the type "Modified-Modified", based on ISDA 2003 definition[21]. However, to increase the sample size, have been considered also CDSs denominated in Dollars and with restructuring clause of the type "Full-restructuring", based on ISDA 1999 definition. In table 5, average cross-sectional correlations of daily spread variations among different types of CDS used in the analysis are presented. The correlations matrix has been obtained considering only those banks for which the different types of 5-year CDSs were contemporaneously available on the market (the number in the brackets indicates the number of banks considered). The high cross-sectional average correlation (around 90%) among the different types of CDSs suggested to increase the sample size in order to increase the robustness of the results. For this reason, given the very small bias introduced in the analysis, the final sample also includes CDSs denominated in dollars or with a different restructuring clause.

To capture the spillover effects of the bail-in related events on the European banking

CDS, are reported in Appendix A, tables A.2 and A.3.

[21] For more details on the restructuring clauses and on when the restructuring event occurs see Berndt et al. 2007 and Packer and Zhu (2005). Appendix B briefly summarizes the description of the new 2014 ISDA definitions and the new “government intervention" credit event, explained in detail in Neuberg et al. (2018).

system, nine dependent variables has been employed for each senior unsecured and subordinated subsample of CDSs. One of these variables, is the Markit iTraxx 5Y CDS index for financial. The other eight variables, obtained considering only the banks included in the sample for each specific event, are the following:

- Equally-weighted index (Equally W.); obtained by averaging the daily spread variations of all the banks considered for the event;
- Asset weighted index (Asset W.); calculated as the weighted sum of all the spread variations, where the weights were given by the ratio between the bank total asset and the sum of the total asset of all the banks considered for the event;
- The G-SIB and non-G-SIB asset weighted indices (G-SIB A.W. and No-G-SIB A.W.); calculated as at point 2 but with a different denominator given by the sum of the total asset of all the banks belonging, respectively, in the group of G-SIB and No-G-SIB. A positive value of the difference between these two variables support the first research hypothesis, namely, the group of G-SIBs react more than the other group;
- Four ΔMedian Rating Indexes (ΔMRI); calculated as the median spread change of all the banks in the same rating group, according to Moody's classification reported in table 6.1.

To construct the last four variables, for each event, the sample has been divided in four groups (table 6.2). Then, for each of the 125 days composing the estimation window (120 days) and event window (5 days), the daily spread variations of the grouped-banks were ordered from the smallest to the highest and the median spread change has been selected. The ΔMRI is a variable that captures the business climate (Galil et al., 2014), providing signals concerning the probability of default of a bond and its expected recovery rate (Altman and Kishore, 1996). A decline in the market conditions increases the probability of default and reduces the expected recovery rate, which leads to an increase in the credit spreads. For this reason, to the extent that the bail-in resolution regime should increase the bank funding cost, the worst market condition experienced by the banks should lead to a positive median credit spread change, especially for those considered "too-big-to-fail" that, also thanks to the artificially high credit rating, should mostly belonging to the high rating group.

As mentioned in the paragraph concerning the research hypothesis, the implicit government guarantee on banks debt kept the bonds risk artificially low, especially for largest banks considered “too-big-to-fail. Consequently, the credit ratings of these banks should be artificially high. For this reason, I assume that banks with a high credit rating should suffer more from the removal of the guarantee than banks with a low rating. Therefore, a positive value of the difference between the ΔMRI G1 (high rating) and the ΔMRI G4 (low rating) will be in favour of the first research hypothesis, on the contrary, a negative value of this variable will be in favour of its rejection. It is most important to highlight that the implicit hypothesis behind this assumption is that banks with a high rating are those with benefitted more from government guarantees. However, this is not always and necessarily the case. An issuer rating could be high because of a substantial government guarantee (or any other external support) and/or because of the bank's high profitability, high asset quality, lower risk, high managerial quality. Therefore, blindly trust in the results obtained by this variable could be misleading. A cleaner and more direct measures of the (not only governmental) rating external support are suggested by Iannotta et al. (2013). However, the ΔMRI variable is not fundamental for testing the validity of the first research hypothesis, it simply provides additional support to the results obtained from the other indices. Even if not extremely precise, the use of this variable is justified by the data availability for the majority of the banks in the sample with respect the two measures proposed by Iannotta et al. (2013)[22].

The most important part of an event study methodology is to correctly estimate the expected variations of the variables under analysis. To estimate the CDS expected variations

[22] In their work they suggest the following two measures: i) the absolute difference between Moody's issuer and individual ratings and (ii) the Support Rating provided by Fitch.

of each single bank the "CDS Factor Model", introduced by Andres et al. (2016), has been employed. The model takes in to account the following four market-wide factors as potential explanatory variables: (i) the level of the risk-free yield curve (ΔR_free), (ii) the slope of the risk-free yield curve (ΔSlope), (iii) the equity implied volatility (ΔVSTOXX), and (iv) the stock market performance (ΔESXX6). Descriptive statistics, as well as the correlation matrix among variables, are summarized in tables 7 and 8.

The Euro Stoxx 50 volatility index (ΔVSTOXX) is a proxy for the European market volatility. Given that a positive increment of this variable increases the probability of the default event, a positive relation between the equity implied volatility and the CDS spread variation is expected.

The Euro Stoxx 600 (excluding financial) index (ΔESXX6) is a proxy for the stock market performance. The expectation is for a negative relation between the variable and the change in the CDS, for several reasons. For example, if the performance of large and mid-cap firms is positive then it is expected that banks should extend the supply of credit (at least in Europe) or should suffer less by NPL, obtaining in this way a good performance that reduces the probability of default.

The last two variables are the Euro Swap Zero Curve at 5 years (ΔR_free), as a proxy for the risk-free rate used in the credit derivatives market, and the term structure slope (ΔSlope), calculated as the difference between the Euro Swap Zero Curve at 10 years minus the Euro Swap Zero Curve at 1 year. For these variables, a negative relation with the CDS spread variations is also expected. Indeed, according to Collin-Dufresne et al. (2001), a high spot rate reduces probability of default and, according to Fama and French (1989), an increase in the yield-curve slope anticipates economic growth, thus improving the recovery rates.

Finally, in the second part of the paper, a cross-sectional analysis aimed at identifying the main bank- and country-related determinants of the cumulative CDS abnormal variation, obtained from the event studies analysis, has been conducted. The variables involved at this step were: *Ln(Asset)*, capturing the size of a bank; *RoA* (return on asset), capturing the profitability of a bank; *Financial Leverage* (total debt on total capital), capturing the risk of the liability structure; *Tier 1 ratio* (Tier 1 capital over RWA assets), capturing the bank's ability to absorb losses; *Deposit ratio* (total deposits over total assets), as an indicator of the type of bank: Commercial Vs Investment bank; *CDS level end of the year* (de-meaned in the time series), as a proxy of the distance between the risk the bank was bearing at the end of the year and the average risk taken in the previous year (daily data); *debt/GDP ratio end of the year* (de-meaned in the time series) related to the country in which the bank is headquartered, as a proxy of the distance between the fiscal capacity of a Country at the time of the event and the average fiscal capacity in previous years (annual data). It should capture the credibility of a country in applying the new bail-in regime instead of bailing out an ailing bank; *Liquidity* of the CDS, calculated as the number of zero-spread variation days during the estimation window of the event over the length of the estimation window its self, 120 days; *SNR/SUB outstanding debt* (measured as the ratio between the outstanding amount of senior unsecured debt and the outstanding amount of subordinated debt at 31/12/2012), capturing the composition of the bank liability structure; and a set of dummy variables, as belonging on the *G-SIB group*, on the *GIIPS country*, on the *supersized banking sector*[23] and on one out of the four *rating groups* (Δ*MRI)*. Tables 9.1 and 9.2 provide summary statistics of all the variables, while in table 10 the correlations matrix among the variables is presented. Data related to the *debt/GDP ratio* come from Eurostat[24], all the others come from Bloomberg and Thomson Reuters Datastream. Tables 15 and 16 show only the results of the best model[25] which include only a part of the variables presented before.

[23]As reported in Schäfer et al. (2016), at 2012 only the United Kingdom, Switzerland, and Ireland were the countries with a total banks' assets over GDP ratio larger than 400%. This dummy variable should capture the effect that some banking sectors may be too large to be rescued, affecting consequently the probability of a bail-in.

[24]Extracted on September 13, 2018.

[25]The regressions with the independent variables that allowed to obtain the highest adjusted R^2. The results for the regressions employed the variables not reported in tables 15 and 16, such as Tier1 ratio and Leverage, are available on request.

3.4 Methodology

To test the two hypotheses, presented in the previous paragraph, has been performed an event study based on the CDSs written on both senior unsecured and subordinated debt of 69 European Banks in 16 countries, also taking into account the rating groups to which banks belong in each event. The analysis has been carried out on two dimensions. At an aggregate level, the impact of the bail-in related events on European banking system has been evaluated using both market CDS indices and other ones developed by the author of this paper. At an individual level, the impact of the same events on a bank-to-bank basis has been evaluated. Then, bank-related cumulative abnormal spreads have been used as dependent variables of a cross-sectional analysis aimed at identifying their most important bank- and country-specific determinants.

To verify the first hypothesis, both the CDS datasets on the senior unsecured and subordinated bond have been divided in two subsamples: G-SIBs and non-G-SIB. As explained in the previous paragraph, the most important part of an event study methodology is to correctly estimate the expected variations of the variables under analysis. For this purpose, has been employed the "CDS factors model", introduced by Andres et al. (2016) and used by Bruno et al. (2018). According to authors, the CDS factor model, which variables are based on the existing literature on CDS spreads, is generally well specified and performs best in detecting abnormal CDS spreads.

Nevertheless, in order to justify the use of the model, as first step has been performed the following regression on the Markit iTraxx CDS index and for the entire time period under consideration (from 1/01/2010 up to 01/01/2016):

$$\Delta S_t = \alpha + \beta_1 \Delta Slope_t + \beta_2 \Delta VSTOXX_t + \beta_3 \Delta ESXX6_t + \beta_4 \Delta R\_free_t + \varepsilon_t \qquad (1)$$

where the dependent variable ΔS_t is the daily relative spread variation of the indices[26], for the market CDSs written on both the senior unsecured and subordinated debt. The four explanatory variables are those described in the previous paragraph. The results of regression 1, summarized in tables 11 and 12, confirm both the goodness of the model and the expectations concerning the sign of the relations between the four factors and the CDS spread variations.

As second step, the entire time series of banks' CDS spread has been divide into eight subsets, one for each event. Then, for each event an estimation window of 120 days was taken into consideration, starting from the third day before the data in which the event occurred (identified as $t = 0$). In this way, it was possible to consider two different event windows composed by three days (including the effects at $t-1$ and $t+1$) and five days (also including the effects at $t-2$ and $t+2$) without any overlaps between the estimation window and the different event windows analysed.

The regression 1 was performed, for each event, on the estimation window of a distinct set of nine dependent variables, explained in detail in the previous paragraph. The alphas and betas, as well as the standard deviation of the residuals of each single regression, were stored and used to predict the daily expected variations in the event window and to test the significance of the abnormal variations (or abnormal return, AR), that has been obtained as follow:

$$AR_t = \Delta S_t - \left[\widehat{\alpha} + \widehat{\beta}_1 \Delta Slope_t + \widehat{\beta}_2 \Delta VSTOXX_t + \widehat{\beta}_3 \Delta ESXX6_t + \widehat{\beta}_4 \Delta R\_free_t\right]$$

Finally, for the events found to be statistically significant[27], the procedure described above has been repeated in order to evaluate the AR and the CARs (cumulative abnormal returns) for each single bank. The aim of this second part of the paper was to identify the

[26] $\Delta S_t = \frac{S_t - S_{t-1}}{S_{t-1}}$

[27] The tests for the significance of the AR and CARs, obtained from regression 1, are shown in Appendix C.

main bank- and country-related determinants of the CDS abnormal variation, performing different cross-sectional regressions. Therefore, the dependent variables were either the AR or the CARs of the CDS written on both the senior unsecured and subordinated bonds for each single bank and each event. The explanatory variables involved in the regressions, referred to the "end of the year" values prior the events, were those explained in the previous paragraph. The cross-sectional regressions were of the type:

$$AR_i = \alpha + \beta_1 \text{Size}_i + \beta_2 \text{Leverage}_i + ... + \gamma_1 \text{G-SIB}_i + \gamma_2 \text{GIIPS}_i + \ ... + \ \varepsilon_i \qquad (2)$$

As a robustness check, the event study analysis has been repeated on the CDS at sovereign level. Once the AR and the CARs of the CDS written on the sovereigns' senior debt were found, they have been inserted as regressors in regression 2 to verify for the presence of a positive correlation between bank and sovereign risk.

4 Empirical results

Time-series analysis

The results of the event study, summarized in tables 13.1, 13.2, 14.1, 14.2 and 14,3 partially confirm the expectations concerning the sign of the CDSs reactions predicted in table 3.

For the events occurred both in Denmark and in Spain, respectively in 2011 and 2012, the day zero abnormal return as well as the cumulative abnormal returns, for the event windows $t \in [-1; +1]$ and $t \in [-2; +2]$, were not statistically different from zero for all the nine dependent variables analyzed. These results can be explained by the fact that the resolutions of both banks were conducted under a purely national scheme. Therefore, the market did not perceive these events as a signal of the introduction of a new resolution framework in Europe. Moreover, for the Danish case, was involved in the resolution process a small bank with a market share of only one percent in Denmark[28].

