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Incentives and Regulation in Banking

Natalya Martynova

This thesis includes three essays on banking. The first two focus on the problem of bank asset opacity in the banking regulatory design. The third essay focuses on the regulatory arbitrage. The first essay “Convertible Bonds and Bank Risk-Taking” (joint with Enrico Perotti) studies the effect of going concern contingent capital on ex ante bank risk-taking incentives. The second essay “Internal Asset Transfers and Risk-Taking in Financial Conglomerates” considers the risk control decision and risk allocation choice via securitization in financial conglomerates organized as a bank holding company. The third essay “Franchise Value and Risk-Taking in Modern Banks” (joint with Lev Ratnovski and Razvan Vlahu) studies how the value of bank relationship business induces risk-shifting through investment in scalable market-based activities.

Natalya Martynova (1985) obtained her Master degree in Economics from the Higher School of Economics in Moscow before proceeding to MPhil programme in Tinbergen Institute. After graduating from Tinbergen Institute in 2010, she continued her Doctoral studies in the Finance group at the University of Amsterdam. During graduate studies, she has visited CEMFI in Madrid and has interned at De Nederlandsche Bank and Bank for International Settlements. Currently, Natalya is a research economist at De Nederlandsche Bank.

Incentives and Regulation in Banking
Natalya Martynova



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Incentives and Regulation in Banking

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Amsterdam, 15 December 2014

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Chapter 1

Introduction

Solutions are fairly easy if we think the bankers violated traffic signals: we should hand them stiff tickets or put them in jail. But what if we built an elaborate set of traffic signals that pointed them in the wrong direction?

– Raghuram G. Rajan, "Fault Lines", 2010.

The financial crisis of 2007-2008 has unveiled the hidden flaws in the regulatory framework of the financial sector. The rules of the game established by regulators were not stringent enough and provided bankers with wrong incentives to gamble with depositors' money. It has been acknowledged that new regulation (Basel III) is needed to address those bankers' incentives in the post-crisis environment, and thus to prevent risk accumulation in banks and enhance financial stability.

There are two major challenges in the design of new rules in banking. First, bank assets are opaque, and regulators do not perfectly observe the risks involved. Moreover, regulators are not able to rely on the information about asset quality provided by bankers, because bankers always have incentives to embellish this. Since regulators' vision is blurred, reported asset risk is not a good foundation for bank regulation. The absence of regulation relying on the quality of bank assets reduces the ability of regulators to react in a timely fashion. It also enables bankers to behave opportunistically and to benefit from moral hazard. As a result, excessive risk-taking is encouraged, while losses are shifted to depositors. This challenge calls for rules that can prevent risk build-up, and respond to bankers' risk decisions, ahead of distress.

The second challenge in the regulatory design is that bankers' behavior changes in response to changes in regulation. This results in regulatory arbitrage through which bankers find ways to take more risk while meeting regulatory requirements (Rochet, 2010). The possible solutions are simpler rules as well as more enhanced supervision. Straightforward regulatory instruments must be easy to implement and to monitor, mitigating the risks of regulatory

arbitrage. Also, regulators should not focus on the current snapshot of bank risk alone, but think about risk-taking in a dynamic setting, and recognize bankers' ability to accumulate risks while going forward.

Under the recent pace of financial innovation these two regulatory challenges are becoming even more acute. Asset securitization, non-traditional instruments of bank funding (such as repurchase agreements offering high seniority) are examples of new methods that bankers deploy in order to engage in risk-shifting.

This thesis consists of three papers. The first two focus on the problem of bank asset opacity in the regulatory design. The first paper highlights the importance of contingent capital regulation as a risk prevention mechanism. The second emphasizes the effect of the organizational structure of financial institutions on the nature of risk transfer via securitization. Finally, the third paper focuses on regulatory arbitrage showing the effect of franchise value on the ability of a bank to raise funding and to make risky gambles.

Three theoretical models share one methodological basis of the asset substitution literature. They all consider a bank which has access to safe and risky investments, and takes advantage of the moral hazard attached to the risk-taking. In the first two models, the bank is subject to prudential regulation (deposit insurance and capital requirements). In the third model, a bank's incentives are considered with and without prudential regulation.

The first paper "*Convertible Bonds and Bank Risk-Taking*" (joint work with Enrico Perotti) studies the effect of convertible bonds on bank risk-taking incentives. Convertible bonds (or CoCos) are debt instruments that convert into equity when bank is doing poorly, for example when its capital to asset ratio drops below some threshold (called a trigger). The paper contributes to the policy initiative of the European Banking Authority and national European central banks to introduce convertible bonds as a part of capital regulation. The goal of this regulation is to create a buffer against banks' financial losses. However, the paper focuses on another role of CoCos, namely its ability to prevent risk build-up ahead of distress. It tries to find the optimal amount of CoCos and the optimal trigger.

Introducing CoCos with a fixed conversion ratio as a substitute for the part of bank deposits produces two effects on bank risk choice. First, CoCos reduce bank risk-taking, because the equityholders' share of profit is diluted upon conversion and bankers try to avoid that. Second, there is a value transfer from CoCoholders to equityholders upon conversion, since CoCoholders always get less than the face value. This may encourage bank risk-taking, especially when the amount of CoCos is too large. As a result, there is an optimal amount of CoCos that ensures maximum risk reduction effect.

In the paper, we compare CoCos with other bank funding instruments: equity and traditional unsecured debt. CoCos are inferior to equity in their risk reduction effect. However, they may be cheaper than unsecured debt due to the ability of the latter to reduce the risk of

bank default when the amount of CoCos is optimal.

The paper has several regulatory implications. First, CoCos must have a sufficiently high trigger to guarantee their preventive function. Second, the amount of CoCos should be moderate to ensure maximum risk reduction. Third, CoCos are also a good solution that allows to minimize the cost of bank capital.

My second paper "*Internal Asset Transfers and Risk-Taking in Financial Conglomerates*" considers the risk-taking incentives in financial conglomerates. A financial conglomerate is organized as a bank holding company with two legal entities: a commercial bank with its opaque assets, and an investment bank.

The paper contributes to the discussion of Vickers' proposal, UK legal initiative to separate commercial banking activities financed by retail deposits from investment banking operations. Following Vickers, it would be forbidden for a commercial bank to purchase derivatives and other market instruments from an investment bank. However, regulation would still allow a commercial bank to sell the loans it originated to an investment bank.

The paper studies how such an internal loan sale in financial conglomerates affects its risk choice in terms of two decisions: loan monitoring choice and risk allocation decision (i.e how the risk is distributed among entities). Since loans are opaque, bank learns information about their quality via monitoring. Another benefit of monitoring is that it enhances loans' expected payoff. However, another friction is costly bank capital. To minimize cost of capital, bank sells loans.

