Equity versus Bail-in Debt in Banking: An Agency Perspective*

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Abstract

We examine the optimal size and composition of banks' loss absorbing buffers. The total buffer size is driven by the trade-off between providing liquidity services (which are attached to deposits) and minimizing deadweight default costs (which can be achieved with equity and bail-in debt buffers). The optimal buffer composition is driven by the importance of two sources of moral hazard. Bank insiders have incentives to shift risk (mitigated by equity) and take private benefits (mitigated by debt). In a calibrated version of the model we find that (a) the adoption of a total loss-absorbing capacity (TLAC) in line with that prescribed in current regulation is appropriate and (b) once a large cushion of TLAC exists risk-shifting becomes relatively less important at the margin than private benefit taking, implying that equity should only be a relatively small fraction of TLAC.

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1 Introduction

The capital deficits revealed among banks during the 2007-2009 global financial crisis and the goal to prevent tax payers from having to bail out the banks in a future crisis have lead to an unprecedented reinforcement in banks' loss-absorbing capacity. Specifically, Basel III has increased the minimum Tier 1 capital requirement first from 4% to 6% (since 2015) and then to 8.5% (since 2019, once the so-called capital conservation buffer gets fully loaded). In addition, the Financial Stability Board (FSB) stipulates that global systemically important banks should have 'Total Loss-Absorbing Capacity' (or TLAC) equal to 16% of risk weighted assets (RWA) from 2019 and up to 18% of RWA by 2022.[1] Policy-makers expect a significant fraction of such TLAC to come from liabilities other than common equity. Accordingly, liabilities such as so-called bail-in debt will be first to absorb losses after equity is wiped out and before the bank receives any support from resolution funds, deposit insurance schemes or taxpayers.

The introduction of TLAC requirements aims to enhance the credibility of commitments to minimize public support to banks during crises and to increase market discipline. However, relatively little analysis exists on the convenience of satisfying it with equity or with bail-in debt, and more generally on banks' optimal level and composition of loss-absorbing liabilities. In this paper we study these issues in the context of a model in which both equity and bail-in debt entail potentially negative incentive effects.

Banks in our framework are run by specialist insiders who take two types of hidden actions under limited liability. The first is a standard unobservable risk shifting choice while the second is a choice of how much private benefits to extract at a cost in terms of the overall revenues of the bank. We consider a situation in which insiders' monetary incentives are determined by their equity stakes at the bank and, hence, in which the bank's capital structure (i.e. the combination of liabilities through which funding is raised among outside investors) is decided taking into account its subsequent impact on insiders' incentives. As is standard in the literature, the risk shifting incentives are minimized by choosing an equity

[1] http://www.fsb.org/wp-content/uploads/TLAC-Principles-and-Term-Sheet-for-publication-final.pdf

heavy capital structure (Jensen and Meckling, 1976). In contrast, excessive private benefit taking can be minimized by giving a large equity stake to insiders and raising all the outside funding in the form of debt (Innes, 1990).

In order to provide richer (and more realistic) predictions for banks' capital structure, we consider two additional departures from Modigliani-Miller ideal conditions. First, we assume that, differently from bail-in debt, insured deposit provide a liquidity convenience yield to investors, so that, other things equal, they are cheaper than bail-in debt.[2] Second, we assume that default on insured deposits (or, equivalently, causing losses to the deposit insurance agency, DIA) involves deadweight losses larger than those associated with the write-off of bail-in debt.[3]

The full model implies a socially optimal capital structure that is driven by two main trade-offs. First, a regulator interested in maximizing the net social surplus generated by banks would like to set the size and composition of TLAC (equity plus bail-in debt) in order to trade off expected deadweight costs of defaulting on deposits against the liquidity services provided by deposits. As a protection against costly default, bail-in debt and equity are perfect substitutes. However, they differ strongly in their impact on incentives. This leads to the second key trade off faced by the regulator: the one between controlling risk shifting (for which outside equity is superior) and preventing excessive private benefit taking (for which bail-in debt dominates).

We calibrate the model and examine its implications for the socially optimal capital structure. As common in the literature, the presence of insured deposits provides a strong need for loss absorbency since banks would otherwise choose to operate with no buffers and enjoy a large implicit bailout subsidy (Kareken and Wallace, 1978). We find that imposing total TLAC requirements similar in size to those currently proposed by the FSB properly trades off the preservation of liquidity services linked to deposits with the protection of the

[2]The liquidity role of bank deposits is microfounded by Diamond and Dybvig (1983) and plays a key role in the assessment of capital regulation provided by Van den Heuvel (2008).

[3]Specifically, in the baseline model we sharpen the presentation by assuming that defaulting on deposits causes some proportional deadweight resolution costs, while bail-in debt can be written-off without cost. Obviously, our qualitative conclusions prevail insofar as defaulting on deposits carries a differential cost.

DIA against deadweight default costs.

Yet, our results imply an optimal mix of equity and bail-in debt within TLAC quite different from that implied by forthcoming regulation. We find that, once TLAC is large enough so as to make default on insured deposits relatively unlikely, equity should only represent slightly above one third of optimal TLAC (or about 5% of total assets), with bail-in debt thus constituting the bulk of the loss-absorbing buffers. This is because, conditional on a large TLAC, private benefit taking is more tempting (and socially costly) at the margin than risk shifting. Intuitively, once the bailout subsidy associated with insured deposits is negligible, residual risk-shifting does not involve large deadweight losses: it has mostly a redistributional impact (from bail-in debt holders to equity holders) which is compensated, in equilibrium, via the pricing of bail-in debt.

Our paper fits in the growing literature that considers loss-absorbing liabilities different from equity in a banking context. Initial discussions centered on policy proposals suggesting the use of contingent convertibles –cocos– (Flannery, 2005) or capital insurance (Kashyap, Rajan, and Stein, 2008) as means to "prepackage" the recapitalization of banks in trouble, reduce the reliance on government bail-outs, and prevent their negative ex ante incentive effects. Albeit the potential role of bail-in debt as a buffer protecting deposits or other senior debt was soon acknowledged (French et al, 2010), most of the academic discussion focused on the going-concern version of contingent convertibles, entertaining issues such as the choice of triggers (McDonald, 2013) and conversion rates (Pennacchi, Vermaelen, and Wolff, 2014), and their influence on the possibility of supporting multiple equilibria (Sundaresan and Wang, 2015) and discouraging risk-shifting (Pennacchi, 2010; Martynova and Perotti, 2014).

Papers in the existing literature typically study the effects of adding an ad hoc amount of a form of TLAC different from equity to some predetermined bank capital structure (typically in substitution for part of the uninsured debt). Our paper differs from the literature in that it looks at bail-in debt and addresses the capital structure and optimal regulation problems altogether, extracting conclusions for both the optimal size and the optimal composition of TLAC requirements of the form envisaged in current regulations. From a conceptual perspective, the most innovative aspect of our contribution is the focus on a dual agency problem that makes the choice between bail-in debt and equity non-trivial. Most existing papers abstract from agency problems between inside and outside equity holders and put all the emphasis on conflicts between equityholders as a whole and debtholders (or the DIA).[4]

The paper is structured as follows. Section 2 describes the model and the capital structure problem solved by the bank. Section 3 parameterizes the model and examines its implications for socially optimal capital and TLAC requirements. Section 4 compares the prescriptions of the baseline model with the regulation on capital and TLAC produced by the Basel Committee and the FSB, and discusses variations of the model that would bring our prescriptions closer to currently proposed regulation. Finally, Section 5 concludes. The Appendix contains additional technical material.

2 The Model

We consider a bank tightly controlled by a group of risk-neutral insiders who, to sharpen the presentation, are assumed to be penniless and yet essential to manage the bank.[5] A bank is a one-period firm that invests in a fixed amount of assets with size normalized to one. The assets originated at a date $t = 0$ yield a random return $\tilde{R}$ at $t = 1$ that depends on the realization of an idiosyncratic continuous bank-performance shock z at $t = 1$, the realization of a dichotomic risk state $i = 0, 1$ at $t = 1$ (where $i = 0$ stands for "safe" and 1 for "risky"), as well as two unobservable choices made by the insiders at $t = 0$: (a) a private benefit taking decision Δ and (b) a risk shifting decision which affects the probability ε of ending up in the risky state.[6]

[4] By construction, their models commonly feature an implicit or explicit dominance of equity over bail-in debt or cocos, unless equity issuance costs or corporate taxes provide an extra advantage to the latter.

[5] As further pointed out below, the analysis could be trivially extended to consider the case in which insiders are endowed with a limited amount of wealth that they can use to finance the bank. All the results qualitatively go through if such wealth is small relative to the total equity financing needed by the bank.

[6] Given that we focus the analysis on a single bank, the risk state i can be thought of as indistinctly driven by idiosyncratic or aggregate factors. In the latter case, ε could be thought of as the exposure of the individual bank to an aggregate risky state rather than directly the probability of such state.

Specifically, bank asset returns are given by:

$$\tilde{R}_i = (1 - \Delta - h(\varepsilon))R_A \exp(\sigma_i z - \sigma_i^2/2), \tag{1}$$

where $z \sim N(0,1)$ and independent of the realization of i. So bank asset returns are, conditional on reaching risk state i at $t = 1$, log-normally distributed with an expected value equal to $(1-\Delta-h(\varepsilon))R_A$, and a variance σ_i that switches depending on the risk state i, with $\sigma_0 < \sigma_1$.[7] R_A is the exogenous expected rate of return on bank assets when $\Delta = h(\varepsilon) = 0$. The function $h(\varepsilon)$, increasing and convex in ε, captures the negative impact of risk shifting on expected asset returns.[8]

Private benefit taking diminishes expected asset returns by a fraction Δ but directly provides a utility $g(\Delta)$ to insiders.[9] Specifically, insiders maximize the expected value at $t = 1$ of a utility function U which is linear in their consumption c and in their private benefits $g(\Delta)$:

$$U = c + g(\Delta), \tag{2}$$

where $g(\cdot)$ is a strictly concave function with $g'(0) = +\infty$ and $g'(\bar{\Delta}) = 0$ at some $\bar{\Delta}$ sufficiently lower than 1, so that insiders' choice of Δ is always contained in the interval $(0, \bar{\Delta})$ and equilibrium solutions satisfy $1 - \Delta - h(\varepsilon) > 0$.