Concerning the bail-in procedure implemented in Spain, it involved only junior debt while the senior unsecured debt and deposits have been bailed-out. This explains why the financial markets did not seriously considered these two events as a signal that a new resolution framework, for large institutes, was taking hold.

The results obtained for the events 3, 4 and the cumulative one (3 and 4 together), highlight that the financial markets realized that a new bank resolution framework was going to be implemented in Europe. The events, described in detail in section 3, are related to the bail-in of the Bank of Cyprus (BoC)[29], for which positive and statistically significant CARs of the CDS written on both the senior unsecured and the subordinated debt has been found. The Cyprus case is of particular importance, not only because it involved senior unsecured debt and large customer deposits, but especially because the decision to involve these categories of debt, always privileged in the past, was taken by the Eurogroup after protracted negotiations. For this reason, the events are considered a watershed in the way of dealing with distressed banks in Europe.

The two specific events analyzed for the Cyprus case were: the initial proposal of reducing part of the deposits, even those below the amount insured by the national DGS[30], announced on 18 March 2013; and the day of the implementation of the bail-in procedure on the senior unsecured debt and only on large deposits (those above the DGS limit), occurred on 25 March 2013. The results obtained for these events highlight an abnormal increase on both the CDS written on the senior unsecured and on the subordinated debt. Looking at the Markit iTraxx index (first column of table 13.1), the abnormal variation at $t = 0$ was not statistically significant for both the events, but considering the enlarged event windows the abnormal increase in the CDS spreads was substantial, between 10% and 13% for the senior

[28] Schäfer et al. (2016) and Denmark's Nationalbank (2013).

[29] Contemporaneously, the "sale-of-business" tool was applied to Cyprus Popular Bank (Laiki) in order to merging it with the BoC. World Bank Group (2016), FinSAC.

[30] Initially, the proposal provided about the 6.75% levy on all deposits under EUR 100.000 and a 9.9% levy above the threshold.

unsecured CDS and between 8% and 10% for the subordinated one, respectively for event 3 and 4. In cumulative terms, the impact was about 22% for the CDS on the senior unsecured debt and 17% for the subordinated one.

The last four columns of table 14.3 show the result for the difference between the indices of table 14.1 (related to the SNR CDS) and the indices of table 14.2 (related to the SUB CDS). The results obtained for the difference between the SNR and SUB Markit iTraxx CDS index confirm the second hypothesis of the paper. The abnormal increase of the SNR CDS was around 5% higher than that of SUB CDS. Apart from event 4 (for the 3 days event window) the other CDS indices, were not able to capture this effect. However, since the Markit iTraxx index refer to the CDS of the 30 largest European banks, the results provided by this index should be more accurate than those provided by the equally and asset weighted indices which took in to account also the small banks present in the sample, partially (or not at all) affected by the introduction of the new resolution regime. Indeed, as shown in the first 2 columns of tables 14.3, the shift from the bail-out framework to the bail-in one had an impact on the group of G-SIBs greater than on No-G-SIBs group.

The difference between the percentage abnormal reaction of the two asset-weighted (by group) indices (first column of table 14.3) reaches the peak of 15% for the cumulative case and for the event window $t \in [-2; +2]$. This result confirms that the spillover effect caused by the first implementation of the bail-in procedure on the European banking system affected more the banks considered too-big-to-fail due to the removal of the government guarantee that drastically reduced the market beliefs concerning the probability of being bailed out in case of future distress. Moreover, even if the ΔMRI variable is not a precise measure of the external support, the results provided by the second column of table 14.3 (ΔMRIG1-ΔMRIG4)), obtained evaluating the difference between the median spread variation of the group of banks with high rating (G1) and the median spread variation of the group of banks with low rating (G4), are very close to the previous ones. This result confirms the assumption made in the data specification paragraph, according to which the banks with a high rating are those with benefitted more from government guarantees that allowed them to keep their credit rating artificially high and funding cost artificially low.

Finally, comparing the results obtained for the equally-weighted index and the asset-weighted index (tables 13.1 and 14.1) the bias discussed at the beginning of the paper shows up. An equally-weighted index underestimates the overall effect on the banking system due to the relative high weights received by the small banks, that were less (or not) affected by the introduction of the new resolution framework. This explain why the difference in the reaction between the CDS on senior unsecured debt and the CDS on subordinated is not fully captured by the indices in which also the CDS of small banks are included (as the equally and asset weighted indices).

The events related to the agreement on the SRM (provisional on 20 March 2014 and official on 15 April 2014), between the Council and the European Parliament, represent the crucial steps in reaching the conclusion of a long negotiation period started on 9 July 2013, when the European Commission proposed the SRM in order to centralize in Brussel the power to wind down failing banks. However, as in Schäfer et al. (2016), the results reported for the event 5, 6 and the cumulative one (tables 13.2 and 14.2) did not provide statistically significant abnormal CDS variation. To justify this result, Schäfer et al. (2016) argued that, *"act speak louder than words."*. Therefore, they assumed that there was a kind of anticipation effect by the market at the time of Cyprus events.

Even if it is reasonable that there might have been a slow price incorporation, also due to the previous public discussion on the new regulation, it is also important to highlight that the BRRD also included more stringent capital requirements that tended to progressively make the financial institution safer. Indeed, Berger et al. (2018) showed that shifting from the bail-out to the bail-in regime the largest banks increased the capital ratios more than other banks, and with a rate of adjustment much faster. Therefore, one can claim that their results can be also used to justify the zero (or also negative) impact of all the events occurred around the period of the BRRD introduction (or immediately after) on the banks' CDS.

The unexpected result provided by the event 7, related to the bail-in of another Danish bank (Andelskassen), goes in the direction of Berger et al. (2018). In line with the anticipation effect of Schäfer et al. (2016), the initial expectation for this event was for a non-statistically significant abnormal variation in the CDS indices. However, even if significant only at a 10%, the results shown a reduction in the credit spreads of some CDS indices, written on both the senior unsecured and the subordinated debt, for the enlarged event windows. Only a deeply analysis on the main differences between this event and the Cyprus one allowed to explain the abnormal reduction in the CDS spread of the G-SIBs.

With respect the Cyprus case, in order to help maintaining financial stability, the Danish government provided guarantees, capital injections and liquidity support to the distressed bank, charging the financial sector to pay for the implementation of these measures. Moreover, the Danish event was considered one of the first implementation of the bail-in procedure that provided a concrete example of the "no creditor worse off" (NCWO) principle. Indeed, it represented the first successful and smoother open bank bail-in process. On the contrary, during the Cyprus events, the uncertainty about the procedure and the severity of the private penalty that would have been imposed to bank creditors scared the entire banking system, leading to a considerable increase in the CDSs written on both the categories of debt, for all the European banks. Therefore, it is possible to consider the Danish event as the first orderly implementation of the new resolution process, which provided to the market a clearer and more complete view of the new resolution mechanism that would have been used in the future, reformulating in such way the pessimistic expectations generated by the Cyprus events.

However, another possible explanation of this result comes from Neuberg et al. (2018). By comparing the CDS market spreads under ISDA 2014 and those under ISDA 2003 definitions, they provided a new measure of the credibility of government commitments to end bank bailouts. Based on this measure, they found that the market expectations of government support initially decreased due to the introduction of the new regulation BRRD in 2014, but then they have increased since 2016 to pre-reform levels due to the decline in credibility of the BRRD[31]. In this second case, the main reason explaining the reduction in the credit spreads of some CDS indices for the event 7 could be attributed to the decline in the credibility of the new resolution framework, that increased again the market expectations concerning the government support since 2016.

Despite the negative sign of the CDS variation, the main paper's hypotheses have been still confirmed. The SNR CDS had a greater reaction (in negative terms) than the SUB CDS by a minimum of 1% up to a maximum of 6%, according to the index and the event window considered. Moreover, also the reaction of the G-SIBs was more negative than the No-G-SIBs, which did not react at all to this event.

The last event analysed concerns the full adoption of the bail-in tool (First January 2016). In line with the results of events 5 and 6, it had not a statistically significant impact on the European banking system. Therefore, in this case, the pure slow price incorporation of the novelties introduced by the regulation should be a reasonable explanation.

Cross-sectional analysis

Tables 15.1, 15.2, 16.1 and 16.2, shown the results for the cross-sectional regression aimed at identifying the main determinants of the banks' CARs obtained from the events 3, 4 and the cumulative one, for both the CDSs written on the senior unsecured and subordinated debt. The dependent variables of tables 15.1 and 15.2 were the three days CARs realized for each of the three events, while the dependent variables of tables 16.1 and 16.2 referred to the CARs obtained for the event window composed by five days. These tables show the main bank- and country- specific determinants that best explain the CDS abnormal variations, according to a standard OLS regression and without including in the analysis the CARs of the European countries' sovereign CDS. The results of cross-sectional analysis made including the CARs at sovereign level as regressors are discussed in the paragraph of the robustness check and are presented in tables 17.1, 17.2, 18.1 and 18.2.

[31] Probably caused by the government response to the distress of Banca Monte dei Paschi di Siena, in Italy.

Among all the variables presented in the data specification paragraph[32], the most important determinants of the 3 days CARs were: liquidity (only for the SNR CDS), Deposit/Asset ratio (only for event 3), the dummy variable GIIPS (only for event 3) and the dummy variable G-SIB. Apart from the CDS-related variables (as liquidity, CDS level and the product of CDS level and D/GDP ratio) the other explanatory variables used were the same for both the regressions related to the CARs obtained for the SNR CDS and for the SUB CDS. Obviously, the sample size differs with respect the previous analysis because data on explanatory variables were not available for all the initial 69 banks in the sample. In particular, for the analysis on the CARs related to the SNR CDS data were available only for 60 banks, the sample reduces to 47 for the analysis on the CARs of the SUB CDS.

The main result of the cross-sectional analysis is that the banks belonging to the G-SIB group experienced statistically significant positive abnormal variations greater than the other banks. The difference in the reaction between the two groups picks for the cumulative event (event 3 and 4 together) in the event window composed by 5 days, reaching respectively the 11% for the CARs obtained from SNR CDS and the 13% for the SUB CDS ones. The importance of belonging to the G-SIB category in order to explain the CARs is in line with the main findings of Schäfer et al. (2016). The signal related to the removal of the implicit government guarantee played a crucial role leading the market to reprice the bonds of all the banks that mostly relied on the too-big-to-fail status, that allowed them to pay artificially low risk premium in the past, when the bail-out regime was in force.

Interesting results are provided by the statistical significance of the variables Deposit/Asset ratio and the GIIPS dummy in explaining the CARs obtained from event 3 and the cumulative one. A 1% increase of the Deposit/Asset ratio leads to an abnormal increase in the CDS spreads between the 0.08% and the 0.32%, according to the event window and the type of CDS analysed. It is not a case that this variable is statistically significant for the

[32] In this paragraph are presented and explained only the results obtained from the best model, which include only the independent variables that allowed to obtain the highest adjusted R^2. The results obtained for the other regressions, in which have been employed also the variables not reported in tables 15 and 16, are available on request.

event 3 and not for the event 4. As described in section 3, event 3 was characterized by the destabilizing announcement of imposing a levy of around 6.75% also on the deposit below the DGS limit of EUR 100.000 while the real deal, put in place one week later (event 4), involved only large deposits, those above the limit. Therefore, it is reasonable that the banks with a high amount of deposits in the liability structure experienced a greater abnormal variation in the CDSs spreads. The same did not hold for the other variable capturing the liability structure composition of the banks, namely the SNR/SUB outstanding debt (calculated as the ratio between the outstanding amount of senior unsecured debt and the outstanding amount of subordinated at 31/12/2012), not reported in the regression because not statistically significant.

Concerning the role of the country's fiscal capacity, captured by the GIIPS dummy variable, the results of the cross-sectional regressions shown a weak relation with the CARs. This variable was statistically significant only for the event 3 and for the SNR CDS. A possible explanation for this result could be still related to the destabilizing solution proposed by the Cyprus government discussed so far. It could be reasonable to assume that, at least at the beginning, the market misinterpreted this proposal, assuming that a similar "penalty" would had been provided due to the impossibility of the Cyprus government in bailing-out the bank due to the low fiscal capacity of the country. This could have led the market to think that only banks located in countries with similar characteristics in terms of fiscal capacity would be treated, in case of distress, in the same way of the Bank of Cyprus

The results of table 14.5, related to the robustness check described in detail in the next subparagraph, seem to confirm this explanation. Indeed, the results obtained repeating the event study on the CDS written on the European countries' sovereign senior debt, highlight that only the CDS of Spain and Portugal experienced an abnormal positive variation at the event 3. These were the two European countries with the lowest fiscal capacity for bailing out their banks, together with Greece (not included in the robustness analysis) Ireland and Italy. When a week later the procedure and the implementation of the new resolution framework became clearer, the market could have understood that the new resolution framework was going to be implemented in all the European countries and not only in the countries belonging to the GIIPS group.