Comparing the choice of a conglomerate and a standalone bank, I find two contrasting effects of loan sale. On one hand, financial conglomerates choose to transfer the most valuable and safest loans out of the commercial bank backed by deposit insurance to the investment bank funded by market investors. The commercial bank in the conglomerate accumulates risky loans on its balance sheet, whereas the standalone bank keeps the safest loans while selling the riskiest. On the other hand, loan sale induces better loan monitoring in the conglomerate than in the standalone bank, since all loans stay inside the conglomerate.

In Vickers' proposal, a regulator must set a higher capital requirement for commercial banks in conglomerates to address higher risk-taking incentives in retail activities. Our model shows that a higher capital requirement in a conglomerate bank must be complemented with a restriction on the volume of internal sales, in order to limit bank risk. The adverse effect of a higher capital requirement is that it induces a conglomerate bank to sell more of safest loans while keeping riskier ones.

Finally, the third paper "*Franchise Value and Risk-Taking in Modern Banks*" (joint work with Lev Ratnovski and Razvan Vlahu) looks into the effect of bank franchise value on bank risk-taking incentives. We understand franchise value as a long-term bank profitability, the value of its traditional business.

It has long been argued that a higher franchise value (reflected in higher bank capital) limits a bank's willingness to invest in risky projects (Keeley, 1990; Demsetz et al., 1996; Repullo, 2004). However, many financial institutions with exceptionally valuable franchises (such as UBS, Washington Mutual, AIG) have in fact been exposed to new financial instruments, resulting in significant losses during the crisis.

This research attempts to reconcile theory and evidence. We consider banks with profitable traditional business (such as relationship banking) which can choose to invest in risky market-based activities by raising extra funds. Banks with higher franchise values have better opportunities to attract funds for financing their risky activities. Higher franchise value allows banks to lever up more, so they can take risk on a larger scale. This effect is more pronounced when banks operate in better institutional environments with more protection of creditor rights. Also, when banks have access to senior funding (such as repos), these incentives are higher.

This theory contributes to the policy debate on bank capital regulation, highlighting adverse effects of capital and franchise value, and advocating repo market reform.

Chapter 2

Convertible Bonds and Bank Risk-Taking

2.1 Introduction

During the recent credit boom, bank capital had fallen at historical lows. In the subsequent crisis, banks could not absorb asset losses, leading to credit market disruption and spillovers to the real economy. Regulatory reform has called for more bank equity to ensure ex post risk absorption by shareholders, as well as to reduce ex ante incentives for excess risk.

Under Basel III rules, the new capital ratios may be satisfied only by common equity. Yet there is support for allowing contingent capital to count for extra buffers, such as those for systemically important financial institutions. This form of long term debt (called also contingent convertible, or CoCo bonds) automatically converts to equity upon a trigger signaling reduced solvency. So called bail-in capital converts into equity only upon bank insolvency, when equity is worthless. This protects other lenders, but does not have an effect on asset risk in equilibrium. The more interesting version is "going-concern" contingent capital, where debt may convert in a timely fashion, ahead of distress.

Originally proposed by Flannery (2002), the case for this form of contingent capital has been carefully outlined in Kashyap et al. (2008). A recent literature has discussed its design in terms of reducing financial distress costs and deposit insurance losses (Albul et al., 2010; McDonald, 2011; Pennacchi, 2011; Pennacchi et al., 2011).

While most authors argue that contingent capital reduce risk shifting incentives (asset substitution), for tractability their models assume asset risk is exogenous and unaffected by the introduction of CoCo bonds, focusing on their ex post buffering effect.¹

In our model, asset risk is a choice that reflects bankers' incentives, which deteriorate as leverage increases. Our basic result is that the chance of conversion in high leverage states reduces ex ante risk shifting. The intuition is that conversion dilutes high returns, discouraging gambling. CoCo effectiveness is shown to depend on the precision of the trigger, which

¹A partial exception is Chen et al. (2013), who analyze endogenous strategic default and show that conversion reduces its frequency.

optimally should deliver deleveraging when this is most valuable, namely when risk incentives deteriorate.

There are clear tradeoffs in CoCo design. A higher trigger and larger CoCo amount lead to more frequent and larger conversions respectively, and a higher equity content. We show that increasing the amount of CoCo ratio capital ultimately becomes counterproductive. Once a very large conversion at a fixed conversion ratio delivers a capital gain to equityholders, this increases their risk incentives.²

As a result of this tradeoff, there is an optimal design in terms of the trigger level and optimal amount of contingent capital, even in the absence of issuance or bankruptcy costs.

CoCos are incorrectly considered as a package of conventional bonds and a short position in a put option on the value of assets. This neglects their risk-reducing effect, which reduces the value of their short put position. (It also ignores the fact that deposit insurance also bears some risk). We obtain the interesting result that optimally designed CoCo bonds may be in equilibrium safer than conventional bank bonds, because they reduce endogenous asset risk.

The model allows to measure how well contingent capital compares with straight equity. More CoCo debt may need to be issued to substitute for equity in terms of risk reduction. However, we show that this ratio declines as trigger precision improves.

In order to focus on their risk prevention effect, CoCo bonds are more stylized in our setting relative to other models in the literature (Albul et al., 2010; Bolton and Samama, 2012; Glasserman and Nouri, 2012; Hilscher and Raviv, 2011; Koziol and Lawrenz, 2012; Madan and Schoutens, 2010). Alternative approaches are offered in Duffie (2010) and McDonald (2011), where the case of conversion in a systemic crisis is examined. A specific design aimed at containing endogenous risk is sketched by Squam Lake Working Group, who propose banker compensation to be based on gradual vesting of contingent bonds.

Similarly to the existing literature, our analysis of the regulatory framework is limited, as we take initial bank leverage as exogenous for the sake of tractability. In principle, an optimal capital ratio already trades off some cost of bank equity capital against endogenous risk shifting. Deposit insurance risk is also not priced. (This is partially justified in our setup, where deposit insurance losses are a transfer among risk neutral agents, and would be zero in the absence of deliberate risk taking.) Changing this assumption would not alter our basic results, though for banks with very high leverage, for which even conversion cannot restore risk incentives, a different policy tool would be needed.

In general, CoCos remain less effective than equity at risk control, so they may be justified only as a cheaper solution for bank shareholders. Just as capital requirements, they are less effective at controlling deliberate exposure to tail risk (Perotti et al., 2011; Chen et al., 2013).