Bank assets are financed with endogenously determined amounts of common equity, ϕ, uninusured bail-in debt χ and insured deposits, $1 - \chi - \phi$, raised from outside investors. Outside investors are also risk-neutral and supply funds elastically at an expected gross rate of return equal to $1/\beta$. Importantly, insured deposits convey a per-unit liquidity convenience yield ψ at $t = 1$, making depositors willing to accept a corresponding reduction in the pecuniary return of their funds.

Insured deposits and bail-in debt promise endogenously determined gross returns of, respectively, R_D and R_B at $t = 1$ per unit of funds invested at $t = 0$, while equity is a

[7] Having log-normal returns conditional on each risk state leads to having close form solutions for the valuation of bank securities similar to those in Black and Scholes (1973) and Merton (1977), while the variation of the risk state produces fat tails in the unconditional distribution of bank asset returns.

[8] This is as in, e.g., Stiglitz and Weiss (1981) and Allen and Gale (2000, ch. 8).

[9] This is as in, e.g., Holmstrom and Tirole (1997).

standard limited-liability claim on the residual cash flow of the bank at $t = 1$. Importantly, we assume that insiders' financial stake at the bank is the (endogenously determined) fraction γ of equity not sold to outside investors.

The bank is insolvent at $t = 1$ if its asset returns $\tilde{R}$ are insufficient to pay $R_D(1 - \chi - \phi)$ to insured depositors. In such case, the deposit insurance agency (DIA) takes over the bank, pays insured deposits in full, and assumes residual losses equal to $R_D(1 - \chi - \phi) - (1 - \mu)\tilde{R}$, where μ is a deadweight asset-repossession (or *bankruptcy*) cost.

Importantly, the bail-in debt is never bailed out and defaulting on it (that is, failing to repay $R_B\chi$ in full) carries no bankruptcy cost.[10] Bail-in debt is junior to insured deposits and, as prescribed in TLAC regulations being currently introduced, experiences a full haircut before the DIA suffers any loss.

The bank is subject to two regulatory constraints: (a) minimum capital requirement which imposes a lower bound $\overline{\phi}$ to the fraction ϕ of initial funding obtained in the form of equity and (b) a minimum total loss-absorbing capacity requirement (TLAC) which states that the bank must issue at least a fraction $\overline{\tau} \geqslant \overline{\phi}$ of loss-bearing liabilities (equity or bail-in debt). Of this, at least a fraction $\overline{\phi}$ must be common equity, while the remaining $\overline{\tau} - \overline{\phi}$ can be indistinctly made up of bail-in debt or common equity.

2.1 The bank's capital structure problem

At date 0, prior to making their unobservable private benefit taking and risk shifting decisions, Δ and ε, insiders establish an overarching contract with the outside investors that fixes the capital structure of the bank as described by ϕ and χ, the fraction of bank equity retained by the insiders γ, the (gross) interest rates promised by bail-in debt R_B and insured deposits R_D and, implicitly, the insiders' subsequent private choices of Δ and ε The corresponding contract problem can be formally described as follows:

$$\max_{\phi,\chi,\gamma,R_B,R_D,\Delta,\varepsilon} \gamma E + g(\Delta) \tag{3}$$

[10] This could be justified by assuming that preventing default on insured deposits allows the bank to either continue as a going concern or to be quickly "purchased and assumed" by another bank, thus preventing any deterioration of residual asset value.

subject to:

$$(1-\gamma)\,E \geq \phi \qquad [PC^E] \tag{4}$$

$$J - E \geq \chi \qquad [PC^B] \tag{5}$$

$$\beta(R_D+\psi) \geq 1 \qquad [PC^D] \tag{6}$$

$$\Delta = \arg\max\nolimits_{\Delta}\left[\gamma E + g\left(\Delta\right)\right] \qquad [IC^B_{\Delta}] \tag{7}$$

$$\varepsilon = \arg\max\nolimits_{\varepsilon}\left[\gamma E + g\left(\Delta\right)\right] \qquad [IC^B_{\varepsilon}] \tag{8}$$

$$\phi \geqslant \overline{\phi} \qquad [CR] \tag{9}$$

$$\phi + \chi \geqslant \overline{\tau} \qquad [TLAC] \tag{10}$$

where J and E are functions specified below. E represents the overall value at $t=0$ the the bank's common equity (that is, the stakes owned by both insiders and outsiders) and J is the joint value of common equity and bail-in debt (so that the value of bail-in debt can be obtained as the difference $J-E$).

Reflecting competition between the outside investors, the contract maximizes the insiders' expected surplus (which equals the expected value of payments associated with their equity stake, γE, plus the private benefits obtained from the control of bank assets, $g\left(\Delta\right)$) subject to a number of constraints that include the participation constraints of the investors who provide the bank with equity financing, (4), bail-in debt financing, (5), and insured deposit financing, (6).[11] The constraints also include (7) and (8) which are the incentive compatibility conditions describing how the insiders decide on Δ and ε, respectively, once the contract is in place. Finally (9) and (10) reflect the existence of a minimum capital requirement $\overline{\phi}$ and a minimum TLAC requirement $\overline{\tau}$.

The fact that, conditional on each risk state at $t=1$, the gross asset returns of the bank, specified in (1), are log-normally distributed makes E and J easily expressible in terms of conventional Black-Scholes type formulas, with:

$$E = \beta \sum_{i=0,1} \varepsilon_i \left[\left(1-\Delta-h\left(\varepsilon\right)\right) R_A F(s_i) - BF\left(s_i-\sigma_i\right)\right], \tag{11}$$

[11] Extending the analysis to the case in whcih insiders can contribute some wealth $w<\phi$ as equity financing to the bank would simply require replacing (4) with $(1-\gamma)\,E \geq \phi - w$.

where $B = R_D(1-\phi-\chi) + R_B\chi$ is the overall contractual repayment obligation on deposits and bail-in debt,

$$s_i = \frac{1}{\sigma_i}\left[\ln(1-\Delta-h(\varepsilon)) + \ln R_A - \ln B + \sigma_i^2/2\right], \tag{12}$$

and $F(\cdot)$ is the cumulative distribution function (CDF) of a $N(0,1)$ random variable. As shown in the Appendix, the threshold s_i is such that $F(s_i - \sigma_i)$ can be interpreted as the probability with which bail-in debt is paid back in full in state i.

Conveniently, the joint value of equity and bail-in debt can be expressed as follows:

$$J = \beta \sum_{i=0,1} \varepsilon_i \left[(1-\Delta-h(\varepsilon)) R_A F(w_i) - R_D(1-\phi-\chi) F(w_i - \sigma_i)\right], \tag{13}$$

where

$$w_i = \frac{1}{\sigma_i}\left[\ln(1-\Delta-h(\varepsilon)) + \ln R_A - \ln R_D - \ln(1-\phi-\chi) + \sigma_i^2/2\right], \tag{14}$$

and $F(w_i - \sigma_i)$ can be interpreted as the probability with which the bank is able to pay back its insured deposits in full in state i.[12] The value of the bail-in debt is therefore equal to $J - E$.

2.2 Deposit insurance costs and the social value of the bank

The presence of the safety net for depositors implies the existence a subsidy on debt financing: the so-called Merton Put identified by Merton (1977):

$$DI = \beta \sum_{i=0,1} \varepsilon_i \left[R_D(1-\phi-\chi)(1-F(w_i-\sigma_i)) - (1-\mu)(1-\Delta-h(\varepsilon)) R_A (1-F(w_i))\right]. \tag{15}$$

Meanwhile, the deadweight losses due to bankruptcy implied by a particular contract can be found as:

$$DWL = \beta\mu \sum_{i=0,1} \varepsilon_i (1-\Delta-h(\varepsilon)) R_A (1-F(w_i)). \tag{16}$$

[12] Clearly the presence of bail-in debt, $R_B\chi$, makes $w_i > s_i$, reflecting that bail-in debt reduces the probability of defaulting on insured deposits.

3 Numerical Results

We specify the private benefits function as follows:

$$g(\Delta) = g_1 \Delta^{g_2} - g_3 \Delta \tag{17}$$

with $g_1 \geq 0$, $0 < g_2 < 1$ and $g_3 \geq g_1 g_2$. This specification makes $g(\Delta)$ concave for $0 < \Delta < 1$, with $g'(0) = \infty$ and $g'(1) \leq 0$, guaranteeing equilibrium choices of Δ lower than 1. Parameter g_1 controls the size of the private benefits while g_2 controls the elasticity of Δ with respect to insiders' equity share γ. Parameter g_3 is introduced for purely technical reasons: setting it sufficiently above $g_1 g_2$ helps to obtain interior solutions with $1 - \Delta - h(\varepsilon) > 0$ without significantly affecting the equilibrium contract.[13]

The sacrifice in expected returns associated with risk shifting is just assumed to be quadratic,

$$h(\varepsilon) = \frac{\zeta}{2}\varepsilon^2, \tag{18}$$

with $\zeta > 0$.