Finally, another statistically significant variable was "liquidity". The variable has been constructed as the ratio between the amount of zero-spread variation days (during the estimation window) and the length of the estimation window (120 days). The variable should capture the degree of liquidity of the CDS instruments itself and not the liquidity of the underlying asset. It is possible to observe that for the event 4 and the cumulative one, a 1% increase in the liquidity ratio reduces the CARs of around 0.5% for the three -and five-days event window. From an economic point of view, the higher is the liquidity of a financial instrument more easily becomes for an investor to buy or sell that instrument in the market. Therefore, the reduction in the CARs could be explain by the additional value generated by the possibility to quickly buy or sell additional protection against the credit event of the underlying asset. This result does not hold for the CDSs written on subordinated debt since they are generally less liquid.

Robustness checks

To test the robustness of the results discussed in the previous paragraphs, the event study analysis for the events 3, 4, the cumulative one (3 and 4 together) and event 7 has been repeated, determining the AR and CARs for the CDSs written on the European countries' sovereign senior debt[33]. It was part of the robustness check, that has been divided in two steps.

Given that the bail-in resolution framework is a bank-related regulation, as a first step, has been verified whether the analysed events correctly affected only the CDSs spread at bank level and not also at sovereign level. Indeed, observing abnormal variations also for the CDSs on sovereign debt it would signal the presence of some confounding factors able to generate,

[33] Table 14.4 shows summary statistics of these CDSs. Greece, Malta and Swiss have been excluded from the robustness analysis due to the illiquidity of their CDS, which spreads remained fixed at 14.904, 208 and 69 respectively, during all the estimation and event windows analysed.

contemporaneously, abnormal CDS variations both at the bank and at the sovereign level. The results of table 14.5 show that during the bail-in related event the CDS written on the countries' sovereign debt did not experience statically significant variations. Only a weak reaction, significant at 10%, was highlighted for the CDS of Spain and Portugal, but only for the event 3. This result should be sufficient to prove the robustness of the event study analysis, allowing to assert that banks' CDS abnormal variations were triggered by bail-in related events and not by other confounding factors.

However, the first robustness check was not sufficient to exclude that the intensity of the banks' CDS reaction did not depend on the sovereigns' CDS spread variations. If some relationship between banking risk and sovereign risk is shown, we would be in the presence of some endogeneity problem, not discussed in Schäfer et al. (2016), that would make the results of the cross-section analysis not robust.

Therefore, as second step of the robustness check, the CARs obtained for the CDS at sovereign level has been included as regressors in the cross-sectional analysis. The results of tables 17.1, 17.2, 18.1 and 18.2 show a positive and statistically significant relation between the CARs of the banks' CDS and the CARs of the countries' CDS. Therefore, as expected, a possible endogeneity problem, especially for the event 4, is present. The presence of endogeneity problem makes the results obtained by Schäfer et al. (2016) not robust, imposing the necessity for further investigations concerning the identification of the bank- and country-related determinants of the abnormal CDS variation. Solving the endogeneity problem goes beyond the scope of this paper and, following what was done by De Bruyckere et al. (2013) over the period related to the banking and sovereign crisis (2006-2011), it could represent an interesting issue for future research.

5 Conclusions

With an events study methodology performed on CDSs written on both the senior and the subordinated debt of 69 European banks, in 16 countries, the spillover effect of some bail-in related events on the European banking system has been estimated. The analysis was carried out on two dimensions. The first dimension looked at the European banking system at aggregate level, analysing nine different CDS indices which referred to both the senior unsecured and the subordinated banks debt.

From this analysis has been found evidence of positive CDS spreads variations for the bail-in event occurred in Cyprus and of negative variations for the bail-in procedure applied to Andelskassen (Denmark) in 2015, while all the other events were found not statistically significant. For these two main events both the hypotheses of the paper have been confirmed. The group of G-SIBs react more than non-G-SIBs, as well as the CDSs written on the senior unsecured debt with respect those written on the subordinated ones.The main economic reason behind both the results is related to the negative effect that the removal of the implicit government guarantee had on banks and debt categories that relied mostly on the government implicit guarantee in the past. Indeed, the market beliefs concerning the probability of a government intervention aimed at bailing out a large and systemically important bank were higher than other small and easily-resolvable banks. At the same time, deposits and senior unsecured debt were the categories of bank's debt that benefited more from the government intervention in case of bank distress. Therefore, the introduction of the new resolution regime has removed the implicit government guarantee that allowed to largest bank to enjoy from credit rating artificially high and to pay artificially low credit premium on the senior unsecured debt. As a consequence, the repricing of the risk made by the market lead to significant CDS variations at bank level. The same effect has not been found at sovereign level, confirming that the spillover effect obtained from the event study analysis was triggered by bail-in related events and not by other confounding factors.

Albeit a far from being extremely precise and completely exhaustive, the empirical analysis highlights the important role played by the implicit government guarantee on bank debt, which distorted the incentive of bankers and managers for long time, especially those of largest banks considered "too-big-to-fail". The removal of the guarantee and the shift in the responsibility from public funds (at tax-payers expense) to some category of creditors was of extremely importance in order to restore market discipline and align banks' funding costs more closely to the risk they are exposed.

The second dimension of the analysis focused on a cross-sectional dimension. The aim was to identify the main banks- and country-related determinants able to explain the CDS abnormal variations for the Cyprus related events. The results of the analysis are in line with the main findings of Schäfer et al. (2016), confirming the importance of belonging on the G-SIB category in explaining the CDS abnormal variations. Another important determinant, especially for the initial announcement made by the Cyprus government (event 3) was the deposit/asset ratio. Given the initial proposal of imposing around a 6,75% levy also on deposits under the national DGS limit of EUR 100.000, it is reasonable that banks with a high amount of deposits in the liability structure reacted more than the others. Moreover, also the degree of the CDSs liquidity was significant, even if only for the analysis of the CDS on senior unsecured debt. The higher was the liquidity of the CDS the lower was the increment in the CDS abnormal spread variation. The reason behind this result is that the investors provided additional value to a security easier to buy or sell in order to quickly adjust their exposition toward the credit event of the underlying asset.

Finally, as expected, the results of the cross-sectional analysis cannot be considered robust given the endogeneity problem between banks and sovereigns risk. The results obtained from the robustness check, not performed in Schäfer et al. (2016), highlight a positive and statistically significant correlation between the CARs of the CDS at bank level and the CARs of the CDS at sovereign level. Therefore, in order to identify the major determinants of the CARs on the banks' CDS it is needed to firstly solve for the endogeneity problem. Solving the endogeneity problem goes beyond the goal of this paper, which simply aims to highlight its presence for this concern. However, following what was done by De Bruyckere et al. (2013) over the period related to the banking and sovereign crisis (2006-2011), it could represent an interesting issue for future research.

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Figure 1:

Average CDS level, from 2010 to 2016, for the two banks' groups (G-SIB and No-G-SIB)

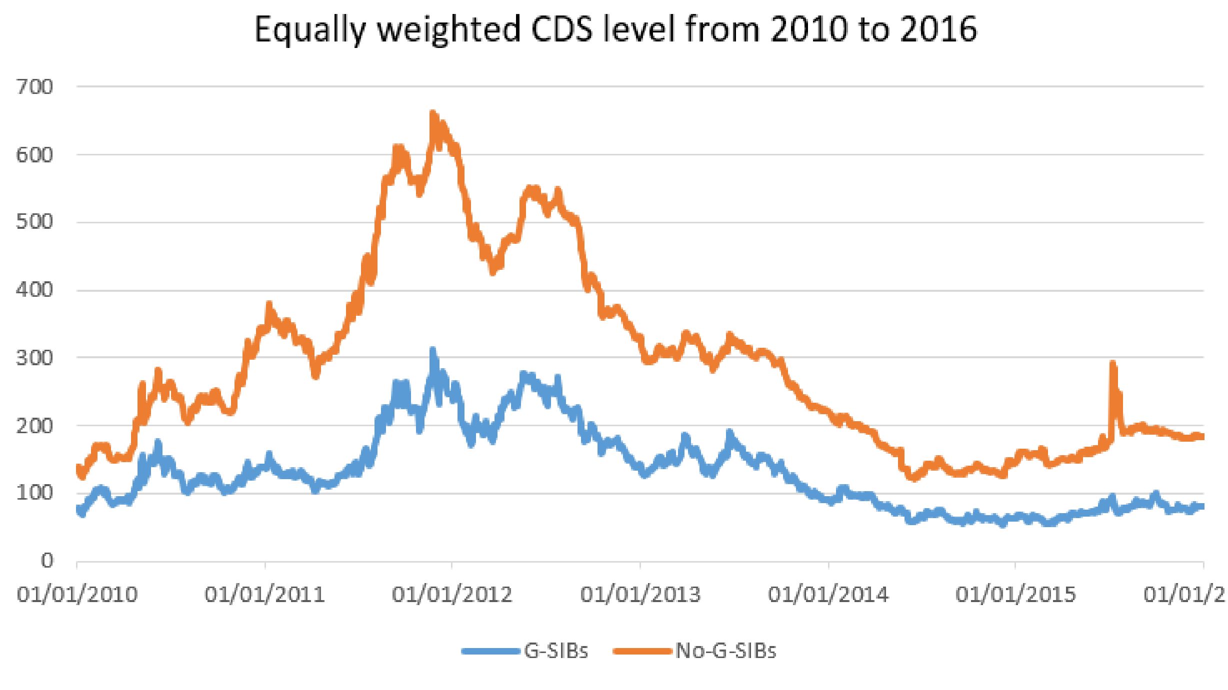

Figure 2:

Average CDS spread variation, from 2010 to 2016, for the two banks' groups (G-SIB and No-G-SIB)

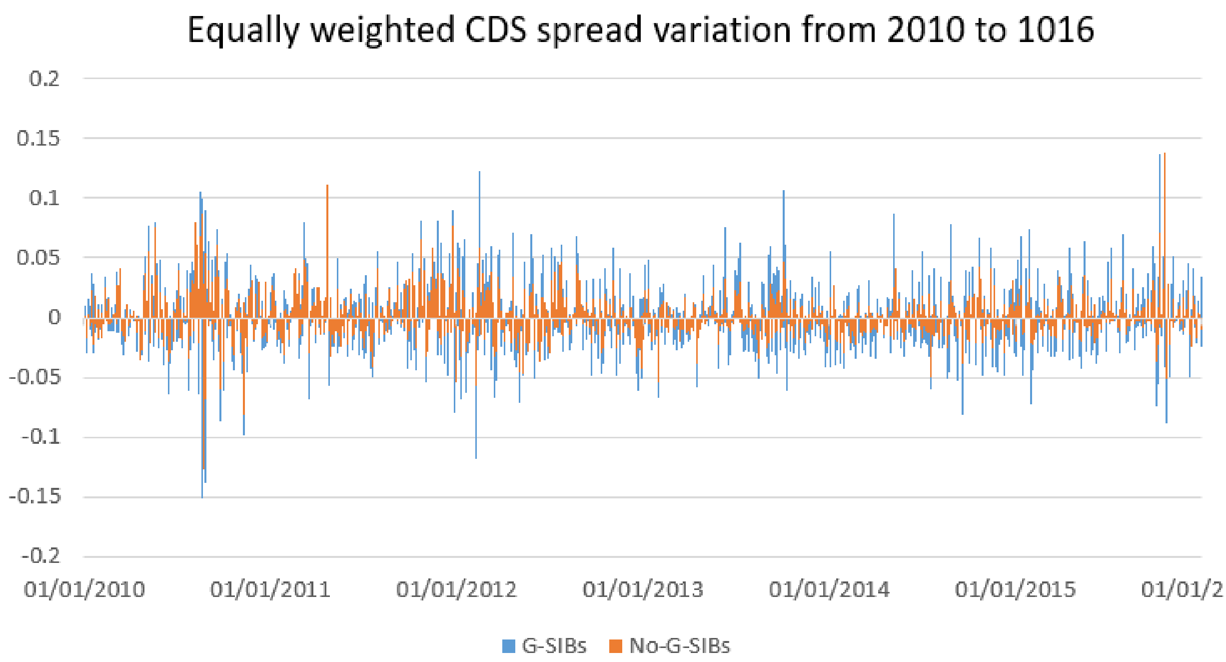

Figure 3:

Markit Itraxx CDS level for financial, from 2010 to 2016, written on SNR and SUB debt

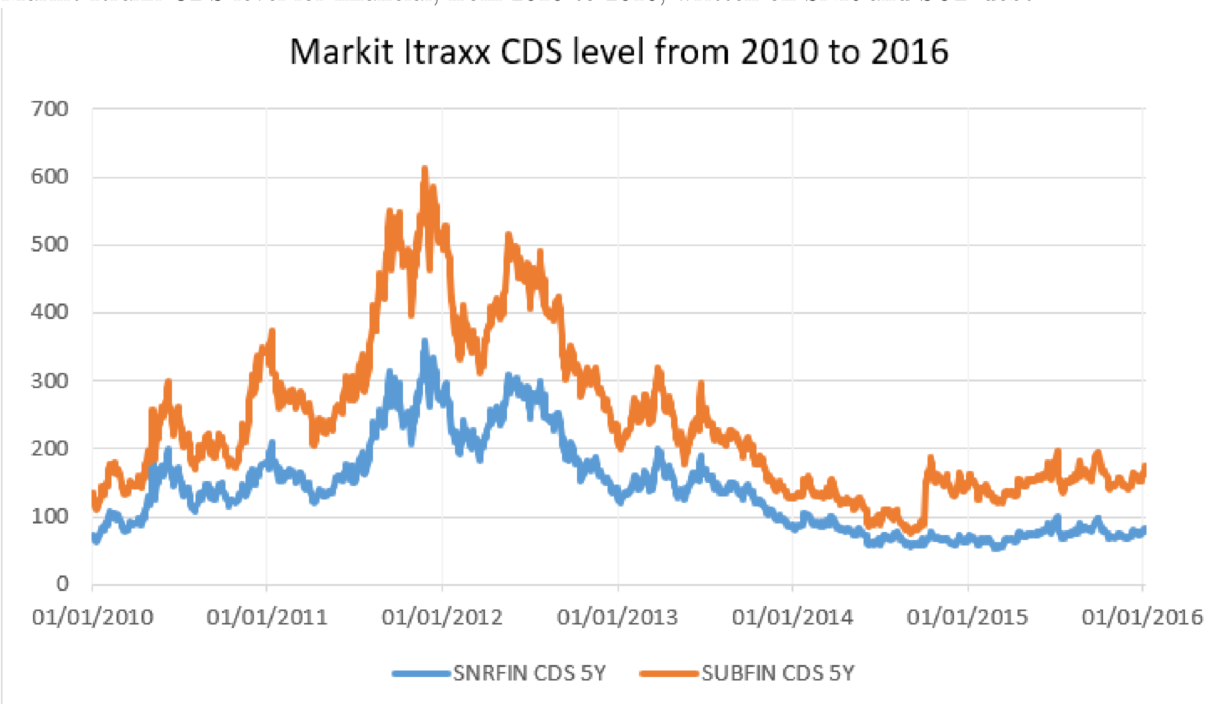

Figure 4:

Markit Itraxx CDS spread variation for financial, from 2010 to 2016, written on SNR and SUB debt.