Section 2 presents the basic model, and Section 3 shows how CoCo design affect the

²Value transfers cannot be ruled out by varying the conversion ratio, unless the bonds may convert in an infinite amount of shares. Such a contractual feature would be impossible in reality, not least for legal reasons.

banker's risk taking incentives. Section 4 compares the risk-reducing effect of CoCos against equity and convertible debentures converted at will, which also have been proposed as a solution to risk-shifting (Green, 1984). Section 5 concludes. All proofs are in Appendix.

2.2 The Model

2.2.1 Setup

The bank has an exogenous amount of debt D , which may include CoCo bonds of amount C and deposits $D - C$. Issuing CoCo bonds substitute a part of deposits, which drop to $D - C$, so the initial leverage does not change. We assume that it is mandatory for the bank to issue CoCos.³ The deposit rate is normalized to zero. Bank deposits are insured.

The bank is financed with $1 - D$ of equity invested at $t = 0$, so as to satisfy an exogenous capital requirements of $1 - D$. The assets are not risk-weighted. The initial assets value at $t = 0$ is 1, so there is no excess capital.

There is one active agent in the model: the banker/bank owner⁴. Borrowers are price-takers, so lending is represented as an asset choice by the banker. Depositors are insured and passive. Agents are risk-neutral and rational.

At $t = 1$, asset value is subject to an exogenous shock $V_1 = 1 + \zeta$, where ζ is uniformly distributed over $[-\delta, \delta]$. We denote the realization of interim asset value V_1 as $v \in [1 - \delta, 1 + \delta]$, observed only by banker. The interim leverage is then $\frac{D}{v}$.⁵

The banker chooses whether to exert effort ($e = 1$) to control credit risk or not ($e = 0$). Effort is costless. The banker's payoff is the value of the original bank equity at $t = 2$.

Depending on her choice, asset values at $t = 2$ may have two outcomes, safe or risky. If the banker exercises risk control, assets at $t = 2$ produce a safe payoff with gross rate of return 1. Alternatively, without risk control, at $t = 2$ a risky credit strategy has payoff V_2 , where V_2 follows a distribution $F(V_2)$ with density function $f(V_2)$, mean $\mathbf{E}(V_2) = v - z$, and standard deviation σ , where $z > 0$. Thus, the riskier strategy yields a lower mean payoff relative to the safer asset choice.⁶

After the risk choice is made, the value v is revealed with probability φ to all investors. A riskier strategy may enhance equity in high leverage states. To ensure bank solvency under a safe strategy, we assume that the maximum interim asset drop never fully wipes out equity, namely $1 - \delta - D \geq 0$.⁷

³Later we show that the banker never issues CoCos voluntarily at $t = 0$.

⁴We assume the bank manager is the sole shareholder, to focus on the interaction of the share price and risk-taking incentives, rather than on the agency conflict between the manager and the shareholder.

⁵We assume that no bank equity may be raised at time $t = 1$ if leverage turns out to be high.

⁶As a result, the distribution of asset return in the safe outcome has second-order dominance relative to risky outcome, though not first-order dominance.

⁷See Appendix for the discussion of the case when this assumption is relaxed.

CoCos are automatically converted into equity when the interim asset value v falls below a pre-specified trigger level v_T at $t = 1$. If $v > v_T$, conversion does not occur. Trigger value is initially set lower than the initial book value 1, else there is an immediate conversion at $t = 0$. To simplify the analysis, the interim coupon rate is normalized to zero.

The conversion ratio, modeled along existing CoCo bonds, is the ratio of nominal value over the trigger asset value minus debt: $d = \frac{C}{v_T - D}$.⁸ After conversion, the amount of shares is $d + 1$. Note that the banker is never wiped out unless the value of CoCos is also zero. The payoff structure is presented in the Figure 2.1.

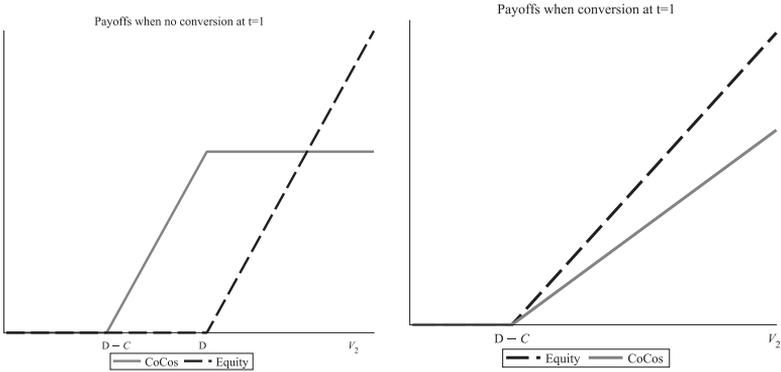


Figure 2.1: Payoff of bondholders and shareholders in case of no conversion and conversion at $t = 1$ ($d < 1$)

The sequence of events is presented in Figure 2.2.

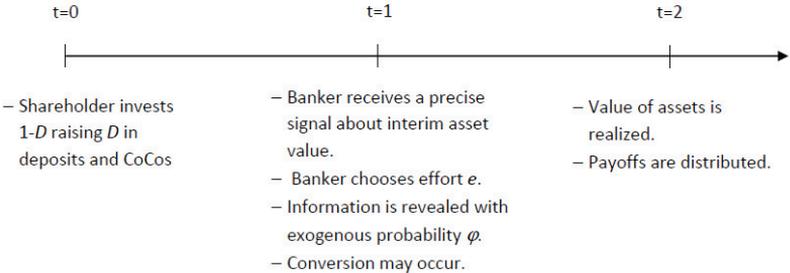


Figure 2.2: The sequence of events

We consider now what CoCo design improves banker’s risk incentives. Intuitively, the trigger should induce CoCos conversion when bank interim leverage is high enough to create

⁸The fixed conversion ratio produces value redistribution at conversion as soon as v is strictly below v_T .

poor risk control incentives, but conversion is unnecessary in well capitalized banks.

2.2.2 Results

The Risk-Taking Incentive

The banker bases her risk decision on the expected payoff, conditional on being solvent. For very low realizations of asset values the bank will default, wiping out also CoCo holders and forcing a payment by the deposit insurance fund.

The expected banker payoff from a risky asset choice is:

$$(1 - F(D)) \cdot \mathbf{E}(V_2 - D | V_2 > D) = \int_D^\infty (V_2 - D) f(V_2) dV_2 \quad (2.1)$$

which can be presented as the sum of its unconditional mean $\mathbf{E}(V_2 - D) = v - z - D$ (which may be negative) and a measure of the right tail return in solvent states:

$$\int_D^\infty (V_2 - D) f(V_2) dV_2 = v - z - D - \int_{-\infty}^D (V_2 - D) f(V_2) dV_2 \quad (2.2)$$

$$= v - z - D + \Delta(v, D, \sigma) \quad (2.3)$$

Here $\Delta(v, D, \sigma) = - \int_{-\infty}^D (V_2 - D) f(V_2) dV_2$ is the value of the put option (also called Merton's put) enjoyed by shareholders under limited liability. It also affects the temptation of the banker to shift risk, defined as the return difference between a risky and safe strategy for the banker:

$$(1 - F(D)) \cdot \mathbf{E}(V_2 - D | V_2 > D) - (v - D) = -z + \Delta(v, D, \sigma)$$

From now on we refer to the return $\Delta(v, D, \sigma)$ as $\Delta(v)$, the measure of bank risk shifting incentives. Next, we characterize how its value depends on the specific distribution of asset risk.