The main purpose of our calibration of the model is to illustrate its key qualitative properties, so we give priority to expositional clarity over maximizing the capacity to match the data closely. Yet we try to focus on a baseline parameterization which is empirically plausible. Table 1 below describes it.

The model is calibrated by assimilating one period to a calendar year. The discount rate β is calibrated at 0.98 giving a risk-free annual interest rate of 2%. We set the liquidity convenience yield ψ equal to 0.0072 in line with the 72 basis points yield reduction that Krishnamurthy and Vissing-Jorgenssen (2012) attribute to the extreme liquidity and safety of US Treasuries. This gives a deposit rate of 1.32%. With $\zeta = 0.44$ the probability of the risky state is 5% which is lower than the frequency of normal recessions. The reference expected gross return on assets R_A is set to 1.0278 implying a potential intermediation margin for banks (conditional on $\Delta = h(\varepsilon) = 0$) of 150 basis points.

[13] It can be show that g_3 has a small effect on the shape of the function $g(\Delta)$ at low values of Δ (which are the economically relevant ones) but a significant effect at large values.

Table 1: Baseline parameter values

Investors' discount factor	β	0.98
Gross return on bank assets (if Δ=ε=0)	R_A	1.0278
Private benefit level parameter	g_1	0.0062
Private benefit elasticity parameter	g_2	0.25
Private benefit extra curvature parameter	g_3	0.025
Cost of risk shifting parameter	ζ	0.44
Deposits' liquidity convenience yield	ψ	0.0072
Deadweight loss from bank default	μ	0.15
Asset risk in the safe state	σ_0	0.034
Asset risk in the risky state	σ_1	0.1075
Capital requirement (CET1)	$\bar{\phi}$	0.04
TLAC requirement (CET1 + other TLAC)	$\overline{\tau}$	0.08

The bankruptcy cost parameter μ is set equal to 0.15 in line with the findings of Bennett and Unal (2014) based on FDIC resolutions in the 1986-2007 period. We set the capital requirement $\bar{\phi}$ equal to 0.04 in line with the requirement of Tier 1 capital under Basel II (assuming a reference risk weight of 100%). As for the TLAC requirement $\overline{\tau}$, we set it equal to 0.08 in line with the Tier 1 plus Tier 2 capital requirement in Basel II, as the type of liabilities other than common equity that were allowed to compute as Tier 2 capital (preferred stock and subordinated debt) had loss-absorbing capacity similar to that currently foreseen for bail-in debt.

We calibrate banks' asset return volatilities in safe and risky states (σ_0 and σ_1) as well as the key private benefit parameters (g_1 and g_2) and cost of risk shifting parameter (ζ) in order to be broadly consistent with recent and international evidence on bank defaults in "normal times" (P^0), bank defaults in crises or "risky times" (P^1), the share of bank equity owned by insiders (γ) and the deadweight losses from bank default. Parameter g_3 is set to a small positive value in order to rule out corner solutions but otherwise does not play an important part in the analysis.

Table 2 below summarizes the solution of the bank's capital structure problem under the baseline parameters. The probability of bank default in the model is small in normal times (0.25%) and substantial in risky times (20%). Risky times occur with a probability of 5%. Laeven and Valencia (2010) analyze bank failures during the last financial crisis and find a wide range of estimates depending on the precise definition of bank failure in the US. Actual bankruptcies occurred in banks holding less than 4% of total bank deposits. However, assimilating bank failure to having been beneficiary of a broad definition of state support, one can reach a figure as high as 20%. For other countries, bank failures were more widespread, reaching 90% in Iceland and Ireland. Our number of 20% for risky times is therefore not far-fetched.

Under the baseline calibration, the equity retained by bank insiders (γ) represents just under one fifth of the total. It is not straightforward to compute the data counterpart to this variable. Direct management ownership (including ownership by close family) provides perhaps the narrowest definition. Based on US banks for the 1990-95 period, Berger and Bonaccorsi (2006) report a number of 9.3% of total equity. However, insiders can be more broadly defined to also include those shareholders who, without being managers, can effectively hold management to account, e.g. institutional shareholders and other large shareholders. On this broad definition, Berger and Bonaccorsi (2006) report a share of inside equity of 17.2% of total equity for US banks. Caprio, Laeven and Levine (2007) use a sample of 244 banks from 44 countries and report average cash flow rights for banks' ultimate controlling owners of 26%. The value of γ implied by our baseline parameterization (23.9%) is consistent with this evidence.

Under our parameterization, the unconditional expected deadweight losses due to bank default, DWL, represent about 0.16% of total bank assets, which is broadly consistent with the estimates in Laeven and Valencia (2010). The unconditional expected value of the deposit insurance subsidy, DI, is of around 0.22% of total bank assets and realizes mostly in risky times where it represents about 3.4% of bank assets. This is slightly higher than Laeven and Valencia's 2.1% median estimate of deposit insurance costs during crises for advanced economies but substantially below the median for all economies (12.7% of bank assets). Finally, it is worth noting that most of the losses suffered by the DIA, DI, are accounted for by the deadweight losses measured by DWL, and hence due to having $\mu > 0$.

Table 2: Baseline results (all variables in per cent)

Common equity as % of assets	ϕ	4.00
Bail-in debt as % of assets	χ	4.00
Insider equity as % of total equity	γ	23.9
Fraction of loan returns lost due to PB taking	Δ	0.12
Probability of the risky state realizing	ε	0.05
Bank default probability in the safe state	P^0	0.25
Bank default probability in the risky state	P^1	20.0
Deposit insurance subsidy as % of assets	DI	0.22
Deadweight default losses as % of assets	DWL	0.16
Private value of the bank as % of assets	U	1.37
Social value of the bank as % of assets	U–DI	1.15

The baseline calibration implies that the reduction in asset returns due to private benefit taking (Δ) and risk shifting ($h(\varepsilon)$) amount to around 0.12% and 0.055% of total bank assets, respectively. Insiders' overall payoff U (including private benefits) amounts to 1.37% of bank assets. Finally, the net social surplus generated by the bank, which can be measured as $U - DI$, equals 1.15% of bank assets.

3.1 The two one-distortion cases

Our model is rich and for didactic purposes we find it convenient to begin by first analyzing simpler special cases in which only one of the agency problems is present. These special cases illustrate clearly how each of the two distortions in the model works. After understanding the working of each of these constituent parts, we study the socially optimal capital and TLAC requirements when both distortions are present.

3.1.1 The risk-shifting model

In the first special case, we shut down the moral hazard problem associated with private benefit taking: we assume that the choice of Δ is fully contractible, while the choice of asset riskiness ε remains unobservable. In Table 3 below we show how the solution to the bank's capital structure problem changes depending on the level of the capital and TLAC requirements, $\bar{\phi}$ and $\bar{\tau}$. As a reference, the first row of the table reports the results under the baseline regime with $\bar{\phi} = 0.04$ and $\overline{\tau} = 0.08$. In the last row of the table we present the capital and bail-in debt requirements that maximize social welfare.

Table 3: Comparative statics of the risk shifting model (variables in per cent)

	ϕ	χ	γ	Δ	ε	P^0	P^1	DI	DWL	U	U–DI
Baseline regime*	8.00	0.00	14.6	0.02	0.023	0.22	19.7	0.11	0.09	1.44	1.33
$\bar{\phi}$=$\overline{\tau}$=0	0.00	0.00	100	0.06	0.097	32.89	46.4	5.94	4.78	2.89	-3.05
$\bar{\phi}$=$\overline{\tau}$=0.08	8.00	0.00	14.6	0.02	0.023	0.22	19.7	0.11	0.09	1.44	1.33
$\bar{\phi}$=0,$\overline{\tau}$=0.08	8.00	0.00	14.6	0.02	0.023	0.22	19.7	0.11	0.09	1.44	1.33
$\bar{\phi}$=0,$\overline{\tau}$=0.12	12.00	0.00	9.98	0.02	0.010	0.00	10.3	0.02	0.01	1.40	1.38
Optimal regime**	12.00	0.00	9.98	0.02	0.010	0.00	10.3	0.02	0.01	1.40	1.38

* In the baseline regime $(\bar{\phi}, \overline{\tau}) = (0.04, 0.08)$. ** In the optimal regime $(\bar{\phi}, \overline{\tau}) = (0.12, 0)$

The model with only risk shifting distortions works quite differently from the full model when subject to the baseline regulatory regime (the first row of the table). Private benefit taking is lower and, as a result, default probabilities are lower and social welfare is higher than in the full model. Interestingly, when the only agency problem is risk shifting, the bank voluntarily holds the entire TLAC buffer $\overline{\tau}$ in the form of common equity ($\phi = \overline{\tau} = 0.08$). This is because equity is superior in dealing with risk shifting since insiders' incentives to take excessive risk grow with leverage and bail-in debt counts, to this effect, as a form of leverage. Bank owners could cover as much as 50% of the TLAC requirements with bail-in debt but choose not to do so.

The second row displays the very bad outcomes obtained in the absence of capital and TLAC requirements. Given the presence of insured deposit liabilities whose pricing is independent of the bank's capital structure, the bank opts for maximum leverage. It decides to issue only deposit liabilities and to hold no buffers either in the form of equity or bail-in debt. Its risk taking increases very sharply (ε quadruples relative to the baseline regime) and the default probability jumps dramatically in both states. Due to the deposit insurance subsidy, the private value of the bank increases while its social value declines to a large negative level.

Further down in the table, we examine the way social welfare is affected by higher capital and TLAC requirements. Increasing $\bar{\phi}$ (and $\overline{\tau}$) to 8% (third row of the table) or just increasing

$\overline{\tau}$ to 0.08 (with $\bar{\phi} = 0$) deliver outcomes identical to those under the baseline regime, since in all three cases the bank voluntarily satisfies both requirements exclusively with equity.