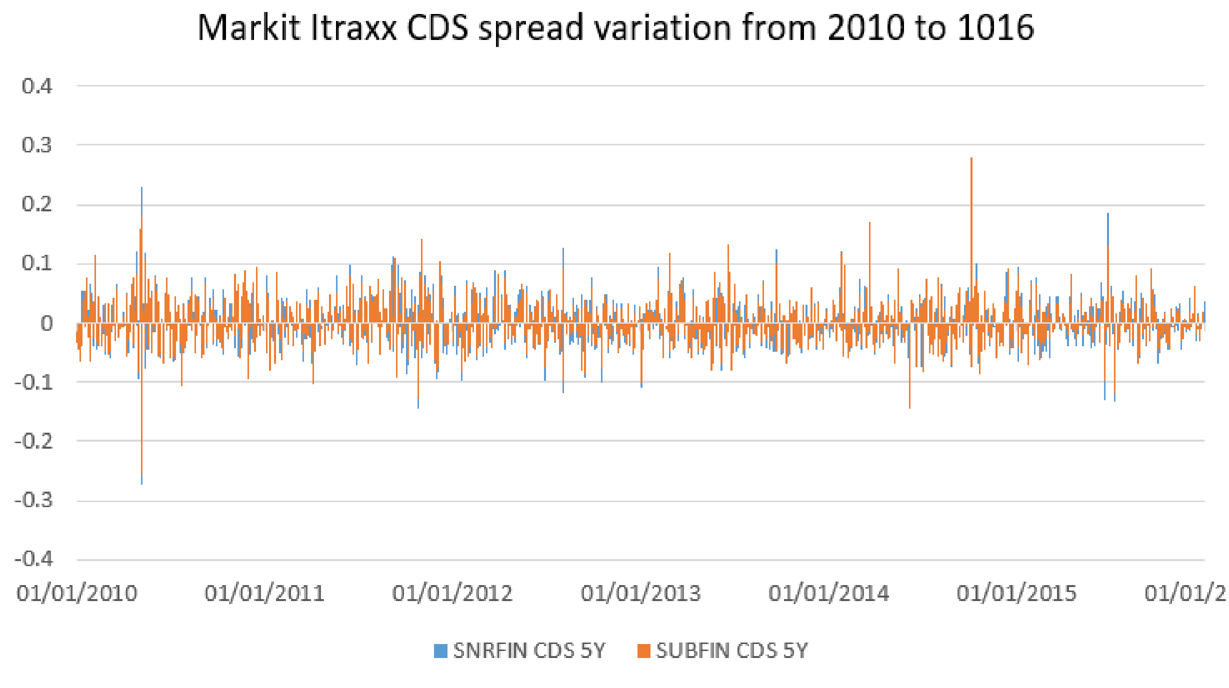

Figure 5:

Average amount outstanding of SNR and SUB debt of the sample from 2010 to 2016.

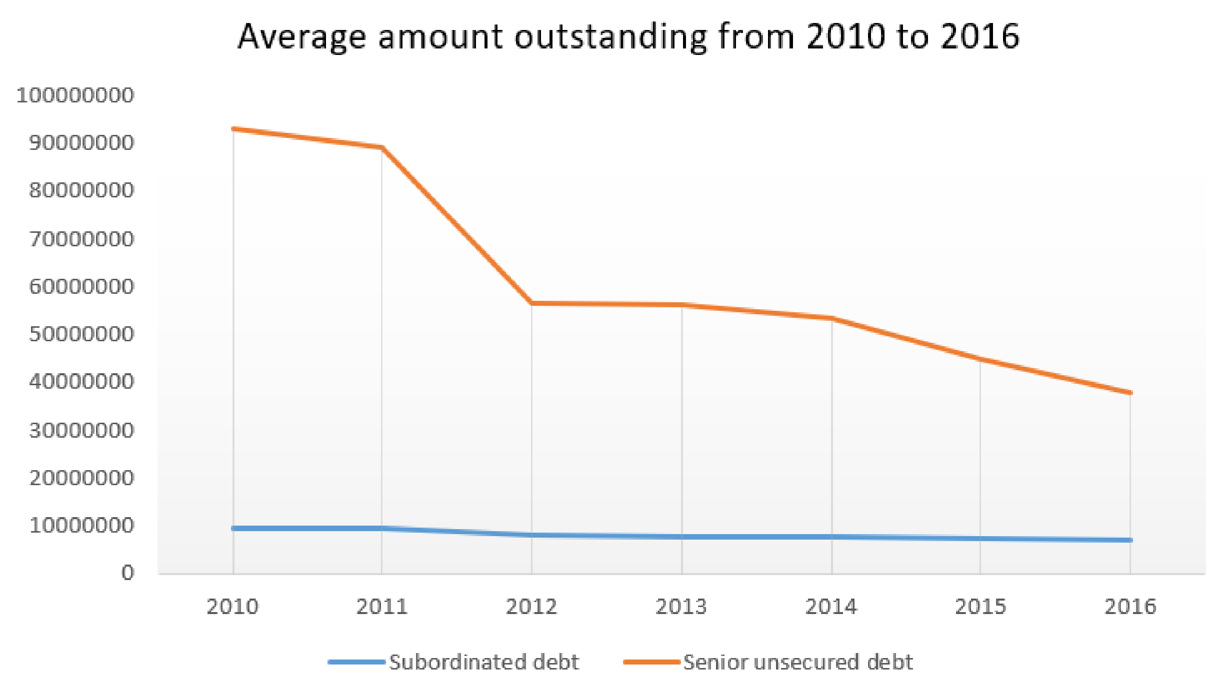

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Table 1:

Assumptions on the CDS reaction in case of bank distress between G-SIBs and No-G-SIBs, before and after the introduction of the bail-in resolution regime.

Table 1	Assumptions on the CDS reaction in case of bank distress			
	Bail-out	Bail-in	Bail-in Vs Bail-out	
G-SIB	$\approx$ Govern. Guarantee	$\uparrow$ Removal of the Gov.Guar.	$\upuparrows$ Not Tested	G-SIB VS No-G-SIB $\upuparrows$ Tested
No-G-SIB	$\uparrow$ Orderly Liquidation	$\uparrow$ Orderly Liquidation	$\approx$ Not Tested	

Table 2:

Assumptions on the reaction, in case of bank distress, between the CDSs on senior unsecured debt and on subordinated debt, before and after the introduction of the bail-in resolution regime.

Table 2	Assumptions on the CDS reaction in case of bank distress			
	Bail-out	Bail-in	B-in Vs B-out	
SNR CDS	$\approx$ Artificially high credit rating of the underlying bond thanks to the government guarantee	$\uparrow$ Downgrading of the underlying bond due to the removal of the implicit government guarantee	$\upuparrows$ Not Tested	SNR CDS VS SUB CDS $\uparrow$ Tested
SUB CDS	$\uparrow$ High LGD and low credit rating of the underlying bond with resepct to the senior unsecured bond	unclear $\uparrow\downarrow$ Possible upside after conversion and low restructuring cost ($\downarrow$) First in line to absorb losses ($\uparrow$)	unclear $\uparrow\downarrow$ Not Tested	

Table 3:

Selected events with date description and expectations.

Table 3	Selected Events	
Date	Description	Expectations
06/02/2011	Denmark: Amagerbanken Bail-in of senior unsecured debt;	≈ 0
10/07/2012	Spain: Bankia's (and other small banks) rescue plan implies bail-in;	≈ 0
18/03/2013	Cyprus: announced losses for all depositors;	> 0
25/03/2013	Cyprus: Bail-in of senior unsecured debt and deposits >100k;	> 0
20/03/2014	Provisional agreement on the SRM;	≈ 0
15/04/2014	Formal agreement on completing the SRM;	≈ 0
05/10/2015	Denmark: Bail-in of Andelskassen bank;	≈ 0
01/01/2016	Bail-in tool and BRRD fully in force;	≈ 0

Table 4.1:
Number of observations and sample composition by country.

Table 4.1	Sample composition by country						
SNR CDS	TOT Banks	G-SIB	No-G-SIB	SUB CDS	TOT Banks	G-SIB	No-G-SIB
Austria	3	0	3	Austria	3	0	3
Belgium	2	1	1	Belgium	2	1	1
Denmark	1	0	1	Denmark	1	0	1
France	7	4	3	France	5	3	2
Germany	10	2	8	Germany	7	2	5
Greece	2	0	2	Greece	2	0	2
Ireland	3	0	3	Ireland	3	0	3
Italy	9	1	8	Italy	8	1	7
Malta	1	1	0	Malta	1	1	0
Netherland	5	1	4	Netherland	3	1	2
Norway	1	0	1	Norway	1	0	1
Portugal	2	0	2	Portugal	2	0	2
Spain	8	2	6	Spain	6	2	4
Sweden	4	1	3	Sweden	4	1	3
Switzerland	2	2	0	Switzerland	2	2	0
United K.	9	4	5	United K.	8	3	5
Total	69	19	50	Total	58	17	41

Table 4.2:
Number of observations and sample composition by event.

Table 4.2	Sample composition by event					
SNR CDS	Event 1	Event 2	Events 3,4	Events 5,6	Event 7	Event 8
TOT Banks	65	67	66	67	58	58
G-SIB	18	17	17	17	16	16
No-G-SIB	47	50	49	50	42	42
SUB CDS	Event 1	Event 2	Events 3,4	Events 5,6	Event 7	Event 8
TOT Banks	51	52	50	50	47	45
G-SIB	18	17	17	17	16	16
No-G-SIB	33	35	33	33	31	29

Table 5:

Observations by types of CDSs and correlation matrices. The number in the brackets indicates the number of banks involved in the analysis.

Table 5	Observations by types of CDSs and correlation matrices					
Types of SNR CDS	M-M	Full Rest.		Correlations	Euro-M-M	Euro-Full Rest.
Euro	60	6		Euro-M-M	1	0.91 (19)
Dollars	3	0		Dollars-M-M	0.88 (26)	-
Types of SUB CDS	M-M	Full Rest.		Correlations	Euro-M-M	Euro-Full Rest.
Euro	55	3		Euro-M-M	1	0.89 (18)
Dollars	0	0		Dollars-M-M	0.85 (22)	-
Total	M-M	Full Rest.		Correlations	Euro-M-M	Euro-Full Rest.
Euro	115	9		Euro-M-M	1	0.90 (37)
Dollars	3	0		Dollars-M-M	0.87 (48)	-
The number in the brackets indicates the number of banks involved in the analysis.						

Table 6.1:

Moody's classification used to group banks with similar credit ratings.

Table 6.1	Moody's Classification			
Credit rating	ΔMRI G1	ΔMRI G2	ΔMRI G3	ΔMRI G4
Aaa	X			
Aa1	X			
Aa2	X			
Aa3	X			
A1		X		
A2		X		
A3		X		
Baa1			X	
Baa2			X	
Baa3			X	
Ba1				X
Ba2				X
Ba3				X
B1				X
B2				X
B3				X
Caa1				X
Caa2				X
Caa3				X
Ca				X
C				X

Table 6.2:

Number of banks grouped in the different MRI classes by event.