Note that if the risky payoff is normally or uniformly distributed, risk shifting incentives $\Delta(v)$ are monotonically increasing and convex in leverage. Moreover, risk shifting incentives increase with a higher volatility of risky asset σ . (See Appendix for details.)

Without any specific assumption on $f(V_2)$, we assume that the risk incentive function has a similar structure as under normal or uniform distribution.

Assumption 1. *Risk shifting incentives $\Delta(v)$ are an increasing and convex function of leverage $\frac{D}{v}$: $\Delta'(v) \leq 0$, $\Delta''(v) \geq 0$. Also $\Delta(v)$ are increasing with σ : $\Delta'(\sigma) \geq 0$.*

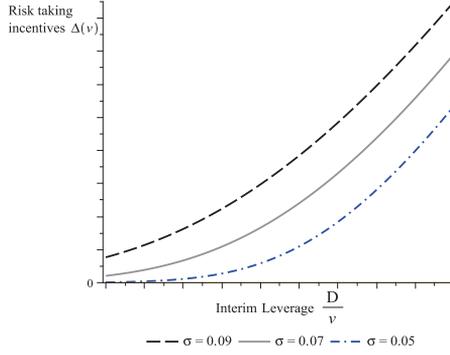


Figure 2.3: Risk incentives under Gaussian risk distribution

For a normal distribution, risk shifting incentives are given by:

$$\Delta(v) = (v - D - z) \cdot \left[\Phi \left(\frac{v - D - z}{\sigma} \right) - 1 \right] + \sigma \cdot \phi \left(\frac{v - D - z}{\sigma} \right) \quad (2.4)$$

Bank Risk Without Convertible Bonds

First, we consider the risk choice of the banker in the absence of convertible bonds $C = 0$.

The banker compares the payoff from the risky and the safe asset. The banker's program is:

$$\begin{aligned} & \max_e e \cdot (v - D) + (1 - e) \cdot (v - z - D + \Delta(v)) \\ & \text{s.t. } e \in \{0, 1\} \end{aligned} \quad (2.5)$$

Under the Assumption 1, the optimal effort choice by the banker takes the form:

$$e = \begin{cases} 1 & \text{if } v \geq \Delta^{-1}(z) \equiv v^* \\ 0 & \text{otherwise} \end{cases} \quad (2.6)$$

We denote as $v^* \equiv \Delta^{-1}(z)$ the cut-off interim asset value, above which the banker exerts effort without conversion. At $v = v^*$ the net present value of the the banker's choice of a risky lending strategy is zero.

For normal distribution function the cut-off interim asset value v^* is given implicitly by:

$$(v - D - z) \cdot \left[\Phi \left(\frac{v - D - z}{\sigma} \right) - 1 \right] + \sigma \cdot \phi \left(\frac{v - D - z}{\sigma} \right) = z \quad (2.7)$$

Lemma 1. *If at the interim period leverage is low ($v \geq v^*$), the banker exerts effort in order*

to control risk. If $v < v^*$, she does not. Moreover, the ex ante probability that the banker will choose at $t = 1$ to control risk ($\frac{1-\delta-v^*}{2\delta}$) decreases with the volatility of risky asset σ .

Note that the asset value revelation of v does not have any effect on the banker's risk incentives, as disclosure does not change leverage.

2.3 Optimal CoCo Design

This section considers the bank which has CoCos. It studies how the banker's incentives change if the bank issues convertible bonds, finds their optimal trigger level v_T and the amount of CoCo debt C .

2.3.1 Trigger Value

First, we look at the banker's risk decision under a given amount of CoCos C with a given trigger v_T .

From Lemma 1, setting a trigger asset value higher than v^* does not change risk incentives for low leverage banks (with $v \geq v^*$). This enables us to restrict the range of trigger values to the interval $v_T < \min[v^*; 1]$.⁹

Next, consider the banker's program:

$$\begin{aligned}
& \max_e e \cdot \underbrace{[(v - D) \cdot (I(v \geq v_T)) + (1 - \varphi) \cdot I(v < v_T)]}_{\text{equity value if no conversion and } e=1} + \\
& \underbrace{\frac{v - D + C}{d + 1} \cdot \varphi \cdot I(v < v_T)}_{\text{equity value if conversion and } e=1} + \\
& (1 - e) \cdot \underbrace{[(v - z - D + \Delta(v)) \cdot (I(v \geq v_T)) + (1 - \varphi) \cdot I(v < v_T)]}_{\text{equity value if no conversion and } e=0} + \\
& \underbrace{\frac{v - z - D + C + \Delta(v + C)}{d + 1} \cdot \varphi \cdot I(v < v_T)}_{\text{equity value if conversion and } e=0} \\
& \text{s.t. } e \in \{0, 1\}
\end{aligned} \tag{2.8}$$

where $I(\cdot)$ is an indicator function, $d = \frac{C}{v_T - D}$ is the conversion ratio, and $\Delta(v + C) = -\int_{-\infty}^{D-C} (V_2 - D + C)f(V_2)dV_2$ is risk taking incentives under CoCos conversion.

Lemma 2. *The introduction of CoCos improves effort for banks with $v_C^* \leq v \leq v_T$. Banks with extremely high leverage $v < v_C^*$ do not change their effort choice since their risk-shifting return is too large. Banks with $v > v_T$ are not affected.*

Figure 2.4 shows that the effort choice may not be monotonic in the interim asset value.

⁹We later show that this is efficient, as dilution which does not affect risk incentive may be counterproductive.