The penultimate row then shows that when the TLAC requirement is increased to 12% (with $\bar{\phi} = 0$), it gets again met with equity. Risk taking declines sharply (ε goes down to 0.01) and so does the probability of bank failure which falls to virtually zero in the safe state and to 10.3% in the risky state. In the last row of Table 3 we see that, in fact, the optimal regulatory regime in this version of the model involves $\overline{\tau}$=0.12 (and any $\bar{\phi} \leq \overline{\tau}$).

3.1.2 The private benefits model

Another special case of our model occurs when the private benefit taking decision Δ is unobservable but risk taking is fixed at an arbitrary exogenous value, for instance $\varepsilon = 0.05$, as in the baseline calibration of the full model. Table 4 shows the outcomes obtained as we vary the regulatory requirements in this special case.

Table 4: Comparative statics of the private benefits model (variables in per cent)

	ϕ	χ	γ	Δ	ε	P^0	P^1	DI	DWL	U	U–DI
Baseline regime*	4.00	4.00	24.8	0.11	0.050	0.24	19.9	0.21	0.16	1.43	1.21
$\bar{\phi}$=$\overline{\tau}$=0	0.00	0.00	100	0.03	0.050	34.7	47.0	6.03	4.98	2.39	-3.64
$\bar{\phi}$=$\overline{\tau}$=0.08	8.00	0.00	13.2	0.21	0.050	0.26	20.2	0.22	0.16	1.34	1.12
$\bar{\phi}$=0,$\overline{\tau}$=0.08	0.00	8.00	100	0.05	0.050	0.22	19.8	0.21	0.15	1.47	1.26
$\bar{\phi}$=0,$\overline{\tau}$=0.12	0.00	12.0	100	0.05	0.050	0.00	10.3	0.09	0.06	1.41	1.32
Optimal regime**	0.00	15.5	100	0.05	0.050	0.00	5.04	0.04	0.03	1.37	1.33

* In the baseline regime $(\bar{\phi}, \overline{\tau}) = (0.04, 0.08)$. ** In the optimal regime $(\bar{\phi}, \overline{\tau}) = (0, 0.155)$.

Since ε is now fixed at its baseline value of 0.05, the baseline regime of this private-benefits-only version of the model (first row of Table 4) yields outcomes very similar to those of the full baseline model (Table 2). In the case without capital or TLAC requirements (the second row), we again see that the bank chooses to hold no buffers of any kind. Since insiders now own all the equity of the bank, private benefit taking declines substantially. Yet the absence of any loss-absorbing buffers makes the bank extremely likely to fail, boosting the incidence of deadweight default costs and turning the social value of the bank equal to a large negative value.

With the introduction of capital requirements only ($\bar{\phi}$=$\overline{\tau}$=0.08), the bank is pushed to place equity among outsiders, γ declines and, as a result, private benefit taking increases substantially ($\Delta = 0.21$) relative to both the laissez faire regime and the baseline regime. Intuitively, having less skin in the game leads insiders to extract a higher level of private benefits. This has a negative effect on efficiency, leading the private and social values of the bank to become slightly lower than in the baseline regime (where the bank is allowed to cover half of its 8% TLAC requirement with bail-in debt). As losses from private benefit taking eat into asset returns, the probability of bank default increases in both states. The conclusion is that, if private benefit taking is the only or key agency distortion, outside equity is a poor way to ensure bank resilience. With less skin in the game, bank insiders run the bank further away from the socially optimum.

Rows 4 and 5 explore regimes that only rely on the TLAC requirement ($\overline{\tau} > 0$ with $\bar{\phi} = 0$). We observe that, if banks can decide how to satisfy such requirement, they choose bail-in debt rather than outside equity. This is an instance of the good incentive properties of outside debt financing shown by Innes (1990). In these two rows, Δ remains very low (less that 25% of its value under $\bar{\phi}$=$\overline{\tau}$=0.08). The private and social values of the bank improve relative to those in the third row. When private benefit taking is important, bail-in debt is strongly privately and socially preferred to outside equity.

In the final row of the table, we show the optimal regulatory regime for this special case. It turns out that the TLAC requirement should be set equal to around 15.5% of assets (with the capital requirement equal to zero). As already discussed above, this requirement is met by the bank entirely with bail-in debt.

3.2 Optimal capital and TLAC requirements in the full model

We started by exploring the two agency problems in the model (private benefits and risk shifting) in versions of our framework with only one of them. From these exercises we learned that bail-in debt provides better incentives than equity against private benefit taking while equity is superior to bail-in debt in dealing with risk shifting. In this section we examine the implications of the full model for optimal capital and TLAC requirements.

Table 5: Comparative statics of the full model (variables in per cent)

	ϕ	χ	γ	Δ	ε	P^0	P^1	DI	DWL	U	U–DI
Baseline regime*	4.00	4.00	23.9	0.12	0.050	0.25	20.0	0.22	0.16	1.37	1.15
$\bar{\phi}$=$\bar{\tau}$=0	0.00	0.00	100	0.03	0.102	37.2	47.8	6.68	5.39	2.39	-4.28
$\bar{\phi}$=0.08, $\bar{\tau}$=0.08	8.00	0.00	12.7	0.22	0.024	0.27	20.2	0.13	0.10	1.30	1.17
$\bar{\phi}$=0.12, $\bar{\tau}$=0.12	12.0	0.00	7.36	0.39	0.011	0.00	10.9	0.02	0.01	1.10	1.08
$\bar{\phi}$=0.0, $\bar{\tau}$=0.08	3.56	4.44	26.2	0.10	0.055	0.25	20.0	0.23	0.17	1.37	1.14
$\bar{\phi}$=0.0, $\bar{\tau}$=0.12	4.05	7.94	22.7	0.12	0.050	0.00	10.5	0.09	0.06	1.30	1.21
Optimal regime**	5.10	8.32	18.5	0.15	0.041	0.00	8.04	0.05	0.04	1.28	1.22

* In the baseline regime $(\bar{\phi}, \bar{\tau}) = (0.04, 0.08)$. ** In the optimal regime $(\bar{\phi}, \bar{\tau}) = (0.051, 0.134)$

We begin in Table 5 with an analysis of different capital and TLAC requirements. Several things become immediately clear. First, setting a very high capital requirement is not the best solution. In the $\bar{\phi}$=0.12 case, both the private (U) and the social ($U - DI$) value of the bank are lower than in the baseline regulatory regime. Second, looking at the last row of the table, we can see that the optimal regulatory regime involves differentiated capital and TLAC requirements, inducing the mix of a significant but relatively low portion of equity financing (5.1% of bank assets) with a moderate portion of bail-in debt financing (13.4% of bank assets). Under the optimal regime, risk taking remains significant ($\varepsilon = 0.041$) and the risk of bank failure in the risky state remains non-negligible (8%). However, trying to further reduce the level of risk shifting ε by means of imposing a larger $\bar{\phi}$ would imply losses via an increase in private benefit taking Δ (as in the forth row of Table 5).

The optimality of combining a capital requirement with a larger TLAC requirement (so as to eventually induce the combined use of equity and bail-in debt) reflects the interaction of two important trade-offs. First, the trade-off between the two agency problems (private benefit taking and risk shifting), which drives the optimal composition of the buffers against bank default. Secondly, the trade-off between the deadweight costs of bank default and the liquidity benefits of insured deposits, which drives the optimal overall size of those buffers.

Relative to the baseline regulatory regime, our calibration implies significantly larger overall buffers (13.4% vs. 8%) and prescribes that most of the increase should consist of bail-in debt. This surprising result reflects the fact that, once the likelihood of defaulting on insured deposits is sufficiently low (thanks to the large buffers), the risk shifting problem (against which equity is the most effective tool) becomes a lesser evil than private benefit taking (against which bail-in debt works better). Bail-in debt holders get compensated from their non-negligible risk of experiencing haircuts in the risky state through the endogenous high yields paid by their debt.

The unconditional probability of bank default under the optimal regime (0.32%) is significantly lower than in the baseline regime (1.24%). However, it is not driven all the way down to zero because insured deposits generate liquidity benefits and therefore it is costly to replace them with other liabilities.

Importantly, the optimal regulatory regime involves a minimum capital requirement as well as a minimum TLAC requirement, instead of just the latter. In Table 6 we study the implications of removing the minimum capital requirement (that is, making $\bar{\phi}$=0 while keeping $\overline{\tau}$=0.134). Interestingly, banks would voluntarily raise some of their TLAC in the form of equity, but they would choose $\phi = 0.042$ rather than the socially optimal $\phi = 0.051$. The chosen value of ϕ reflects that banks internalize the impact of equity funding on risk shifting incentives and, through it, on the pricing of bail-in debt. Yet such value is lower than the socially optimal one because the losses caused to the DIA are not internalized. Anyhow, as shown in the last column of the table, the size of the DI subsidy with TLAC of 13.4% is quite small and the losses from the sub-optimal choice of ϕ are also very small.

Table 6: Capital requirements are needed at the optimum

	ϕ	χ	γ	Δ	ε	P^0	P^1	DI	DWL	U	$U{-}DI$
Optimal regime*	5.10	8.32	18.5	0.15	0.041	0.00	8.04	0.05	0.04	1.28	1.22
$\bar{\phi}$=0.0, $\overline{\tau}$=0.134	4.15	9.25	22.0	0.13	0.049	0.00	8.06	0.07	0.05	1.28	1.22

* In the optimal regime $(\bar{\phi}, \overline{\tau}) = (0.051, 0.134)$.