Table 6.2	Total banks by group, for event					
SNR CDS	Event 1	Event 2	Events 3,4	Events 5,6	Event 7	Event 8
ΔMRI G1	29	5	5	6	9	9
ΔMRI G2	22	29	25	21	16	16
ΔMRI G3	3	14	15	15	13	13
ΔMRI G4	2	9	10	12	9	9
No Rating Available	13	12	14	15	22	22
SUB CDS	Event 1	Event12 2	Events 3,4	Events 5,6	Event 7	Event 8
ΔMRI G1	12	0	0	0	0	0
ΔMRI G2	21	4	3	2	4	4
ΔMRI G3	9	20	19	19	19	19
ΔMRI G4	2	19	18	18	15	15
No Rating Available	25	26	29	30	32	31

Table 7:

Summary statistics of the four factors variables

Table 7	Summary statistics				
Variables	N. Obs.	Mean	St. Dev.	Min	Max
Slope	1571	1.166	0.479	0.038	2.451
VSTOXX	1571	23.632	6.806	12.713	53.547
R_free 5Y	1571	1.358	0.831	0.142	3.255
ESXX6	1571	200.47	43.996	135.99	296.312
SNR CDS 5Y	1571	139.94	67.980	52.716	357.5
SUB CDS 5Y	1571	238.84	116.576	75.033	613.667

Table 8:

Correlation Matrix of the four factors variables and the senior unsecured and subordinated 5 years CDS Markit Itraxx Indices for financials

Table 8	Correlation Matrix					
Variables	Slope	VSTOXX	R_free 5Y	ESXX6	SNR CDS 5Y	SUB CDS 5Y
Slope	1					
VSTOXX	-0.158	1				
R_free 5Y	0.619	-0.114	1			
ESXX6	-0.008	-0.759	0.049	1		
SNR CDS 5Y	-0.195	0.617	-0.117	-0.611	1	
SUB CDS 5Y	-0.159	0.536	-0.104	0.869	-0.529	1

Table 9.1 CDS on SNR debt	Summary statistics of the explanatory variables used in regression 2 and the sample composition							
Variables (31/12/2012)	Missing data	N Obs.	Mean	St. Dev.	Min	Max	Summary observations	N
LN(Asset)	0	60	12.70	1.34	8.68	15.06	G-SIB	17
RoA %	1	59	-0.07	0.64	-2.01	1.05	NO-G-SIB	43
D/A %	0	60	37.81	15.17	1.35	76.75	GIIPS	19
Tier 1 %	4	56	13.04	3.24	7.70	21.30	NO-GIIPS	41
D/GDP %	0	60	87.76	27.70	30.60	159.60	Group 1SNR	5
D/GDP (d-Me)* %	0	60	18.21	14.25	-2.95	61.63	Group 2SNR	25
SNR CDS Level (d-Me)*	0	60	-118.01	113.66	-479.91	0.40	Group 3SNR	13
D/GDP*SNR CDS Level (d-Me)*	0	60	-31.83	57.52	-286.96	2.02	Group 4SNR	9
Leverage (Tot.Debt/Tot.Capital)%	3	57	86.38	8.55	46.33	105.72	Undefined Group	8
SNR/SUB Outstanding debt	9	51	14.30	18.88	0.77	111.85	Supersized banking sector	13
Liquidity SNR %	0	60	3.78	4.59	0	22.5	*(d-Me) means "de-meaned"	

Table 9.2	CDS on SUB debt							
Variables (31/12/2012)	Missing data	N Obs.	Mean	St. Dev.	Min	Max	Summary observations	N
LN(Asset)	0	47	12.88	1.35	8.68	15.06	G-SIB	15
RoA %	0	47	-0.09	0.68	-2.01	1.05	NO-G-SIB	32
Depoit/Asset %	0	47	40.58	13.26	2.89	76.74	GIIPS	15
Tier 1 %	3	44	13.10	3.38	7.70	21.30	NO-GIIPS	32
D/GDP %	0	47	87.43	30.24	30.60	159.60	Group 1SNR	0
D/GDP (d-Me)* %	0	47	17.56	13.94	-2.95	61.63	Group 2SNR	3
SNR CDS Level (d-Me)*	0	47	-200.50	222.05	-1370.23	48.59	Group 3SNR	19
D/GDP*SNR CDS Level (d-Me)*	0	47	-48.41	84.17	-448.75	63.17	Group 4SNR	16
Leverage (Tot.Debt/Tot.Capital) %	2	45	86.07	8.97	46.33	105.718	Undefined Group	9
SNR/SUB Outstanding debt	6	41	13.24	18.04	0.77	111.85	Supersized banking sector	11
Liquidity SUB	0	47	2.91	5.88	0.00	39.17	(d-Me) means "de-meaned"	

Table 10

Correlation Matrix of the variables used in the regression 2 to explain the abnormal spread variation of events 3 and 4.

Variables as at 31/12/2012	LN(Asset)	RoA	Deposit/Asset	Tier 1 ratio	D/GDP	D/GDP (d-Me)	SNR CDS Level (d-Me)	D/GDP*SNRCDS Level (d-Me)	Leverage (D/CAP)	Liquidity SNR CDS	Liquidity SUB CDS	SNR/SUB Outst.debt
LN(Asset)	1											
RoA	0.26	1										
Deposit/Asset	-0.25	-0.08	1									
Tier 1 ratio	0.51	0.45	-0.33	1								
D/GDP	-0.47	-0.52	0.14	-0.53	1							
D/GDP (d-Me)	-0.28	-0.37	0.34	-0.30	0.57	1						
SNR CDS Level (d-Me)	0.32	0.60	-0.21	0.07	-0.63	-0.64	1					
D/GDP*SNR CDS (d-Me)	0.36	0.52	-0.26	0.06	-0.56	-0.80	0.92	1				
Leverage (Debt/Capital)	0.20	-0.39	-0.39	0.00	0.11	-0.02	-0.25	-0.14	1			
Liquidity SNR	-0.19	0.02	-0.13	-0.01	0.09	0.12	-0.08	-0.13	0.11	1		
Liquidity SUB	-0.29	-0.42	0.17	-0.28	0.44	0.24	-0.48	-0.41	0.36	0.25	1	
SNR/SUB Outst..Debt	-0.17	-0.10	-0.40	0.24	0.06	-0.29	-0.06	0.13	0.46	0.15	0.07	1

Tables 11 and 12:

Regression 1 with the SNR FIN CDS 5Y and SUB FIN CDS 5Y as dependent variable and the four factors variables as explanatory variables in the first part of the table, the same dependent variable and explanatory variables, excluded the ESXX6, in the second part.

Table 11	Regression 1. Dependent Variable: SNR FIN CDS 5Y						
Variables	Exp. Sign	Coefficient	St.Error	t-stat	P-Value	R^2	0.43
Constant	0	0.001	0.001	1.188	0.235	SER	0.028
Slope	-	-0.041**	0.021	-1.905	0.057	F	297.56
VSTOXX	+	0.203***	0.017	11.883	0.000	dF	1563
R_free 5Y	-	-1.249***	0.110	-11.347	0.000	SSreg	0.956
ESXX6	-	-0.027	0.017	-1.630	0.103	SSresid	1.255
	Regression 1 without ESXX6						
Variables	Exp. Sign	Coefficient	St.Error	t-stat	P-Value	R^2	0.386
Constant	0	0.000	0.001	0.066	0.947	SER	0.029
Slope	-	-0.066***	0.022	-2.986	0.003	F	327.12
VSTOXX	+	0.349***	0.012	30.042	0.000	dF	1564
R_free 5Y	-	-0.008	0.017	-0.461	0.645	SSreg	0.853
.	.	.	.	.	.	SSresid	1.359

Table 12	Regression 1. Dependent Variable: SUB FIN CDS 5Y						
Variables	Exp. Sign	Coefficient	St.Error	t-stat	P-Value	R^2	0.325
Constant	0	0.001	0.001	1.147	0.252	SER	0.033
Slope	-	-0.021**	0.002	-8.417	0.040	F	188.21
VSTOXX	+	0.188***	0.020	9.569	0.000	dF	1563
R_free 5Y	-	-1.139***	0.127	-8.981	0.000	SSreg	0.802
ESXX6	-	-0.033*	0.019	-1.739	0.082	SSresid	1.666
	Regression 1 without ESXX6						
Variables	Exp. Sign	Coefficient	St.Error	t-stat	P-Value	R^2	0.29
Constant	0	0.000	0.001	0.255	0.798	SER	0.033
Slope	-	-0.044*	0.025	-1.744	0.081	F	213.19
VSTOXX	+	0.322***	0.013	24.368	0.000	dF	1564
R_free 5Y	-	-0.016	0.020	-0.810	0.418	SSreg	0.716
.	.	.	.	.	.	SSresid	1.752

Table 13.1	Abnormal variations of SNR CDS for different dependent variables and different event windows, by events.									
	AR/CAR	SNR CDS	Equally W.	Asset W.	G-SIB A.W.	NO-G-SIB A.W.	ΔMRI G1	ΔMRI G2	ΔMRI G3	ΔMRI G4
Event 1										
	Day Zero	0.03	0.00	0.00	-0.01	0.01	0.00	0.00	0.00	0.00
		(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Denmark	[-1;+1]	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
06/02/2011		(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
	[-2;+2]	0.04	-0.01	0.00	0.00	0.00	-0.02	-0.01	0.02	0.00
		(0.07)	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)
Event 2										
	Day Zero	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00
		(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Spain	[-1;+1]	-0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.00
10/07/2012		(0.04)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)	(0.04)	(0.04)	(0.02)
	[-2;+2]	-0.03	0.03	0.04	0.05	0.03	0.02	0.03	0.02	0.00
		(0.06)	(0.04)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.05)	(0.02)
Event 3										
	Day Zero	0.01	0.03**	0.04**	0.04**	0.03***	0.04***	0.03***	0.02*	0.02**
		(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.10***	0.06***	0.07***	0.09***	0.06***	0.09***	0.05***	0.06**	0.04**
18/03/2013		(0.04)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[-2;+2]	0.09**	0.07**	0.08***	0.10**	0.06**	0.10***	0.05**	0.06**	0.04**
		(0.05)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Event 4										
	Day Zero	0.01	0.03**	0.04***	0.05***	0.03**	0.04***	0.03**	0.03**	0.01
		(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.12***	0.08***	0.09***	0.13***	0.06***	0.11***	0.06***	0.04*	0.06***
25/03/2013		(0.04)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[-2;+2]	0.13***	0.12***	0.15***	0.21***	0.10***	0.16***	0.12***	0.09***	0.08***
		(0.05)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Cumulative										
event 3 and 4	Day Zero	0.02	0.06***	0.08***	0.10***	0.06***	0.09***	0.05***	0.05***	0.03**
		(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Cyprus	[-1;+1]	0.23***	0.14***	0.17***	0.21***	0.12***	0.20***	0.12***	0.10***	0.10***
18/03/2013		(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
25/03/2013	[-2;+2]	0.22***	0.19***	0.23***	0.31***	0.16***	0.26***	0.18***	0.15***	0.13***
		(0.07)	(0.04)	(0.05)	(0.06)	(0.04)	(0.05)	(0.03)	(0.04)	(0.03)
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent										

Table 13.2	Abnormal spread variations of SNR CDS for different dependent variables and different event windows, by events.									
	AR/CAR	SNR CDS	Equally W.	Asset W.	G-SIB A.W.	NO-G-SIB A.W.	ΔMRI G1	ΔMRI G2	ΔMRI G3	ΔMRI G4
Event 5										
	Day Zero	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
SRM Prov. Ann	[-1;+1]	-0.01	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	0.01
20/03/2014		(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
	[-2;+2]	0.00	0.00	-0.01	0.00	-0.02	-0.01	0.00	0.00	0.04
		(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Event 6										
	Day Zero	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
		(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
SRM Final Ann.	[-1;+1]	0.02	-0.01	-0.01	-0.01	-0.01	0.00	0.00	-0.01	0.01
15/04/2014		(0.04)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[-2;+2]	0.02	0.02	0.03	0.04	0.02	0.02	0.02	0.04	0.04
		(0.05)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Cumulative										
event 5 and 6	Day Zero	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.01	0.02
		(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
SRM Ann.	[-1;+1]	-0.01	-0.02	-0.02	-0.02	-0.03	-0.01	-0.02	0.00	0.03
20/03/2014		(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)
15/04/2014	[-2;+2]	0.01	0.02	0.03	0.01	0.00	0.01	0.03	0.04	0.05
		(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Event 7										
	Day Zero	-0.03	-0.03	-0.04*	-0.06**	-0.03	-0.02	-0.04	-0.04	-0.01
		(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
Denmark	[-1;+1]	-0.09*	-0.07*	-0.09**	-0.12**	-0.06	-0.05	-0.08	-0.10**	-0.05
05/10/2015		(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.03)	(0.05)	(0.05)	(0.03)
	[-2;+2]	-0.08	-0.09*	-0.11**	-0.15**	-0.08*	-0.07	-0.11*	-0.13**	-0.06
		(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.04)	(0.06)	(0.06)	(0.04)
Event 8										
	Day Zero	-0.01	-0.01	-0.01	-0.02	0.00	0.00	-0.01	-0.01	-0.01
		(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Bail-in Fully	[-1;+1]	-0.03	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.01
Implemented		(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
01/01/2016	[-2;+2]	-0.03	0.02	0.03	0.02	0.04	0.02	0.03	0.02	0.01
		(0.04)	(0.03)	(0.04)	(0.05)	(0.03)	(0.02)	(0.04)	(0.04)	(0.03)
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent										