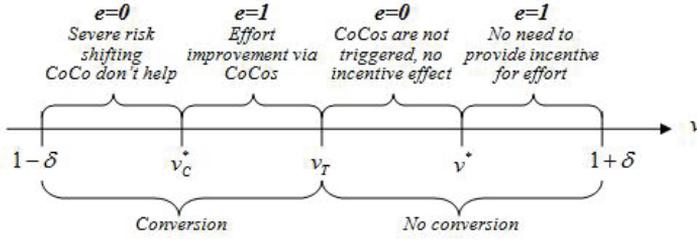


Figure 2.4: Risk incentives

There are two critical interim asset values. The first is v^* , the threshold for effort even when no conversion takes place. The second is v_C^* , the value of interim assets above which the introduction of CoCos improves effort, defined in (2.9):

$$\frac{\varphi}{d+1} \cdot \Delta(v+C) + (1-\varphi) \cdot \Delta(v) - z \left(1 - \varphi + \frac{\varphi}{d+1} \right) = 0 \quad (2.9)$$

Intuitively, risk incentives may improve with CoCos only if $\varphi > 0$, that is, if the trigger is informative about poor incentives and forces recapitalization in the right states.

A bank with $v < v_C^*$ has such high leverage that CoCos can not improve its risk-shifting incentives¹⁰.

Note that the difference $\frac{v_T - v_C^*}{2\delta}$ measures the expected improvement in risk incentive $E(\Delta e)$ induced by CoCos. It is strictly decreasing in v_C^* . It is easy to see that v_C^* is in the range $[v^* - C, v^*]$ and decreases with the probability of information revelation φ (see Figure 2.5).

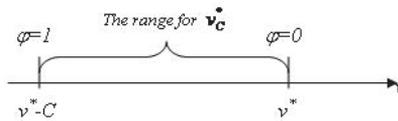


Figure 2.5: Cut-off value v_C^*

Proposition 1. *The trigger value is optimally set at $v_T = v^*$, which maximizes the expected effort $\frac{v_T - v_C^*}{2\delta}$ for a given amount of CoCos C .*

Figure 2.4 shows that unless the trigger v_T is chosen optimally, risk incentives are not necessarily monotonic in v . If the trigger is too high (above v^*), CoCos will not affect effort. But if it is too low (below v^*), there will be no conversion for an intermediate range of highly

¹⁰If CoCos are large enough ($v_C^* < 1 - \delta$), this range does not arise, and all banks with $v < v_T$ have incentives to contain asset risk.

levered banks. This is clearly inefficient. As it is easier to induce effort for higher v , so it cannot be efficient to allow effort to fall as v increases.

As a result, setting the trigger to $v_T = v^*$ guarantees the monotonicity of incentives with respect to leverage, as shown in Figure 2.6.

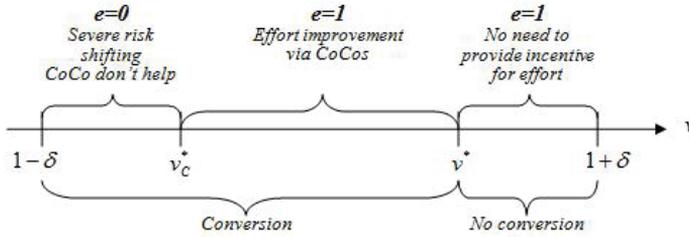


Figure 2.6: Risk incentives with restricted trigger asset value $v_T = v^*$

The optimal trigger value v^* depends on the risky opportunities available to the banker. A higher asset volatility increases the risk shifting return, which becomes attractive to the banker for a larger range of interim values v . Intuitively, the trigger value should be raised to adjust incentives when asset values are riskier in a mean-preserving sense.

Lemma 3. *A higher asset volatility under the risky strategy requires that the trigger value be raised to maintain risk-shifting incentives.*

2.3.2 Optimal Amount of CoCo Bonds

Having set v_T , we now seek to optimize risk incentives by varying the amount of CoCos.

Convertible bonds have two effects on the banker's effort for low interim asset values $v \leq v^*$. We can separate two effects: an equity dilution and a CoCo dilution effect.

Proposition 2. *The potential reduction in the banker's equity due to CoCo increases effort incentives when risk-shifting is most severe. The value transfer from CoCo to equity discourages effort.*

The equity dilution effect arises because the chance of conversion reduces the banker's share of high payoffs, reducing the return to risk shifting.¹¹ This effect is more pronounced for highly levered banks.

Second, conversion leads to a value transfer from CoCo to equity due to the fixed conversion ratio. This may reduce effort. Figure 2.7 illustrates two effects.

¹¹Note that this result matches the intuition in Green's (1984) model of convertible debt. However, here conversion is automatic and occurs earlier, before risk is fully realized.

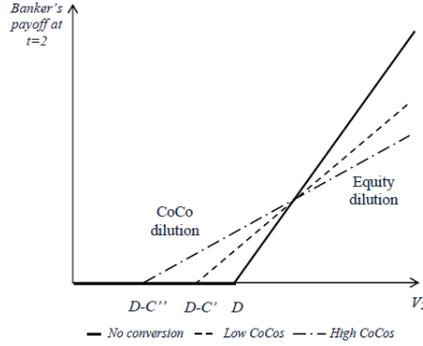


Figure 2.7: Equity and CoCo dilution effects

When the amount of CoCos is so large that conversion exceeds what would be required to eliminate all risk shifting incentives, CoCo dilution effect is excessive. Recall that effort is both risk-reducing and value increasing. Thus, the disincentivizing CoCo dilution effect is strongest for low levered banks $v \geq v^* - C$, for which the risk shifting effect is limited.

This suggests there is an optimal amount of CoCo funding, which trades off reducing risk shifting while maintaining incentives for value enhancement.

Expected effort $\mathbf{E}(e)$ reflects the range of states v when the banker exerts effort, and equals $\frac{1+\delta-v^*}{2\delta}$. In the Appendix we show the effect of an increase in the amount of CoCos, disentangling equity dilution and CoCo dilution effects.

Proposition 3. *Expected effort increases with the amount of CoCos up to a threshold C^* , and then declines. Thus, there exists an optimal amount of CoCos in terms of effort improvement.*

$$\Delta'_C(v + C^*)(C^* + v_T - D) - \Delta(v + C^*) + z = 0 \quad (2.10)$$

Figure 2.8 shows effort improvement under the uniform distribution¹².

Lemma 4. *The amount of CoCos and trigger value act as substitutes in reducing risk.*

Thus a lower trigger value can be compensated by a higher amount of CoCos to achieve the same risk incentives. Intuitively, a less frequent conversion can be compensated by a larger dilution.

We next look at how key parameters on the economic environment (risky asset volatility σ , probability of information revelation φ) affect the expected improvement in effort.

¹²The graph uses the parameter values $D = 0.93$, $z = 0.04$, $\delta = 0.07$, $\varphi = 0.8$.