Finally it is worth noting that the social value of the bank in the socially optimal regime of Table 5 is considerably lower than its counterparts in either of the two one-distortion cases (tables 3 and 4). The combination of the two agency problems produces trade-offs between addressing each of them, keeping the corresponding second best allocation further distant from the first best.

3.2.1 Marginal effects of capital and TLAC requirements around the optimum

The top left panel of Figure 1 shows our measure of social welfare —the social value of the bank, $U - DI$— for different levels of the TLAC requirement (with the capital requirement fixed at its value of 5.3% under the optimal regime). Social welfare is expressed in percentage points of bank assets.

We can see that social welfare deteriorates significantly when the TLAC requirement $\overline{\tau}$ falls below 10%. The fall in welfare when $\overline{\tau}$ increases above its socially optimal value happens relatively slowly. At that stage, the only loss comes from missing additional liquidity value from insured deposit, which is a relatively small loss under the calibrated value of the liquidity convenience yield (72bps).

Other panels in Figure 1 show how key variables from the bank's optimal capital structure problem change as a function of the TLAC requirement $\overline{\tau}$. The most important effect of increasing $\overline{\tau}$ is to reduce the unconditional probability of defaulting on insured deposits, P_D, due entirely to the mechanical protection provided by the loss-absorbing buffers. Forcing the bank to use expensive bail-in debt instead of cheaper deposits damages its profitability and, with it, the incentives of the insiders. As a result, the two underlying agency problems worsen as $\overline{\tau}$ increases, although quantitatively these effects are very small.

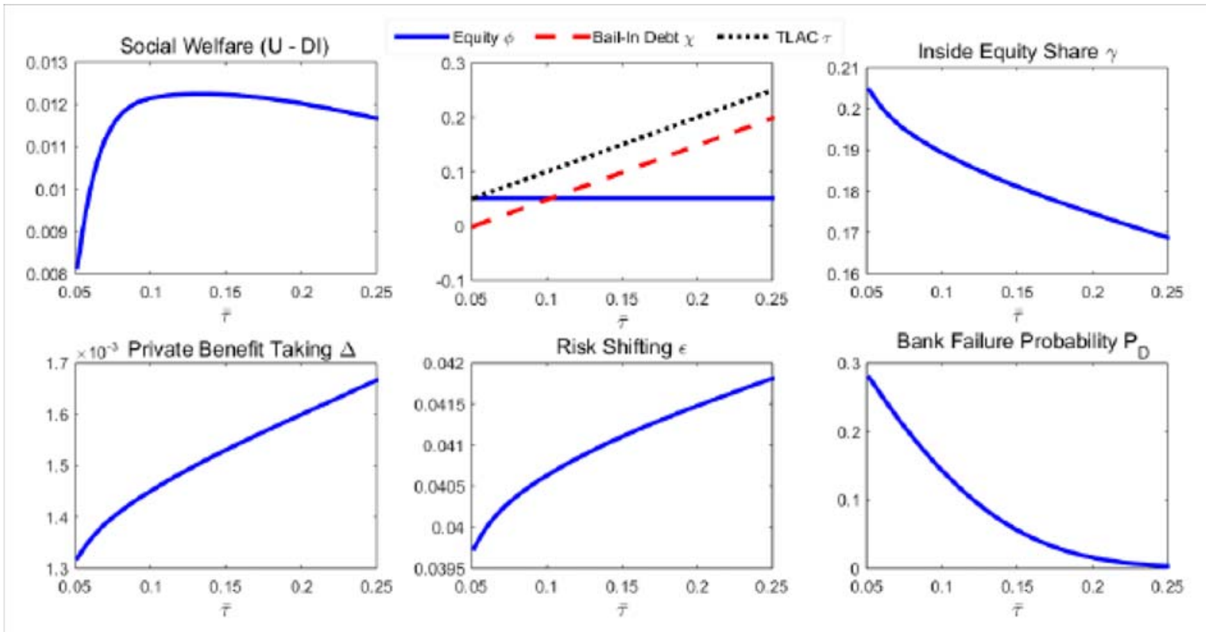

Figure 1: Equilibrium outcomes as a function of the TLAC requirement $\bar{\tau}$

Figure 2 describes the effects of varying the capital requirement $\bar{\phi}$ while keeping the TLAC requirement at its optimal value of 13.4%. The top left panel shows the welfare implications of moving $\bar{\phi}$ between 0% and 10%. As anticipated in prior discussions, these implications are very small because with an overall TLAC of 13.4% the exact composition of the loss-absorbing buffers is of secondary importance. The flat section of the curve at low values of $\bar{\phi}$ reflects that the regulatory minimum becomes not binding once it becomes lower than 4.15%, as banks try to control the implications of risk shifting for the pricing of their bail-in debt.

As shown in some of the other panels of Figure 2, above that point, rising $\bar{\phi}$ would further reduce risk shifting but at the cost of increasing private benefit taking (which comes from insiders' reaction to the reduction of their share in total equity). Quite interestingly, the deterioration of incentives (together with keeping constant the overall size of the loss-absorbing buffers) implies that rising $\bar{\phi}$ actually increases (albeit quite tinily) the probability of defaulting on deposits.

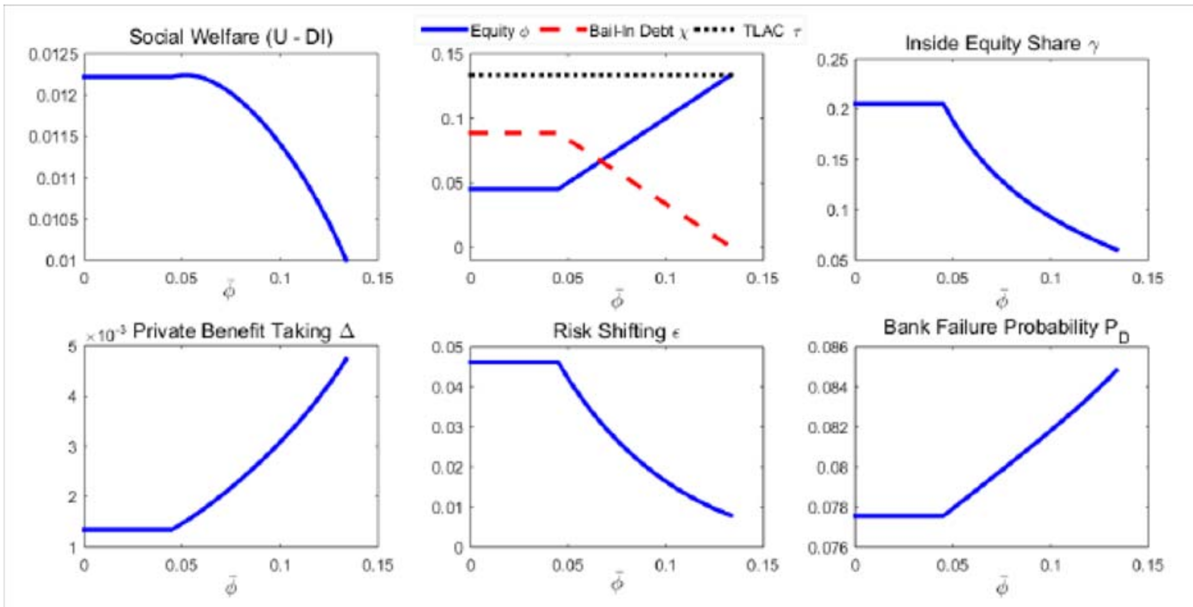

Figure 2: Equilibrium outcomes as a function of the capital requirement $\bar{\phi}$

3.2.2 Sensitivity of the optimal regulatory ratios to parameter values

The precise optimal capital and TLAC requirements under the baseline calibration are of course less interesting than the way they depend on the parameters of the model. In this section we examine how $\overline{\phi}^*$, $\overline{\tau}^*$, and the equilibrium outcomes associated with them change in response to variations in parameters ζ , σ, g_1, μ and ψ.

Sensitivity to the asset return cost of risk shifting (ζ) Figure 3 below shows the socially optimal arrangement and its associated equilibrium outcomes change as ζ increases from 0.2 to 0.7. Importantly, other things equal, a larger ζ implies that insiders' temptation to shift risk becomes lower. Conversely, when ζ is low, increasing the exposure of the bank to the realization of the risky state does not imply a large loss in terms of expected asset returns so insiders' temptation to shift risk is large. However, a larger exposure to the risky state always implies a large cost for society via the deadweight cost of bank default, which is an important part of DI. The optimal regulatory response is then to make the capital requirement $\overline{\phi}$ (and the overall TLAC requirement $\overline{\tau}$) a decreasing function of ζ. Consistent with insights already obtained in prior subsections, when the risk shifting problem is more severe (low ζ) loss-absorbing buffers increase and their composition gets tilted towards equity.