Table 14.1	Abnormal spread variations of SUB CDS for different dependent variables and different event windows, by events.									
	AR/CAR	SUB CDS	Equally W.	Asset W.	G-SIB A.W.	NO-G-SIB A.W.	ΔMRI G1	ΔMRI G2	ΔMRI G3	ΔMRI G4
Event 1										
	Day Zero	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	-0.03
		(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)
Denmark	[-1;+1]	0.01	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.10
06/02/2011		(0.06)	(0.04)	(0.04)	(0.05)	(0.03)	(0.05)	(0.03)	(0.04)	(0.08)
	[-2;+2]	0.01	-0.01	0.00	0.00	-0.01	-0.02	-0.01	0.00	0.08
		(0.07)	(0.05)	(0.05)	(0.06)	(0.04)	(0.06)	(0.04)	(0.06)	(0.10)
Event 2										
	Day Zero	0.03	-0.01	-0.01	-0.01	-0.01	NA	-0.01	-0.01	-0.01
		(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(NA)	(0.02)	(0.02)	(0.02)
Spain	[-1;+1]	0.00	0.02	0.01	0.02	0.01	NA	-0.02	0.01	0.01
10/07/2012		(0.04)	(0.03)	(0.04)	(0.05)	(0.03)	(NA)	(0.04)	(0.04)	(0.03)
	[-2;+2]	0.00	0.04	0.04	0.06	0.02	NA	0.02	0.02	0.03
		(0.05)	(0.04)	(0.05)	(0.06)	(0.04)	(NA)	(0.05)	(0.05)	(0.03)
Event 3										
	Day Zero	0.02	0.04**	0.05***	0.06***	0.03***	NA	0.07***	0.04***	0.03***
		(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(NA)	(0.02)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.10***	0.07***	0.09***	0.11***	0.06***	NA	0.12***	0.08***	0.05***
18/03/2013		(0.04)	(0.02)	(0.03)	(0.04)	(0.02)	(NA)	(0.04)	(0.02)	(0.02)
	[-2;+2]	0.09**	0.07**	0.09***	0.12***	0.06***	NA	0.15***	0.09***	0.05**
		(0.05)	(0.03)	(0.03)	(0.05)	(0.02)	(NA)	(0.05)	(0.03)	(0.03)
Event 4										
	Day Zero	-0.01	0.03**	0.04**	0.05**	0.03**	NA	0.04*	0.04**	0.03***
		(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(NA)	(0.02)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.7**	0.05**	0.07***	0.09***	0.05***	NA	0.08**	0.07***	0.06***
25/03/2013		(0.04)	(0.02)	(0.03)	(0.04)	(0.02)	(NA)	(0.04)	(0.02)	(0.02)
	[-2;+2]	0.08*	0.10***	0.14***	0.18***	0.10***	NA	0.17***	0.13***	0.011***
		(0.05)	(0.03)	(0.03)	(0.05)	(0.02)	(NA)	(0.05)	(0.03)	(0.03)
Cumulative										
event 3 and 4	Day Zero	0.01	0.06***	0.08***	0.11***	0.06***	NA	0.11***	0.08***	0.06***
		(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(NA)	(0.02)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.17***	0.12***	0.16***	0.20***	0.12***	NA	0.19***	0.15***	0.11***
18/03/2013		(0.04)	(0.02)	(0.03)	(0.04)	(0.02)	(NA)	(0.04)	(0.02)	(0.02)
25/03/2013	[-2;+2]	0.17***	0.17***	0.24***	0.31***	0.16***	NA	0.32***	0.22***	0.16***
		(0.05)	(0.03)	(0.03)	(0.05)	(0.02)	(NA)	(0.05)	(0.03)	(0.03)
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent										

Table 14.2 — Abnormal spread variations of SUB CDS for different dependent variables and different event windows, by events.

	AR/CAR	SUB CDS	Equally W.	Asset W.	G-SIB A.W.	NO-G-SIB A.W.	ΔMRI G1	ΔMRI G2	ΔMRI G3	ΔMRI G4
Event 5										
	Day Zero	0.02	0.01	0.01	0.02	0.01	NA	0.01	0.01	0.01
		(0.03)	(0.01)	(0.01)	(0.02)	(0.01)	(NA)	(0.02)	(0.01)	(0.01)
SRM Prov. Ann	[-1;+1]	0.03	-0.01	-0.01	-0.01	0.00	NA	-0.01	-0.01	-0.01
20/03/2014		(0.05)	(0.02)	(0.02)	(0.03)	(0.02)	(NA)	(0.03)	(0.02)	(0.02)
	[-2;+2]	0.07	0.00	0.00	0.00	0.00	NA	0.00	-0.01	-0.01
		(0.06)	(0.03)	(0.03)	(0.04)	(0.02)	(NA)	(0.04)	(0.03)	(0.03)
Event 6										
	Day Zero	0.01	0.00	0.01	0.01	0.00	NA	0.01	0.01	0.00
		(0.03)	(0.01)	(0.01)	(0.02)	(0.01)	(NA)	(0.02)	(0.01)	(0.01)
SRM Final Ann.	[-1;+1]	0.03	0.00	-0.01	-0.01	0.00	NA	-0.01	0.00	0.01
15/04/2014		(0.05)	(0.02)	(0.02)	(0.03)	(0.02)	(NA)	(0.03)	(0.02)	(0.02)
	[-2;+2]	0.04	0.02	0.03	0.04	0.01	NA	0.03	0.03	0.03
		(0.06)	(0.03)	(0.03)	(0.04)	(0.02)	(NA)	(0.04)	(0.03)	(0.03)
Cumulative										
event 5 and 6	Day Zero	0.03	0.01	0.02	0.03	0.01	NA	0.02	0.02	0.02
		(0.03)	(0.01)	(0.01)	(0.02)	(0.01)	(NA)	(0.02)	(0.01)	(0.01)
SRM Ann.	[-1;+1]	0.06	-0.01	-0.01	-0.02	0.00	NA	-0.02	-0.01	0.00
20/03/2014		(0.05)	(0.02)	(0.02)	(0.03)	(0.02)	(NA)	(0.03)	(0.02)	(0.02)
15/04/2014	[-2;+2]	0.10*	0.02	0.03	0.04	0.02	NA	0.03	0.02	0.02
		(0.06)	(0.03)	(0.03)	(0.04)	(0.02)	(NA)	(0.04)	(0.03)	(0.03)
Event 7										
	Day Zero	-0.04	-0.03*	-0.04*	-0.05*	-0.03	NA	-0.03	-0.04*	-0.03*
		(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(NA)	(0.02)	(0.02)	(0.02)
Denmark	[-1;+1]	-0.07*	-0.07*	-0.07*	-0.10*	-0.05	NA	-0.07	-0.07	-0.07*
05/10/2015		(0.04)	(0.03)	(0.04)	(0.05)	(0.03)	(NA)	(0.04)	(0.04)	(0.03)
	[-2;+2]	-0.06	-0.08*	-0.10*	-0.14**	-0.07	NA	-0.10*	-0.09*	-0.09*
		(0.05)	(0.04)	(0.05)	(0.06)	(0.04)	(NA)	(0.05)	(0.05)	(0.04)
Event 8										
	Day Zero	0.03	-0.01	-0.01	-0.02	0.00	NA	-0.01	-0.01	-0.01
		(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(NA)	(0.02)	(0.02)	(0.01)
Bail-in Fully	[-1;+1]	0.02	0.02	0.02	0.03	0.02	NA	0.01	0.02	0.03
Implemented		(0.03)	(0.03)	(0.03)	(0.04)	(0.02)	(NA)	(0.03)	(0.03)	(0.02)
01/01/2016	[-2;+2]	0.01	0.03	0.04	0.03	0.04	NA	0.03	0.02	0.04
		(0.04)	(0.03)	(0.04)	(0.05)	(0.03)	(NA)	(0.03)	(0.03)	(0.03)

*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent

Table 14.3	Differences in the abnormal spread variations among indices.						
	AR/CAR	G-SIB Vs No-G-SIB mesures		CDS on Senior Unsecured Vs CDS on Subordinated debt			
		G-SIB A.W. - No-G-SIB A.W.	ΔMRIG1-ΔMRIG4	Markit iTrax CDS	Equally W.	Asset W.	G-SIB A.W.
Event 3							
	Day Zero	0.01	0.02*	-0.01	0.00	-0.01*	-0.02**
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.03	0.05***	0.00	-0.01	-0.01	-0.02
18/03/2013		(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
	[-2;+2]	0.04	0.06**	0.00	0.00	-0.01	-0.02
		(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Event 4							
	Day Zero	0.02**	0.03***	0.02**	0.00	0.00	0.01
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.02***	0.06***	0.05***	0.03**	0.02**	0.04**
25/03/2013		(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
	[-2;+2]	0.11***	0.08***	0.05***	0.02	0.01	0.02
		(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Cumulative							
event 3 and 4	Day Zero	0.04**	0.05***	0.00	0.00	-0.01	-0.01
		(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cyprus	[-1;+1]	0.09***	0.10***	0.05***	0.02	0.01	0.01
18/03/2013		(0.03)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)
25/03/2013	[-2;+2]	0.15***	0.13***	0.05**	0.01	0.00	0.00
		(0.04)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)
Event 7							
	Day Zero	-0.03**	-0.01	0.01	0.00	0.00	-0.01
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Denmark	[-1;+1]	-0.06***	0.00	-0.02	0.00	-0.01	-0.02
05/10/2015		(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
	[-2;+2]	-0.07**	-0.01	-0.02	-0.01	-0.02	-0.01
		(0.03)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent							

Table 14.4	Summary statistics of the European countries' sovereign CDSs written on Senior debt							
Country	Currency	Rest. Clauses	N. observations	Liquidi ratio	Average CDS Level	Stand. Dev.	Min	Max
Austria	E	Full Rest.	1571	0.15	45.3	35.1	12.2	159.2
Belgium	E	Full Rest.	1571	0.07	81.4	67.2	21.5	342.0
Denmark	E	Full Rest.	1571	0.31	36.4	34.1	10.0	147.1
France	E	Full Rest.	1571	0.21	55.3	34.0	16.8	171.6
Germany	E	Full Rest.	1571	0.25	24.1	15.9	6.6	79.3
Greece	E	Full Rest.	1571	0.67	10421.3	6253.5	229.2	14911.7
Ireland	E	Full Rest.	1571	0.09	258.5	248.7	29.3	1191.2
Italy	E	Full Rest.	1571	0.06	182.1	106.2	69.3	498.7
Norway	US$	Full Rest.	1571	0.30	20.0	8.8	10.6	52.1
Malta	US$	Full Rest.14	1571	0.54	230.2	69.4	106.4	448.1
Netherland	E	Full Rest.	1571	0.33	31.8	22.3	7.7	122.9
Portugal	E	Full Rest.	1571	0.06	416.7	330.0	73.1	1521.5
Spain	E	Full Rest.	1571	0.05	178.6	104.2	45.4	492.1
Sweden	E	Full Rest.	1571	0.31	22.8	15.2	7.7	75.7
Swiss	E	Modified-Modified	1447	0.90	62.3	11.6	36.6	69.7
U.K.	US$	Full Rest.14	1571	0.06	47.6	24.4	16.5	101.6
Liquidity is the ratio between the days with zero CDS spread variation and N.Observ. Countries with illiquid CDS (ratio over 0.5) have been excluded.								

Table 14.4: Summary statistics of the European countries' sovereign CDSs written on senior debt. Greece, Malta and Swiss have been excluded from the robustness analysis due to the illiquidity of their CDS, which spreads remained fixed during all the estimation and event windows.

Table 14.5 — Abnormal variations of the CDS at sovereign level, for different event windows.