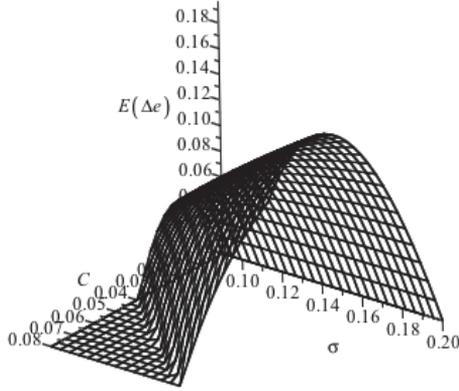


Figure 2.8: Effort improvement for different amount of CoCos

Proposition 4. For an exogenously given trigger value, the expected effort improvement $\frac{v_T - v_C^*}{2\delta}$ decreases in the volatility of risky asset (σ), since the risk shifting incentives grow with σ .

Lemma 5. Higher σ implies a higher optimal trigger value: $\frac{\partial v^*}{\partial \sigma} \geq 0$.

Lemma 6. A higher probability of information revelation increases the expected effort improvement $\frac{v^* - v_C^*}{2\delta}$.

Clearly, if the state is never revealed $\varphi = 0$, convertible bonds never convert and thus do not change risk incentives. An increasing chance of conversion upon revelation of high leverage triggers conversion precisely when incentives are poor.

2.4 Extensions

2.4.1 Private Choice to Issue CoCo Bonds

It is easy to show that banks will not be willing to issue CoCos voluntarily. Since deposits are guaranteed by the deposit insurance fund, they can be issued at par, whereas CoCos are risky.¹³ Moreover, CoCos force the banker to choose a safer strategy than she would prefer in some cases. This decreases the banker's return for a range of intermediate value states.

¹³This result would not hold if deposit insurance fees (which we set to zero) were risk sensitive and properly priced. In our approach, such pricing is not easy, as risk is endogenous.

Suppose the banker may choose between the issuing CoCos of amount C at $t = 0$ or deposits of amount C . Consider the payoff of the CoCo holders. If the interim asset value v is not revealed, this is similar to conventional bondholders. If $v \geq v_C^*$, CoCo holders get the face value of the bond C , since the bank invests in the safe strategy. If $v < v_C^*$, CoCo holders face the risk that bank won't repay the value of the bond fully. As the risk is not borne by deposit insurance, it is fully priced.

It is easy to show that on average for $v < v^*$, CoCo holders get less than the face value of the bond ¹⁴, although post conversion they may enjoy a capital gain as shareholders.

Figure 2.1 show the payoff of the CoCo holders in highly leveraged banks ($v < v_C^*$).

As a result, CoCos are sold at the discount on their face value. Their price equals to:

$$\begin{aligned}
 P_C = & \underbrace{\varphi \cdot [\underbrace{Prob(v > v_C^*) \cdot C}_{\text{safe strategy, no conversion}} + \underbrace{Prob(v_C^* < v \leq v^*) \cdot \frac{d}{d+1} \cdot \mathbf{E}(v - D + C | v_C^* < v \leq v^*)}_{\text{safe strategy, conversion}}]}_{\text{if information is revealed}} + \\
 & \underbrace{Prob(v \leq v_C^*) \cdot \frac{d}{d+1} \cdot Prob(V_2 > D - C) \cdot \mathbf{E}(V_2 - D + C | V_2 > D - C, v \leq v_C^*)}_{\text{risky strategy, conversion}} + \\
 & (1 - \varphi) \underbrace{[\underbrace{Prob(v \geq v_C^*) \cdot C}_{\text{safe strategy}} + \underbrace{Prob(v < v_C^*) \cdot \mathbf{E}(B | v < v_C^*)}_{\text{risky strategy}}]}_{\text{if information is not revealed}} \quad (2.11)
 \end{aligned}$$

where B is the value of a traditional bond of face value C for a risky bank defined as:

$$\begin{aligned}
 B = & Prob(V_2 \geq D, v) \cdot C + \\
 & Prob(D - C \leq V_2 < D, v) \cdot \mathbf{E}(V_2 - D + C | D - C \leq V_2 \leq D, v) \quad (2.12)
 \end{aligned}$$

Figure 2.9 shows that the discount is at minimum when the CoCo amount is optimal. The intuition is that at that point, the risk reduction is maximized, and the discount increases with the asset risk.

Proposition 5. *The banker never chooses to issue CoCos instead of deposits, since CoCos are not insured and have a higher funding cost.*¹⁵

Therefore, CoCos will be issued only if required by regulators. Note that CoCos provide higher welfare, since the value of assets increases. The social welfare gain due to CoCos equals the range of states on which the inefficient risk outcome (which has an average cost z)

¹⁴While CoCo holder gets less than face value at conversion because of the fixed conversion ratio, this loss is fully priced ex ante.

¹⁵When initial capital is very high, CoCos may actually be riskless, if they always improve risk incentives ($v_C^* \leq 1 - \delta$).

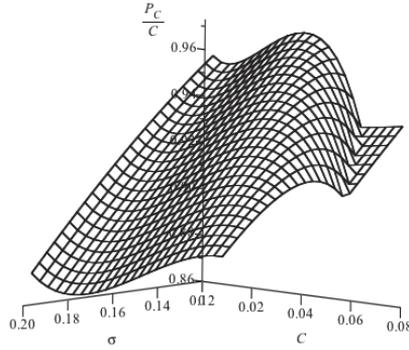


Figure 2.9: Price of CoCos as a percentage of face value

is avoided:

$$\frac{v^* - v_C^*}{2\delta} \cdot z \quad (2.13)$$

2.4.2 CoCo Bonds versus Debt

Are CoCos cheaper than ordinary uninsured bond?

There are two effects. CoCo bonds face less protection when converted than traditional debt, but they induce safer asset choices. We are able to show that an optimal amount of CoCos under some parameter values represent a less risky security than traditional bank debt.

The difference in payoffs is shown in the Figure 2.10.

The value of a traditional bond with face value C is:

$$P_B = Prob(v \geq v^*) \cdot C + Prob(v < v^*) \cdot \mathbf{E}(B|v < v^*) \quad (2.14)$$

The price of CoCos may be higher than for a traditional bond, when asset risk and trigger precision are high and the amount of CoCos is chosen optimally (Figure 2.11)¹⁶.

Note that when the asset risk increases, the optimal trigger price on CoCo bonds should be raised to adjust incentives. Traditional bond holders instead will passively bear the increased risk.

2.4.3 CoCo Bonds versus Equity

What amount of contingent capital is required to substitute equity, to provide the same effort incentives?