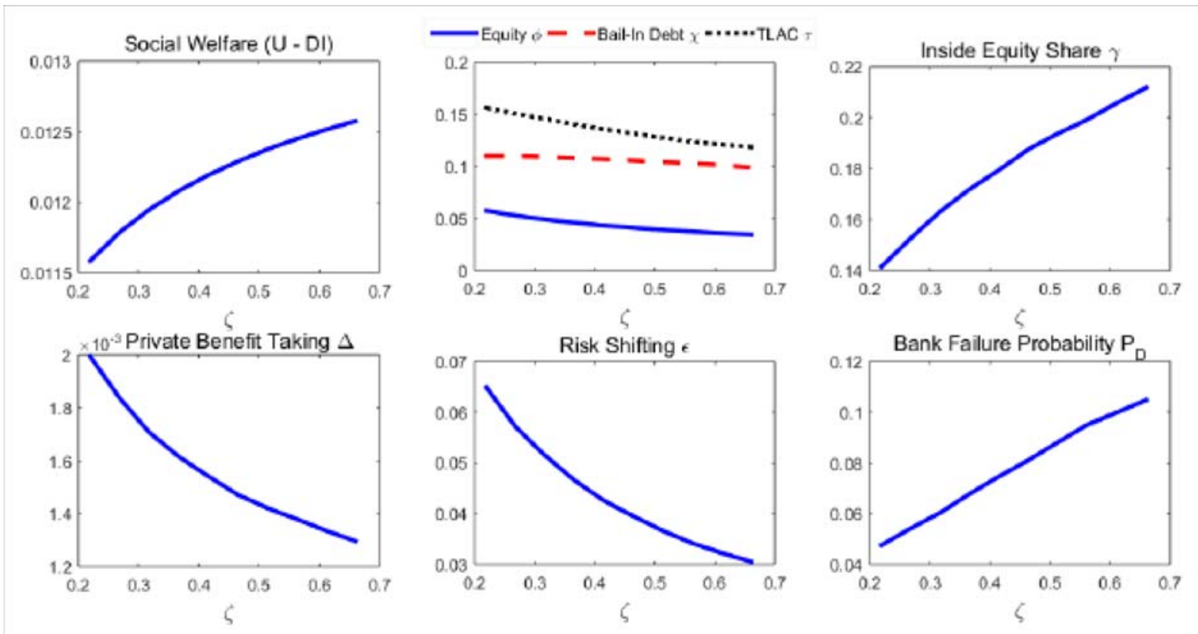

Figure 3: Sensitivity of the optimal regulatory ratios and related outcomes to ζ

As shown in Figure 3, as ζ increases, the trade-off between providing insiders with incentives not to shift risk and not to take private benefits improves. As a larger ζ per se already reduces risk shifting, the reduction in the capital requirement allows insiders to retain a larger share of equity, which in turn leads to a reduction in private benefit taking. Welfare increases but, somewhat paradoxically, the unconditional probability of bank failure P_D increases (reflecting the optimal resolution of the trade-off between the lower costs and maintained benefits of deposit financing).

Sensitivity to the volatility of asset returns (σ_0 and σ_1) Figure 4 below shows how the optimal regulatory ratios and the implied equilibrium outcomes respond to changes in the variance of asset returns. Because such variance is different across risk states, Figure 4 explores the case in which the baseline values of σ_0 and σ_1 get multiplied by a same factor

σ, which is depicted on the horizontal axes. So with $\sigma = 1$ we have the baseline where the optimal capital requirement is around 5% and the overall TLAC ratio is 13.4%. With $\sigma = 0.5$ (the leftmost part of the graph), we have $\sigma_0 = 0.017$ and $\sigma_1 = 0.054$, the optimal capital requirement falls to just over 1%, and the TLAC requirement to 6%. With $\sigma = 1.5$ (the rightmost part of the graph), we have $\sigma_0 = 0.051$ and $\sigma_1 = 0.162$, the optimal capital requirement rises to around 7%, and the TLAC requirement to 17%.

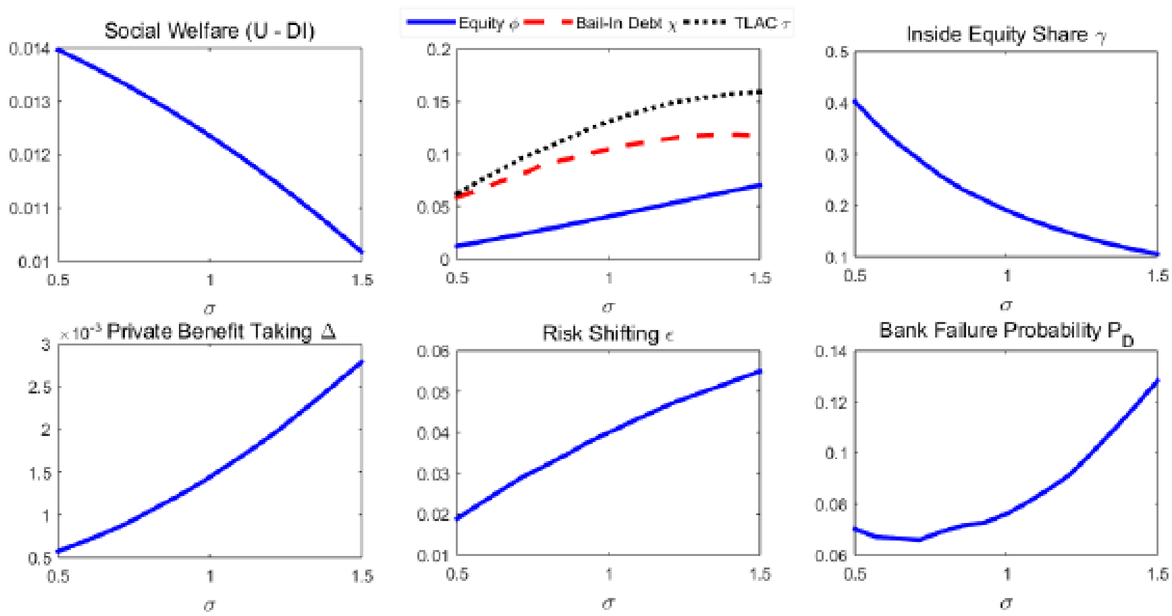

Figure 4: Sensitivity of the optimal regulatory ratios and related outcomes to σ_i

Increasing the variance of asset returns increases the degree of exogenous uncertainty faced by the bank and, other things equal, increases its probability of default. This increases the incidence of the deadweight default costs suffered by the DIA. It is then optimal to impose higher TLAC buffers on banks. In parallel, the greater exogenous uncertainty makes insiders' temptation to shift risk stronger, calling for a larger component of equity in TLAC. However, increasing the capital requirement reduces insiders' share in total equity and pushes them into greater private benefit taking. All in all, even after optimally adjusting the regulatory ratios, welfare decreases and the unconditional probability of bank failure increases.

Sensitivity to the intensity of the 'private benefit taking' problem (g_1) Figure 5 below shows the implications of changing the parameter g_1 which measures the size of the private gains that insiders may get by diverting resources from the bank (i.e. by increasing Δ). The social planner responds to the worsening of this agency problem by reducing the reliance on capital as a loss-absorbing buffer. This allows insiders' equity share to increase, partly but not fully offsetting their temptation to choose larger values of Δ. The side effect of lowering the capital requirement $\overline{\phi}$ is that risk shifting also increases.

To counteract the combined effect of worsened private benefit and risk shifting incentives on the probability of bank default and its associated social costs, the overall TLAC requirement $\overline{\tau}$ is also increased. Eventually, both social welfare and the unconditional probability of bank failure decline with g_1.

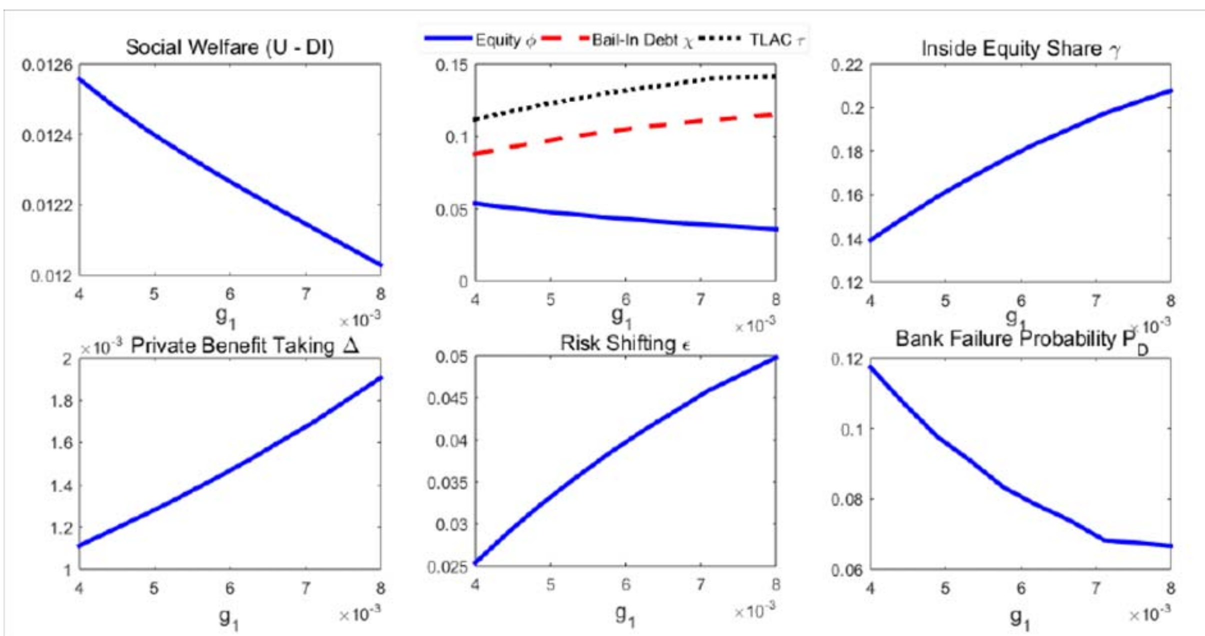

Figure 5: Sensitivity of the optimal regulatory ratios and related outcomes to g_1

Sensitivity to the deadweight costs of bank default (μ) Figure 6 shows the impact of varying the deadweight costs of defaulting on insured deposits μ. As might be expected, the optimal TLAC requirement $\overline{\tau}$ is increasing in μ, while somewhat more surprisingly, the optimal capital requirement is barely sensitive to μ, therefore implying a larger and larger reliance on bail-in debt as μ increases. Intuitively, the greater deadweight costs of default forces the optimal contract to sacrifice some liquidity provision in order to make the bank safer. As a result, the bank's overall profitability declines, obliging insiders to give a larger fraction of equity returns to outside equity holders and worsening the private benefit taking problem. The social planner counteracts this problem by making the additional buffers to consist mainly on bail-in debt even if, beyond some point, this makes risk shifting to slightly deteriorate as well.