	AR/CAR	AUSTRIA	BELGIUM	DENMARK	FRANCE	GERMANY	IRELAND	ITALY	NETHER.	NORWAY	PORTUGAL	SPAIN	SWEDEN	U.K.
Event 3														
	Day Zero	0.02	0.04	-0.04	0.01	0.02	0.03	0.04	0.03	0.00	0.05*	0.06*	-0.04	0.00
		(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.08)	(0.02)	(0.03)	(0.03)	(0.13)	(0.03)
Cyprus	[-1;+1]	0.03	0.04	-0.04	0.00	0.03	0.05	0.09	-0.01	0.02	0.08*	0.10*	-0.13	-0.01
18/03/2013		(0.07)	(0.08)	(0.07)	(0.07)	(0.08)	(0.09)	(0.06)	(0.14)	(0.04)	(0.05)	(0.06)	(0.22)	(0.04)
	[-2;+2]	0.06	0.06	0.04	0.02	0.01	0.08	0.09	0.03	0.05	0.09	0.14*	-0.14	-0.01
		(0.09)	(0.10)	(0.09)	(0.09)	(0.10)	(0.12)	(0.08)	(0.18)	(0.05)	(0.06)	(0.08)	(0.28)	(0.06)
Event 4														
	Day Zero	0.04	0.04	0.03	0.05	0.03	0.01	0.02	0.04	0.02	-0.01	0.02	-0.02	0.01
		(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.08)	(0.02)	(0.03)	(0.03)	(0.13)	(0.03)
Cyprus	[-1;+1]	0.03	0.07	0.04	0.10	0.05	0.00	0.01	0.08	0.02	0.00	0.01	-0.01	0.01
25/03/2013		(0.07)	(0.08)	(0.07)	(0.07)	(0.08)	(0.09)	(0.06)	(0.14)	(0.04)	(0.05)	(0.06)	(0.22)	(0.04)
	[-2;+2]	0.05	0.11	0.09	0.15*	0.09	0.03	0.04	0.06	0.04	0.04	0.03	0.01	0.01
		(0.09)	(0.10)	(0.09)	(0.09)	(0.10)	(0.12)	(0.08)	(0.18)	(0.05)	(0.06)	(0.08)	(0.28)	(0.06)
Cumulative														
event 3 and 4	Day Zero	0.06	0.08	-0.01	0.06	0.05	0.05	0.06	0.07	0.02	0.04	0.08	-0.06	0.01
		(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.08)	(0.05)	(0.11)	(0.03)	(0.04)	(0.05)	(0.18)	(0.04)
Cyprus	[-1;+1]	0.07	0.11	0.00	0.10	0.08	0.06	0.09	0.07	0.04	0.08	0.11	-0.14	0.00
18/03/2013		(0.10)	(0.11)	(0.10)	(0.10)	(0.11)	(0.13)	(0.09)	(0.20)	(0.06)	(0.07)	(0.08)	(0.31)	(0.06)
25/03/2013	[-2;+2]	0.11	0.17	0.13	0.17	0.10	0.10	0.13	0.08	0.08	0.13	0.16	-0.14	0.01
		(0.12)	(0.14)	(0.13)	(0.13)	(0.14)	(0.17)	(0.12)	(0.26)	(0.07)	(0.09)	(0.11)	(0.40)	(0.08)
Event 7														
	Day Zero	0.01	0.00	-0.05	0.01	-0.04	0.00	0.00	0.01	0.00	0.00	0.00	-0.02	-0.01
		(0.05)	(0.04)	(0.10)	(0.04)	(0.06)	(0.02)	(0.05)	(0.02)	(0.02)	(0.04)	(0.05)	(0.12)	(0.02)
Denmark	[-1;+1]	-0.02	-0.06	-0.11	-0.06	-0.03	0.00	-0.05	0.07	0.01	-0.05	-0.08	0.05	-0.03
05/10/2015		(0.08)	(0.07)	(0.17)	(0.06)	(0.10)	(0.03)	(0.08)	(0.04)	(0.03)	(0.07)	(0.09)	(0.20)	(0.04)
	[-2;+2]	0.12	-0.03	-0.07	0.01	-0.05	-0.01	-0.06	0.01	-0.03	-0.03	-0.08	-0.04	-0.01
		(0.11)	(0.10)	(0.22)	(0.08)	(0.13)	(0.04)	(0.10)	(0.05)	(0.03)	(0.09)	(0.11)	(0.26)	(0.05)

*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent

Table 15.1	Cross-sectional regression: CDS on Senior unsecured debt		
Estimation window: 3 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.005	0.002	0.007
D/GDP*SNR CDS L.(d-Me)	0.000	0.000	0.000
Deposit/Asset	0.079**	0.074	0.153**
D/GDP (d-Me)	-0.001	0.001	0.000
SNR CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SNR	-0.129	-0.368**	-0.5**
G-SIB	0.032**	0.035*	0.067***
GIIPS	0.037**	0.011	0.05
Supersized banking sector	0.006	0.025	0.031
Constant	-0.03	0.003	-0.027
R2	0.37	0.33	0.43
R2 adjusted	0.25	0.21	0.33
SER res	0.04	0.06	0.07
N Obs	60	60	60
Table 15.2	Cross-sectional regression: CDS on Subordinated debt		
Estimation window: 3 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.009	-0.001	0.008
D/GDP*SUB CDS L. (d-Me)	0.000	0.000	0.000
Deposit/Asset	0.180***	-0.007	0.173*
D/GDP (d-Me)	-0.001	0.000	0.000
SUB CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SUB	-0.093	-0.106	-0.200
G-SIB	0.049***	0.027**	0.076***
GIIPS	0.013	-0.008	0.005
Supersized banking sector	0.020	0.014	0.034
Constant	-0.144*	0.059	-0.085
R2	0.55	0.31	0.47
R2 adjusted	0.44	0.14	0.35
SER res	0.03	0.03	0.06
N Obs	47	47	47
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent			

Results of regression 2, the dependent variables are the 3 days CAR of the SNR CDS (15.1) and SUB CDS (15.2) of events 3, 4 and the cumulative one.

Table 16.1	Cross-sectional regression: CDS on Senior unsecured debt		
Estimation window: 5 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.006	0.001	0.007
D/GDP*SNR CDS L.(d-Me)	0.000	0.000	0.000
Deposit/Asset	0.099**	0.044	0.143
D/GDP (d-Me)	0.000	0.001	0.001
SNR CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SNR	-0.053	-0.56***	-0.61**
G-SIB	0.038***	0.071***	0.109***
GIIPS	0.035**	0.014	0.050
Supersized banking sector	0.009	0.033	0.041
Constant	-0.067	0.070	0.003
R2	0.39	0.44	0.47
R2 adjusted	0.28	0.33	0.38
SER res	0.04	0.07	0.09
N Obs	60	60	60
Table 16.2	Cross-sectional regression: CDS on Subordinated debtt		
Estimation window: 5 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.012	0.013	0.025
D/GDP*SUB CDS L. (d-Me)	0.000	0.000	0.000
Deposit/Asset	0.217***	0.106	0.322*
D/GDP (d-Me)	0.000	0.001	0.000
SUB CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SUB	-0.118	0.005	-0.113
G-SIB	0.062***	0.072***	0.133***
GIIPS	0.033	0.012	0.045
Supersized banking sector	0.029	0.016	0.045
Constant	-0.217*	-0.144	-0.361
R2	0.47	0.29	0.38
R2 adjusted	0.35	0.11	0.23
SER res	0.05	0.07	0.12
N Obs	47	47	47
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent			

Results of regression 2, the dependent variables are the 5 days CAR of the SNR CDS (16.1) and SUB CDS (16.2) of events 3, 4 and the cumulative one.

Table 17.1	Robustness check: CDS on Senior unsecured debt		
Estimation window: 3 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.013	0.015	0.027**
D/GDP*SNR CDS L.(d-Me)	0.000	0.000	0.000
Deposit/Asset	0.042	0.092*	0.173**
D/GDP (d-Me)	0.000	0.000	0.000
SNR CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SNR	-0.118	-0.365**	-0.643***
G-SIB	0.02	0.004	0.03
GIIPS	0.05**	0.05	0.05
Supersized banking sector	0.008	0.028	0.014
3Days CARs of Sovereign CDS	-0.13	0.938*	1.266**
Constant	-0.09	-0.18	-0.27
R2	0.37	0.45	0.49
R2 adjusted	0.21	0.31	0.35
SER res	0.04	0.05	0.07
N Obs	55	55	55

Table 17.2	Robustness check: CDS on Subordinated debt		
Estimation window: 3 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.02**	0.014**	0.036***
D/GDP*SUB CDS L. (d-Me)	0.000	0.000	0.000
Deposit/Asset	0.173***	0.002	0.172
D/GDP (d-Me)	-0.001	0.000	-0.002
SUB CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SUB	0.171	0.107	0.267
G-SIB	0.039**	0.001	0.040
GIIPS	0.014	0.032	0.011
Supersized banking sector	0.025	0.034	0.049
3Days CARs of Sovereign CDS	0.087	0.605**	0.336
Constant	-0.285**	-0.156	-0.447**
R2	0.53	0.39	0.48
R2 adjusted	0.38	0.20	0.31
SER res	0.03	0.03	0.06
N Obs	42	42	42

*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent

Table 18.1	Robustness check: CDS on Senior unsecured debt		
Estimation window: 5 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.008	0.019*	0.033*
D/GDP*SNR CDS L.(d-Me)	0.000	0.000	0.000
Deposit/Asset	0.066	0.088	0.182*
D/GDP (d-Me)	0.000	0.002	0.000
SNR CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SNR	-0.041	-0.56***	-0.748**
G-SIB	0.028	0.018	0.058
GIIPS	0.05**	0.072	0.072
Supersized banking sector	0.022	0.053	0.064
5Days CARs of Sovereign CDS	0.136	0.719**	0.644
Constant	-0.129	-0.245*	-0.334
R2	0.40	0.54	0.54
R2 adjusted	0.23	0.41	0.41
SER res	0.041	0.06	0.09
N Obs	55	55	55
Table 18.2	Robustness check: CDS on Subordinated debt		
Estimation window: 5 Days	CAR Event 3	CAR Event 4	CAR Cumulative Event
LN(Asset)	0.023**	0.036**	0.06**
D/GDP*SUB CDS L. (d-Me)	0.000	0.000	0.000
Deposit/Asset	0.233**	0.131	0.335
D/GDP (d-Me)	-0.001	0.000	-0.003
SUB CDS Level (d-Me)	0.000	0.000	0.000
Liquidity SUB	0.271	0.128	0.466
G-SIB	0.058**	0.024	0.091
GIIPS	0.05*	0.075	0.068
Supersized banking sector	0.036	0.066	0.092
5Days CARs of Sovereign CDS	-0.060	0.894**	0.383
Constant	-0.384**	-0.509**	-0.846**
R2	0.50	0.40	0.42
R2 adjusted	0.34	0.21	0.23
SER res	0.05	0.07	0.12
N Obs	42	42	42
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent			

Appendix

A Sample details

Table A.1	Markit iTraxx 5Y CDS (for financial)		
Company Name	Wgt	Company Name	Wgt
Aegon NV	3.334	Hannover Rueck SE	3.333
Allianz SE	3.334	HSBC Holdings PLC	3.333
Assicur. Generali SpA	3.334	ING Groep NV	3.333
Aviva PLC	3.334	Intesa Sanpaolo SpA	3.333
AXA SA	3.334	Lloyds Banking Group PLC	3.333
Banco (BBVA)SA	3.334	Mediobanca SpA	3.333
Banco Santander SA	3.334	Muenchener Rueckv.Gesel. AG	3.333
Barclays PLC	3.334	Prudential PLC	3.333
BNP Paribas SA	3.334	Royal Bank of Scotland PLC	3.333
Commerzbank AG	3.334	Societe Generale SA	3.333
Coop. Rabobank UA	3.333	Standard Chartered PLC	3.333
Credit Agricole SA	3.333	Swiss Reinsurance Co Ltd	3.333
Credit Suisse Group AG	3.333	UBS Group AG	3.333
Danske Bank A/S	3.333	UniCredit SpA	3.333
Deutsche Bank AG	3.333	Zurich Insurance Co Ltd	3.333
Composition at September 2018			

Table A.2 Summary statistics by bank for the CDS written on senior unsecured bond.