¹⁶We use parameter values: $D = 0.93$, $z = 0.04$, $\delta = 0.07$, $\varphi = 0.8$, $\sigma = 0.14$

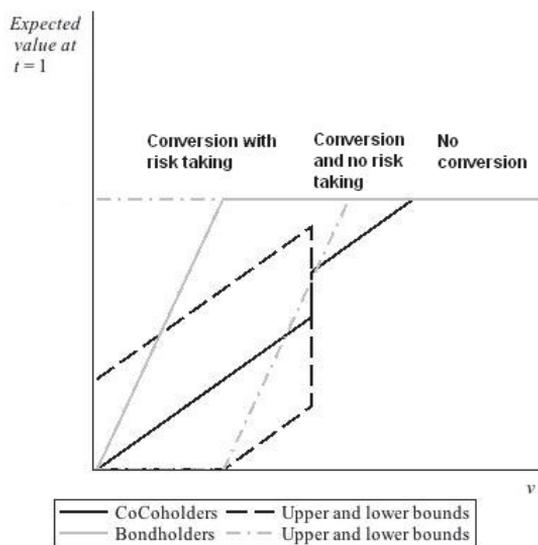


Figure 2.10: Expected CoCo and debt value and bounds

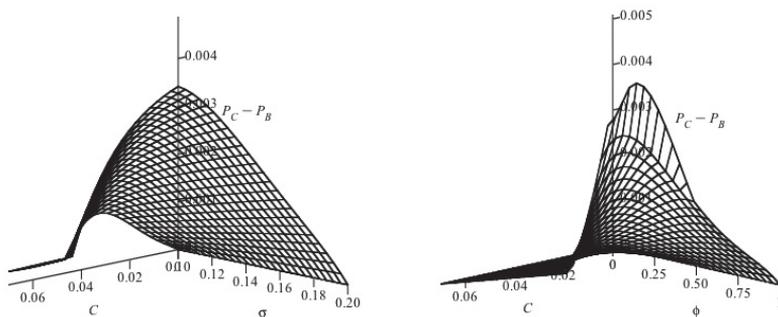


Figure 2.11: CoCo price minus bank debt around C^*

Suppose the bank substitutes one unit of deposits by an extra amount of equity ϵ , or by an amount $k\epsilon$ of CoCos. We solve for the level of k which guarantees an equivalent improvement in risk incentives as with equity.¹⁷

¹⁷Note that after adding extra equity ϵ , the bank has debt $D - \epsilon$, so the amount of equity in the interim stage is $v - D + \epsilon$. The bank operates with lower leverage.

The banker chooses effort according to the schedule:

$$e = \begin{cases} 1 & \text{if } v \geq v^* - \epsilon \\ 0 & \text{if } v < v^* - \epsilon \end{cases} \quad (2.15)$$

The expected improvement in effort compared to basic model (2.20) is $\frac{\epsilon}{2\delta}$, which reflects the increased range of asset values for which there are improved risk incentives. From earlier results, the improvement in effort achieved by CoCos is $\frac{v^* - v_C^*}{2\delta}$.

So the condition $v^* - v_C^* = \epsilon$ guarantees that the expected improvement in effort from introducing extra equity ϵ and CoCos $k\epsilon$ is the same.¹⁸

Proposition 6. *The effect of CoCos on effort is in general weaker than of equity, unless the trigger is perfectly informative ($\varphi = 1$).*

Lemma 7. *The substitution ratio k between extra equity and CoCos k decreases in a convex way with the probability of information revelation φ . It reaches its minimum in the fully informative trigger ($\varphi = 1$), when CoCos and equity are equivalent.*

Figure 2.12 shows the equivalence ratio is very sensitive to φ . As φ approaches zero, the substitution ratio becomes infinite.¹⁹ The substitution ratio increases with asset risk (for a given v_T).

The key efficiency factor for CoCos depends on the precision of the trigger to signal a state where incentives are poor, relatively to equity which is always risk bearing. When the trigger is less precise, conversion takes less often when required. As a result, a larger amount of CoCos must be used.

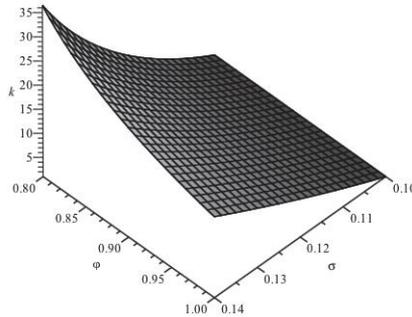


Figure 2.12: Substitution ratio between CoCos and equity for exogenous trigger price v_T

¹⁸As before, we set the trigger value to insure monotonic incentives in v , so $d = \frac{C}{v_T - D} = \frac{k\epsilon}{v^* - D}$.

¹⁹The graph assumes an uniform distribution and parameters $D = 0.93$, $z = 0.04$, $\delta = 0.07$, $\epsilon = 0.001$.

2.4.4 Debt with Warrants

In this section we compare the overall risk incentive of automatic conversion against the convertible bonds proposed by Green (1984) as a solution to risk shifting.

Convertible bonds, freely convertible in shares at maturity, dilute higher risk-shifting payoffs, as investors always convert when asset value is high at maturity. This reduces the attractiveness of high risk strategies.²⁰

There are three differences between CoCos and convertibles. First, conversion is not automatic. Bondholders have an option to convert into some amount of shares w . Second, the risky payoff in Green's model reflect a mean preserving spread.²¹ Finally, conversion there occurs, if at all, only at the final stage $t = 2$.

We compare their effectiveness in containing risk choices and compute an equivalence ratio with CoCos. Consider a bank with a face value ϵ of convertibles outstanding, and deposits $D - \epsilon$. Bondholders will convert into w shares at $t = 2$ only if they are worth more than ϵ , namely when $V_2 > D + \frac{\epsilon}{w}$.

As in Section 2, the banker chooses to control risk according to the schedule shown in Figure 2.13.

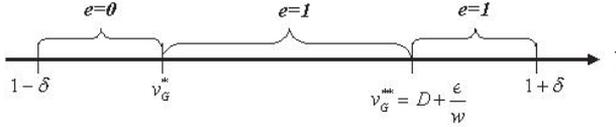


Figure 2.13: Risk incentives of bank with Green's convertibles

v_G^* and v_G^{**} are defined as:

$$\Delta(v_G^*) - \frac{w}{w+1} \cdot \gamma(v_G^* + \epsilon) - z = 0 \quad (2.16)$$

$$w \cdot (v_G^{**} - D - z + \Delta(v_G^{**}) - \gamma(v_G^{**} + \epsilon)) + \epsilon + z - \Delta(v_G^{**}) = 0 \quad (2.17)$$

The conversion ratio w is set optimally to ensure monotonicity of bank incentives, such that $D + \frac{\epsilon}{w} = v_G^{**}$. As in the basic model, by assumption we ensure the monotonicity of effort incentives in v .