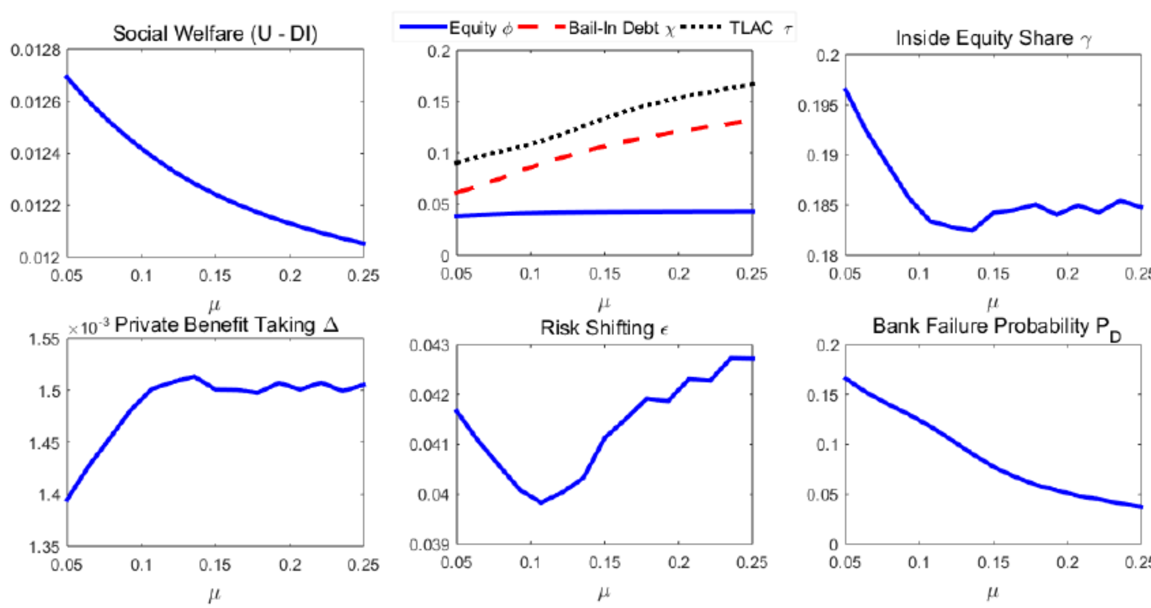

Figure 6: Sensitivity of the optimal regulatory ratios and related outcomes to μ

Sensitivity to the liquidity convenience yield of insured deposits (ψ) Finally, we consider the effects of changing the liquidity convenience yield of insured deposits ψ. The most direct effects of this parameter are to increase bank profitability and the social opportunity cost of increasing the TLAC requirement $\overline{\tau}$. Other things equal, the rise in profitability has a positive impact on the two underlying incentive problems. Similarly, other things equal, the change make the social planner more willing to reduce $\overline{\tau}$ and tolerate a rise in the probability of bank default. But in fact both effects reinforce each other, as the decline in $\overline{\tau}$ has additional positive effects on profitability and incentives, which in turn reduces the need for large regulatory buffers. All in all, rising ψ increases welfare but also (in a few basis points) the unconditional probability of bank default under the optimal regulatory ratios.

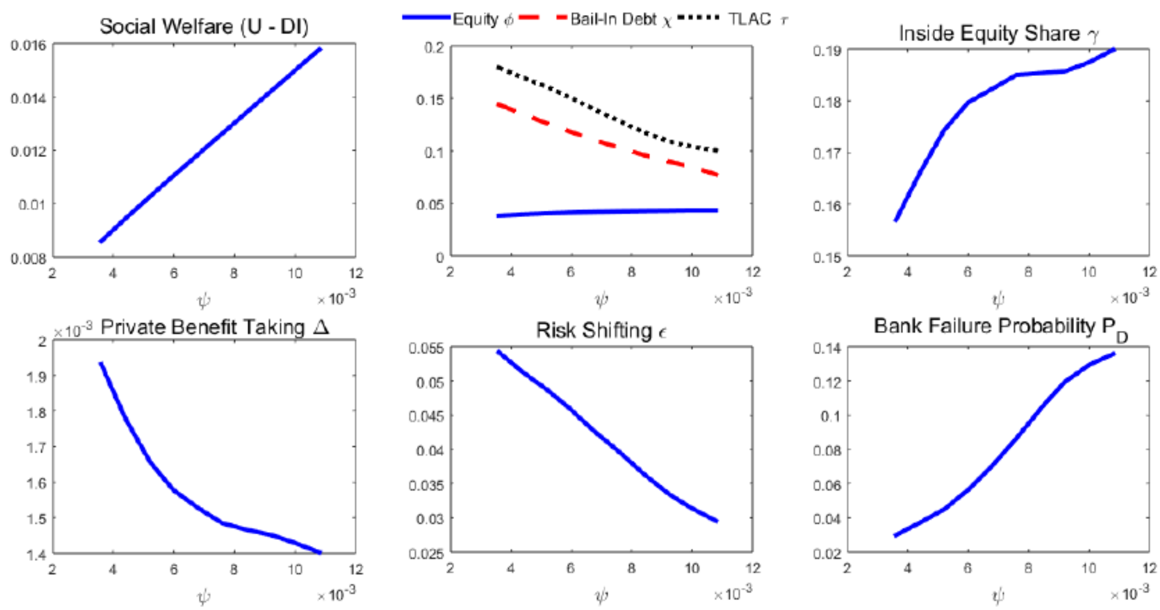

Figure 7: Sensitivity of the optimal regulatory ratios and related outcomes to ψ

4 Comparison with Basel III

The latest capital and TLAC proposals emanated from the Basel Committee and the FSB establish that TLAC eligible liabilities should represent first 16% and eventually 18% of RWA, with common equity representing at least 8.5% of RWA. How do the prescriptions of our baseline calibration compare with these ones? One difficulty for the comparison stems from the fact the Basel requirements are expressed as a percentage of RWA, while in our model the bank invests a single assets class and, implicitly, we describe our requirements $\overline{\phi}$ and $\overline{\tau}$ as if such asset carried a 100% risk weight. Therefore while under our baseline calibration the optimal $\overline{\tau}$ is 13.4% its comparison with, say, the 18% requirement of Basel

III would require knowing the average risk weight that our calibrated bank faces in practice. For a risk weight of 74.4% (which is arguably a large one for a typical bank portfolio) both requirements would be equivalent.

At a more qualitative level, the main difference between our prescriptions and those of forthcoming Basel regulations refers to the proportion of TLAC represented by common equity. In our results the optimal $\overline{\phi}$ is slightly more than one third of the optimal $\overline{\tau}$, while in Basel III $\overline{\phi}$ is slightly less than half of $\overline{\tau}$. In the rest of this section we explore ingredients whose addition to our model might help reconcile its prescriptions with those of Basel III.

Table 7: Optimal policy under extended parameterizations (variables in per cent)

	ϕ	χ	γ	Δ	ε	P^0	P^1	DI^*	DWL	U	U–DI
μ^S=μ^T=0	5.10	8.32	18.5	0.15	0.041	0.00	8.04	0.05	0.04	1.28	1.22
μ^S=0.3, μ^T=0	4.80	14.8	18.6	0.15	0.044	0.00	1.84	0.03	0.01	1.22	1.19
μ^S=0, μ^T=0.075	8.80	1.30	10.8	0.26	0.021	0.03	14.8	0.06	0.07	1.20	1.14
μ^S=0.3, μ^T=0.075	8.80	6.20	10.2	0.28	0.021	0.03	5.89	0.05	0.05	1.14	1.09

* DI now also includes the social cost of bank failure, if present.

The first ingredient that we explore in Table 7 is a social cost of bank failure equal to a proportion μ^S of the gross return of the assets of the failed bank. This cost applies above and beyond the also proportional cost μ incurred by the DIA when resolving the defaulting bank and is intended to capture externalities associated with bank failure. As shown in the second row of the table, with $\mu^S = 0.3$ the optimal TLAC ratio rises to 19.6% (even above the benchmark TLAC requirements proposed by the FSB), which has the main effect of sharply reducing the probability of bank default in the risky state.

Interestingly, under this variation the model prescribes an even lower capital requirement than before (4.8%). This happens for two reasons. First, substituting cheaper deposits for more expensive bail-in debt reduces profits and makes insiders more inclined towards private benefit taking. In parallel, the low probability of default makes the underlying deposit insurance subsidy very small, counteracting insiders' larger incentives to shift risk.[14] As a

[14]Column DI in Table 7 now adds the external social cost of bank failure to the deposit insurance cost. Under the optimal regulatory ratios, the actual deposit insurance cost falls to around 0.01% of assets.

result, the optimal capital requirement falls, making equity represent an even lower share of TLAC than in the baseline model.

In the penultimate row of Table 7, we consider another ingredient: a cost associated with the write-off of on bail-in debt.[15] We model this cost as a proportion μ^T of gross asset returns for realizations of asset returns that impede paying back bail-in debt in full but are still sufficient to pay insured deposits in full. When we set $\mu^T = 0.075$, just half as large as μ, the obtain a socially optimal capital requirement of 8.8%, quite in line with the 8.5% of Basel III. However, under this formulation, the optimal amount of bail-in debt falls quite dramatically, to only 1.3% of assets, reflecting the vanishing of its capacity to effectively save on deadweight default costs. The larger reliance on equity comes at the cost of lowering insiders' equity stake and pushing them into larger private benefit taking.