Banks	Country	N.Obs.	Mean	St.Dev.	Min	Max	G-SIB	GIIPS	Banks	Country	N.Obs.	Mean	St.Dev.	Min	Max	G-SIB	GIIPS
BAWAG PSK	Austria	1571	193.4	57.4	119.9	417.3	0	0	UBI banca	Italy	1571	229.9	129.5	68.4	661.0	0	1
Erste Group	Austria	1571	167.1	60.1	91.2	414.8	0	0	UniCredit Spa	Italy	1571	230.9	136.6	73.4	678.3	1	1
Raiffeisen Zentralb.	Austria	1571	158.0	50.8	73.5	323.2	0	0	HSBC Bank PLC	Malta	1571	84.2	29.6	35.3	183.5	1	0
Dexia	Belgium	1571	372.0	222.7	138.9	954.2	1*	0	ABN AMRO	Netherl.	1397	115.1	54.7	50.9	317.2	0	0
KBC Group	Belgium	1571	166.5	101.3	45.0	508.4	0	0	Coop Rabobank	Netherl.	1571	143.7	67.1	53.3	361.3	0	0
Danske Bank	Denmark	1571	126.1	75.3	53.2	338.7	0	0	De Volksbank	Netherl.	1571	308.3	68.0	145.9	434.4	0	0
Banque PSA Fin.	France	1571	374.7	199.0	144.0	824.9	0	0	ING	Netherl.	1571	116.4	55.8	45.6	269.6	1	0
BNP Paribas	France	1571	121.8	65.6	50.8	361.2	1	0	Van Lanschot	Netherl.	1571	176.5	29.2	111.6	209.1	0	0
Crédit Agricole	France	1571	78.7	26.6	37.5	156.6	1	0	DNB bank	Norway	1041	77.5	33.3	43.3	182.5	0	0
Credit Lyonnais	France	1571	145.5	77.0	51.8	397.9	0	0	Banco Com. Port.	Portugal	1571	571.9	385.7	69.7	1875.5	0	1
Credit Mutuel	France	1571	149.8	80.6	52.2	416.1	0	0	Banco Espirito Santo	Portugal	1571	505.8	270.2	98.0	1277.0	0	1
Natixis* (BPCE)	France	1571	144.7	64.8	51.8	295.3	1	0	BBVA	Spain	1571	212.7	109.5	56.7	510.4	1***	1
Societe generale	France	1571	154.2	86.8	63.3	434.6	1	0	Banco de Sabadell	Spain	1571	348.2	209.1	106.4	837.9	0	1
Bayerische Land.	Germany	1571	121.5	54.7	65.5	313.2	0	0	Banco Pop. Esp.	Spain	1571	371.5	215.1	126.5	908.9	0	1
Commerzbank AG	Germany	1571	389.8	300.6	55.7	1103.5	1*	0	Banco Santander	Spain	1571	207.8	106.3	63.8	506.7	1	1
Deutsche Bank	Germany	1571	109.9	41.4	53.2	308.1	1	0	Bankinter	Spain	1571	305.1	193.1	82.1	820.1	0	1
HSH Nordbank AG	Germany	1571	198.5	43.2	114.7	342.5	0	0	Caixa Geral de Dep.	Spain	1571	129.6	69.2	51.9	356.1	0	1
IKB Deutsche	Germany	1571	316.1	113.5	138.5	526.2	0	0	Caja De A.del Med.	Spain	1571	434.9	252.2	66.7	1178.4	0	1
Landesbank Baden	Germany	1571	114.1	60.8	39.0	303.3	0	0	Fund. Banc. Caixa	Spain	1571	201.2	96.1	82.0	457.1	0	1
Landesbank Hessen	Germany	1571	110.5	54.2	45.6	302.6	0	0	Nordea Bank	Sweden	1571	81.6	35.6	38.4	200.4	1	0
Norddeutsche Land.	Germany	1571	134.9	37.3	92.0	249.7	0	0	SEB	Sweden	1571	97.5	46.1	44.8	254.6	0	0
Portigon AG	Germany	1571	137.7	92.8	49.6	451.1	0	0	Svenska Handelsb.	Sweden	1571	69.1	28.1	37.8	170.7	0	0
Unicredit Bank AG	Germany	1446	153.2	80.2	70.1	399.9	0	0	Swedbank	Sweden	1571	101.3	44.6	47.3	249.4	0	0
Alpha Bank	Greece	1571	1165.3	609.6	297.5	3153.4	0	1	Credit Suisse	Switzerl.	1571	98.2	37.5	44.2	212.8	1	0
National Bank of G,	Greece	1571	1169.9	675.2	295.1	6289.0	0	1	UBS AG	Switzerl.	1571	98.8	48.1	34.8	244.5	1	0
Allied Irish	Ireland	1571	880.4	567.9	107.5	1813.0	0	1	Bank of Scotland	U.K.	1571	115.3	62.1	35.3	289.8	0	0
Bank of Ireland	Ireland	1571	513.5	445.1	114.9	2299.0	0	1	Barclays plc	U.K.	1571	120.4	53.9	40.2	282.6	1	0
Permanent tsb plc	Ireland	1571	608.7	508.1	154.7	2498.7	0	1	HBOS PLC	U.K.	1571	114.4	61.9	35.3	287.6	0	0
Banca Italease	Italy	1571	222.1	76.9	96.0	490.6	0	1	HSBC holding PLC	U.K.	1571	92.7	28.6	40.7	196.1	1	0
Banca MPS	Italy	1571	363.0	193.1	64.1	906.4	0	1	Lloyds Banking Group	U.K.	1571	152.7	88.6	39.4	383.5	1*	0
BNL	Italy	1571	123.0	66.2	51.3	371.1	0	1	Natwest PLC	U.K.	1571	167.5	86.8	44.6	406.8	0	0
Banca Pop. Milano	Italy	1571	303.9	187.3	51.8	803.8	0	1	Royal Bank of Scot.	U.K.	1571	169.5	85.3	46.9	397.0	1	0
Banco Popolare	Italy	1571	342.3	197.4	85.2	941.1	0	1	Santander UK PLC	U.K.	1446	150.4	77.7	56.7	350.8	0	0
Intesa Sanpaolo	Italy	1571	206.1	131.6	48.7	607.9	0	1	STD Chartered bank	U.K.	1571	111.1	31.3	59.3	215.6	1**	0
Mediobanca	Italy	1571	201.0	116.3	51.3	598.6	0	1									
Total CDS Observations	107445																

*Natixis is the only listed subsidiary of the non-listed Groupe BPCE;
1*: only in 2011; 1**:since 2012; 1***: only from 2012 to 2014.

Table A.3

Summary statistics by bank for the CDS written on subordinated bond.

Banks	Country	N.Obs.	Mean	St.Dev.	Min	Max	G-SIB	GIIPS
BAWAG PSK	Austria	1571	342.6	139.3	215.0	921.1	0	0
Erste Group	Austria	1571	294.4	102.9	174.3	693.8	0	0
Raiffeisen Zentralb.	Austria	1571	307.4	88.0	131.6	555.2	0	0
Dexia	Belgium	1571	698.2	552.2	206.2	2243.0	1*	0
KBC Group	Belgium	1571	294.3	190.4	69.9	897.3	0	0
Danske Bank	Denmark	1571	200.7	120.4	78.3	510.5	0	0
Banque PSA Fin.	France	0	-	-	-	-	0	0
BNP Paribas	France	1571	206.2	133.3	72.8	612.4	1	0
Crédit Agricole	France	1571	259.1	160.9	81.8	709.4	1	0
Credit Lyonnais	France	1571	264.4	165.7	81.8	733.1	0	0
Credit Mutuel	France	1571	237.2	150.8	88.5	587.0	0	0
Natixis* (BPCE)	France	0	-	-	-	-	1	0
Societe generale	France	1571	259.8	167.0	85.2	798.6	1	0
Bayerische Land.	Germany	1571	334.7	172.7	140.3	927.1	0	0
Commerzbank AG	Germany	1571	334.6	206.8	112.8	1053.5	1*	0
Deutsche Bank	Germany	1571	176.9	79.4	79.3	483.9	1	0
HSH Nordbank AG	Germany	0	-	-	-	-	0	0
IKB Deutsche	Germany	1571	979.8	186.8	650.0	1475.7	0	0
Landesbank Baden	Germany	1571	352.8	194.8	129.7	825.0	0	0
Landesbank Hessen	Germany	0	-	-	-	-	0	0
Norddeutsche Land.	Germany	0	-	-	-	-	0	0
Portigon AG	Germany	1571	343.7	201.4	117.1	1035.3	0	0
Unicredit Bank AG	Germany	1446	252.1	128.9	112.7	654.8	0	0
Alpha Bank	Greece	1571	1498.4	958.6	432.3	4054.5	0	1
National Bank of G,	Greece	1571	1334.9	351.9	440.8	1854.4	0	1
Allied Irish	Ireland	1571	5094.1	1856.3	400.6	6858.6	0	1
Bank of Ireland	Ireland	1571	917.1	880.4	166.6	4198.3	0	1
Permanent tsb plc	Ireland	1571	4798.5	1992.8	416.1	7424.9	0	1
Banca Italease	Italy	0	-	-	-	-	0	1
Banca MPS	Italy	1571	590.4	332.8	89.1	1314.7	0	1
BNL	Italy	1571	210.3	138.3	75.9	642.8	0	1
Banca Pop. Milano	Italy	1571	484.3	321.3	78.2	1304.0	0	1
Banco Popolare	Italy	1571	537.6	362.5	85.2	1598.0	0	1
Intesa Sanpaolo	Italy	1571	317.5	211.2	80.2	961.4	0	1
Mediobanca	Italy	1571	351.1	240.9	70.0	850.0	0	1
Total CDS Observations 90029								

Banks	Country	N.Obs.	Mean	St.Dev.	Min	Max	G-SIB	GIIPS
UBI banca	Italy	1571	367.2	221.3	99.0	1036.7	0	1
UniCredit Spa	Italy	1571	371.5	232.9	105.6	1090.5	1	1
HSBC Bank PLC	Malta	1571	126.5	46.6	58.1	291.0	1	0
ABN AMRO	Netherl.	0	-	-	-	-	0	0
Coop Rabobank	Netherl.	1571	127.1	47.2	59.6	259.7	0	0
De Volksbank	Netherl.	1571	377.4	162.2	133.1	823.2	0	0
ING	Netherl.	1571	192.7	97.8	69.3	474.4	1	0
Van Lanschot	Netherl.	0	-	-	-	-	0	0
DNB bank	Norway	735	102.3	22.5	73.4	155.8	0	0
Banco Com. Port.	Portugal	1571	756.2	480.2	110.6	2126.1	0	1
Banco Espirito Santo	Portugal	1571	672.1	351.0	147.7	1844.6	0	1
BBVA	Spain	1571	330.0	195.4	85.0	821.5	1***	1
Banco de Sabadell	Spain	1571	544.3	348.8	145.6	1499.8	0	1
Banco Pop. Esp.	Spain	1571	592.7	413.8	155.9	2007.5	0	1
Banco Santander	Spain	1571	302.8	169.9	83.2	721.4	1	1
Bankinter	Spain	0	-	-	-	-	0	1
Caixa Geral de Dep.	Spain	0	-	-	-	-	0	1
Caja De A.del Med.	Spain	1571	593.1	486.6	84.7	1958.3	0	1
Fund. Banc. Caixa	Spain	1571	391.0	236.7	120.6	1010.6	0	1
Nordea Bank	Sweden	1571	131.9	54.3	74.9	279.5	1	0
SEB	Sweden	1571	164.7	79.2	69.3	399.0	0	0
Svenska Handelsb.	Sweden	1571	110.6	43.6	58.5	242.6	0	0
Swedbank	Sweden	1571	170.7	76.2	81.8	413.8	0	0
Credit Suisse	Switzerl.	1571	151.9	69.2	63.8	366.3	1	0
UBS AG	Switzerl.	1571	153.9	78.6	54.4	394.1	1	0
Bank of Scotland	U.K.	1571	247.0	151.4	71.8	677.9	0	0
Barclays plc	U.K.	1571	213.9	118.2	64.4	543.2	1	0
HBOS PLC	U.K.	1571	256.7	155.8	72.7	688.9	0	0
HSBC holding PLC	U.K.	1568	163.3	40.9	110.8	346.9	1	0
Lloyds Banking Group	U.K.	1571	284.4	178.5	69.5	751.8	1*	0
Natwest PLC	U.K.	1571	325.6	194.9	79.2	903.8	0	0
Royal Bank of Scot.	U.K.	0	-	-	-	-	1	0
Santander UK PLC	U.K.	1446	232.5	127.7	84.4	580.5	0	0
STD Chartered bank	U.K.	1571	161.3	49.1	85.7	317.3	1**	0

*Natixis is the only listed subsidiary of the non-listed Groupe BPCE;
1*: only in 2011; 1**:since 2012; 1***: only from 2012 to 2014.

B New 2014 ISDA definition

In 2013 and 2014, SNS Bank and Banco Espirito Santo failed and the 2003 Subordinated CDS triggered. The payouts paid to buyers of these CDSs were smaller than the losses faced by the subordinated bonds. It happened that the government interventions imposed huge losses on subordinated debt, while it largely protects the senior debt.

The main reason explaining this difference lies with the actions taken by governments in dealing with the failures of these banks, not covered in the 2003 ISDA definitions. For example, when SNS bank's debt was expropriated, it was not clear enough whether a 2003 CDS credit event would be declared or not. Moreover, the government interventions expressly contemplated by the BRRD may not trigger a 2003 CDS according to the definitions provided in terms of credit event. For these reasons, in 2014, ISDA presented new CDS definitions adding a new credit event, the so called "government intervention event", that triggers 2014 CDS not only for the credit events described in the 2003 ISDA but also when a government's action results in binding changes to the underlying bond, for example by reducing its principal, further subordinating it, or expropriation.

The aim of the new definitions is to better align the payouts of CDSs with the losses faced by the underlying bonds, taking into account also the "government interventions" as new credit event. These changes were also introduced to be in line with the new bail-in requirements under the BRRD, announced during the same year.

C Tests for the significance of the AR and CARs obtained from regression 1

The daily abnormal spread variations were obtained as follow:

$$AR_t = \Delta S_t - \left[\widehat{\alpha} + \widehat{\beta}_1 \Delta Slope_t + \widehat{\beta}_2 \Delta VSTOXX_t + \widehat{\beta}_3 \Delta ESXX6_t + \widehat{\beta}_4 \Delta R\_free_t\right]$$

and the statistical significance of the day zero abnormal spread variations has been tested as follows:

$$H_0 \quad : \quad AR_0 = 0$$
$$H_1 \quad : \quad AR_0 \neq 0$$

$$t \quad = \quad \frac{AR_0}{\widehat{\sigma}_\varepsilon}$$

while, the significance of the cumulative abnormal spread variation, calculated as:

$$CAR_{t_1,t_2} = \sum_{t=t_1}^{t_2} AR_t$$

has been tested through the following test:

$$H_0 \quad : \quad CAR_{t_1,t_2} = 0$$
$$H_1 \quad : \quad CAR_{t_1,t_2} \neq 0$$

$$t \quad = \quad \frac{CAR_{t_1,t_2}}{\widehat{\sigma}_\varepsilon \times \sqrt{t_2 - t_1 + 1}}$$

where the standard deviation of the residuals was multiplied by the square root of the time period under consideration (3 or 5 days and 6 or 10 days for the cumulative events).