In the final row of Table 7, we put together the two new ingredients, which gets us really close to the capital and TLAC requirements of Basel III. The optimal TLAC ratio becomes 15% –close to the Basel III 16% requirement for 2019– while the optimal capital ratio goes to 8.8%.

5 Conclusions

The increase in capital requirements and the revision of regulation regarding non-equity liabilities such as bail-in debt that may provide banks with total loss-absorbing capacity (TLAC) are two important aspects of the deep reform of bank solvency regulation undertaken in the aftermath of the global financial crisis. Yet surprisingly little research has been done on the optimal size and composition of TLAC.

In this paper we build a banking model in the spirit of Merton (1977) and insert in it a number of frictions, starting with two relevant agency problems, ending up with a framework which we think is useful for the analysis of banks' capital structure and its optimal regulation. Our banks have the possibility to issue deposits that are cheap due to the presence of deposit

[15] This cost might represent legal tangles and delays due to bail-in debtholders' resistance to accept a haircut on their promised repayments.

insurance as well as to the fact that they provide a liquidity convenience yield to their holders. However, defaulting on these deposits produces large social deadweight costs. Hence, this model assigns an important role to liabilities with loss-absorbing capability (such as common equity, bail-in debt and other possible components of TLAC which can be written-down without producing large default costs), even if these liabilities are inferior to deposits in terms of liquidity provision.

In our model, even if equity and bail-in debt are perfect substitutes in their role as a protection against deadweight losses from bank default, they greatly differ in their incentive role. Our bank insiders have control on two unobservable decisions that they adopt based on self-serving motives but have implications for other stakeholders and the society as large. One decision concerns risk shifting (exposing the bank to riskier but lower on average asset returns) and private benefit taking (extracting utility from the bank in the detriment of its asset returns).

These two agency problems bring in the key trade-off driving the optimal composition of banks' TLAC. Incentivizing banks to restrain their risk shifting requires that the loss-absorbing buffer is mainly made up of equity, since intuitively bail-in debt counts like debt in terms of inviting equity holders to gamble. However, following the analysis of Innes (1990), forcing banks to issue large amounts of outside equity has the disadvantage of reducing insiders' equity share, which pushes them into excessive private benefit taking. The optimal composition of TLAC is determined by trading off these two competing agency problems. Under our calibration of the model, the optimal regulatory regime features a large but limited TLAC requirement (13.4% of assets) and a significant but not sizeable capital requirement (5.1%), therefore assigning a very significant role to bail-in debt (8.3%).

The intuition for the sparing use of equity financing under our baseline calibration is that, once overall buffers are large enough to make the bank little likely to default on its insured deposits, private benefit taking becomes a more serious threat to the social value of the bank than risk shifting. Private benefit taking reduces bank efficiency and leads to deadweight losses. In contrast, risk shifting mainly leads to redistribution between equity and bail-in debt holders (which can be compensated for by paying a high interest rate on TLAC eligible debt).

In the final section of the paper, we explore how some additional ingredients might bring the normative prescriptions of the model closer to current policy proposals. In general, we find that it is difficult to justify both a very large TLAC buffer and a large common equity component. The overall TLAC buffer grows rapidly if we assume large social costs of bank default. However, by the logic described in the previous paragraph, the large buffers make bank default so unlikely that private benefit taking becomes the key agency concern at the margin. As a result, if bank failure is attributed a larger social cost, the share of common equity in TLAC does not increase but decreases.

The optimal capital requirement grows very much when we assume that writing down bail-in debt also implies deadweight costs. However, under our parameterization, we find that bail-in debt almost disappears from the optimal capital structure of the bank and the overall TLAC requirement actually goes down even further below the $16-18\%$ of assets proposed by the FSB. Putting the two additional frictions (bail-in debt resolution costs and large social costs of bank failure) together helps to get the bank capital structure closer to where the new regulatory proposals are (an equity ratio of 8.8% and an overall TLAC ratio of 15%).

A Appendix

Black-Scholes type formula for E Investors' risk neutrality implies that the overall value of equity can be found as

$$E = \beta \sum_{i=0,1} \varepsilon_i E_i, \tag{A.1}$$

where $E_i = E(\max\{\tilde{R}_i - B, 0\})$ and $B = R_D(1 - \chi - \phi) + R_B\chi$. Using (1), we can write

$$\begin{aligned} E_i &= E\left(\max\{(1-\Delta)R_A \exp(\sigma_i z - \sigma_i^2/2) - B, 0\}\right) \\ &= (1-\Delta)R_A \int_{\bar{z}_i}^{\infty} \exp(\sigma_i z - \sigma_i^2/2) f(z) dz - B\left(1 - F(\bar{z}_i)\right), \end{aligned} \tag{A.2}$$

where $f(z)$ and $F(z)$ are the density and CDF of a $N(0,1)$ random variable, and $\bar{z}$ is implicitly defined by $(1–\Delta)R_A \exp(\sigma_i\bar{z}–\sigma_i^2/2)–R_D(1–\phi) = 0$, so

$$\bar{z}_i = \frac{1}{\sigma_i}\left[\ln B - \ln(1-\Delta) - R_A + \sigma_i^2/2\right].$$

Now, the fact that $f(z) = \frac{1}{\sqrt{\pi}} \exp(-z^2/2)$ allows us to write

$$\begin{aligned} \int_{\bar{z}_i}^{\infty} \exp(\sigma_i z - \sigma_i^2/2) f(z) dz &= \int_{\bar{z}_i}^{\infty} \frac{1}{\sqrt{\pi}} \exp(\sigma_i z - \sigma_i^2/2 - z^2/2) f(z) dz \\ &= \int_{\bar{z}_i}^{\infty} \frac{1}{\sqrt{\pi}} \exp(-(z-\sigma_i)^2/2) f(z) dz \\ &= \int_{\bar{z}_i - \sigma_i}^{\infty} \frac{1}{\sqrt{\pi}} \exp(-\frac{1}{2}y^2) f(y) dy = 1 - F(\bar{z}_i - \sigma_i), \end{aligned}$$

where the last line follows from the change of variable $y = z - \sigma_i$.

Finally, it follows from the symmetry of the normal distribution and prior definitions that $1–F(\bar{z}_i–\sigma_i) = F(\sigma_i–\bar{z}_i) = F(s_i)$ and $1–F(\bar{z}_i) = F(-\bar{z}_i) = F(s_i–\sigma_i)$, so (A.2) implies

$$E_i = (1-\Delta) R_A F(s_i) - BF(s_i - \sigma_i), \tag{A.3}$$

which substituted into (A.1) yields (11).

Black-Scholes type formula for J To obtain the expression for the joint value of equity and bail-in debt, J, we can similarly write

$$J = \beta \sum_{i=0,1} \varepsilon_i J_i, \tag{A.4}$$

where $J_i = E(\max\{\tilde{R}_i - R_D (1–\phi–\chi), 0\})$ and, reproducing the steps followed for the derivation of (A.3), we can find

$$J_i = [(1 - \Delta - h(\varepsilon)) R_A F(w_i) - R_D (1 - \phi - \chi) F(w_i - \sigma_i)], \quad \text{(A.5)}$$

where

$$w_i = \frac{1}{\sigma_i}\left[\ln(1 - \Delta - h(\varepsilon)) + \ln R_A - \ln R_D - \ln(1 - \phi - \chi) + \sigma_i^2/2\right], \quad \text{(A.6)}$$

justifying equations (13) and (14) in the main text.

Merton type formula for DI To derive the expression for DI in (15), it is convenient to start with the special case in which $\mu = 0$. In such case DI is given by

$$DI_{|\mu=0} = \beta \sum_{i=0,1} \varepsilon_i [R_D (1 - \phi - \chi) - D_i], \quad \text{(A.7)}$$

where $D_i = E(\min\{R_D (1–\phi–\chi), \tilde{R}_i\})$ represents the expected value of the bank's final payments on deposits under $\mu = 0$, taking into account that the bank defaults on them when $\tilde{R}_i < R_D (1–\phi)$, paying back $\tilde{R}_i$ rather than $R_D (1–\phi–\chi)$, in which case the DIA loses the difference $R_D (1–\phi–\chi) - D_i$.

Now, given that $\min\{R_D (1–\phi–\chi), \tilde{R}_i\} = \tilde{R}_i – \max\{\tilde{R}_i - R_D (1–\phi–\chi), 0\}$, we can write

$$D_i = E(\tilde{R}_i) - J_i. \quad \text{(A.8)}$$

But then, substituting $E(\tilde{R}_i) = (1–\Delta)R_A$ and (A.5) in (A.8), we find

$$D_i = R_D (1 - \phi - \chi) F(w_i - \sigma_i) + (1 - \Delta) R_A (1 - F(w_i)), \quad \text{(A.9)}$$

where the first and second terms account for the bank's payments on deposits in non-default states and default states, respectively.

Plugging (A.9) into (A.7) and reordering yields

$$DI_{|\mu=0} = \beta \sum_{i=0,1} \varepsilon_i [R_D (1–\phi–\chi)(1 - F(w_i–\sigma_i)) - (1–\Delta–h(\varepsilon)) R_A (1 - F(w_i))]. \quad \text{(A.10)}$$

In the general case with $\mu > 0$ the only required adjustment is to add to DI the deadweight losses incurred when the bank defaults on insured deposits. These losses are given by (16). Adding them to (A.10) leads to (15).

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