Proposition 7. *The effect from CoCos on effort is stronger than from Green's convertibles for a sufficiently informative trigger, and certainly when $\varphi = 1$, as a lower amount is required to provide the same incentives. The substitution ratio k increases in a convex fashion with a lower trigger precision, and may become higher than 1.*

²⁰However, it relies on the counterintuitive notion of increasing bank equity in the best states, as opposed to the worse states. Voluntary conversion bonds also do not protect depositors, once the bank defaults.

²¹This could be easily introduced in our setting, provided we also add a (realistic) cost of bankruptcy.

2.5 Discussion and Conclusion

The paper assesses the optimal design of bank contingent capital. The literature so far has relied on models where the asset choice is exogenous, so CoCos have no effect on risk incentives. Pennacchi (2011) and Chen et al. (2013) study how CoCos terms affect credit yields. While not treating formally endogenous asset risk creation, their comparative statics analysis shows how conversion decreases shareholder returns in higher risk banks. Our contribution is to study explicitly contingent capital's effect on bank risk choices, a necessary feature for its optimal design and pricing.

We show that its effectiveness in controlling risk incentives and bankruptcy losses depends on the precision of its trigger in converting into equity in the worse incentive states, when leverage is very high. The intuition is that conversion contains risk shifting, as it dilutes high returns.

Our approach establishes how the optimal amount of CoCo and their trigger level trade off a risk reduction versus a dilution effect. It enables to assess what amount of CoCo produces an equivalent risk reduction as common equity, as well as freely convertible bonds. It helps clarify a key difference between bail in bonds, which convert in equity only in default, and going concern contingent capital which restore equity while the bank is still solvent. A one for one exchange ratio of CoCo for equity is equivalent in terms of loss absorption upon default. But once the risk prevention effect is taken into account, even optimally designed contingent capital is much less efficient than equity because of limited trigger precision, which does not ensure recapitalization in all states of excessive leverage.

Future research should focus on better understanding the effect of CoCo on share pricing, which is distorted by risk shifting. Share prices increase with bank risk when leverage is high, which may explain why Lehman shares peaked just a year before its default. For this reason, shareholder returns drop on conversion, creating multiple equilibria. This discontinuity, driven by the tendency of the share price to fall towards the trigger level once it comes in its neighborhood, is inappropriately named "death spiral". Yet it comes from the corrective effect of CoCo conversion on an underlying distortion (i.e, risk shifting), not from a distortion it introduces.

An open issue is whether potential CoCo conversion helps increase share pricing precision when leverage is excessive. Once CoCos are issued, the possibility of conversion may create downside risk. Were this to produce higher equity volatility, it would also enhance investor incentives to monitor bank risk.

2.6 Appendix

Relaxing the initial capital constraint

In our model we assume that for any interim asset value v , book equity is non-negative. In this case the choice of the safe asset always provides the banker with a positive return, equal to $v - D$. It is equivalent to the condition $1 - \delta - D \geq 0$.

However, if initial capital is low (the banker observes interim asset value $v < D$) and this condition does not hold, the banker's return to the safe asset changes and the banker has different incentives to exert effort. .

In case if conversion is not triggered $v \geq v_T = v^*$, the banker's return from the safe strategy is zero, and then chooses $e = 0$. If conversion is triggered $v \leq v_T = v^*$, the choice of the banker depends on v . If $v < D - C$, the banker's payoff from the safe asset is zero. If $v \geq D - C$, the banker's payoff is positive and equal to $\frac{v-D+C}{d+1}$.

The banker's program becomes:

$$\begin{aligned}
 & \max_e e \cdot \{I(v \geq D) \cdot \underbrace{[(v - D) \cdot (I(v \geq v_T) + (1 - \varphi) \cdot I(v < v_T))]}_{\text{equity value for } v \geq D \text{ if no conversion and } e=1} + \\
 & \quad \underbrace{\frac{v - D + C}{d + 1} \cdot \varphi \cdot I(v < v_T)}_{\text{equity value for } v \geq D \text{ if conversion and } e=1} + \\
 & \quad I(v < D) \cdot \underbrace{\frac{v - D + C}{d + 1} \cdot \varphi \cdot I(D - C < v < v_T)}_{\text{equity value for } v < D \text{ if conversion and } e=1} \} \\
 & (1 - e) \cdot \underbrace{[(v - z - D + \Delta(v)) \cdot (I(v \geq v_T) + (1 - \varphi) \cdot I(v < v_T))]}_{\text{equity value if no conversion and } e=0} + \\
 & \quad \underbrace{\frac{v - z - D + C + \Delta(v + C)}{d + 1} \cdot \varphi \cdot I(v < v_T)}_{\text{equity value if conversion and } e=0} \\
 & \text{s.t. } e \in \{0, 1\} \tag{2.18}
 \end{aligned}$$

We solve the problem assuming that $v_T = v^*$.

The banker's incentives change when either two conditions hold: (1) $v^* < D$ and (2) $v_C^* < D - C$.

If we don't impose any condition on $v - D$ and the conditions defined above hold, the

banker's effort choice is:

$$e = \begin{cases} 1 & \text{if } D < v \leq 1 + \delta \\ 0 & \text{if } v^* < v \leq D \\ 1 & \text{if } D - C < v \leq v^* \\ 0 & \text{if } 1 - \delta < v \leq D - C \end{cases} \quad (2.19)$$

As in the basic model, it is best to ensure monotonicity of e in v . In order to incentivize the banker to exert effort when $v^* < v \leq D$, the trigger value must be set as $v_T = D$.

As a result, when v may be below D , but $\forall v : v \geq D - C$, the banker's incentives don't change if the trigger value is set optimally: $v_T = D$. However, for all interim asset values v below $D - C$, risk incentives for bank with $v < D - C$ can not be improved.

Thus, our results will be valid for the weaker restriction of $v \geq D - C$. This leaves open the possibility of losses for depositors as V_2 may be below $D - C$.

Proof of Statement about Convex Risk Incentives

We consider two possible distribution of the asset value: normal and uniform.

In the first case let $x = V_2 - D$ be normally distributed with mean is $v - D - z$ and variance σ^2 . We refer to x as the difference between the value of assets and debt.

In the second case let $x = V_2 - D$ be uniformly distributed with support $[v - D - z - \sigma\sqrt{3}, v - D - z + \sigma\sqrt{3}]$, so that mean is $v - D - z$ and variance is σ^2 . We assume that the highest possible equity value when the bank takes the risky asset is positive, $v - D - z + \sigma\sqrt{3} \geq 0$. Otherwise, risky asset is never chosen. Moreover, the lowest possible capital value is negative $v - D - z - \sigma\sqrt{3} \leq 0$, else no risk shifting takes place.

The expected value of bank equity is the expected value of assets minus debt conditional on being solvent, multiplied by the probability of being solvent.

$$(1 - F(0, v)) \cdot \mathbf{E}(x|x > 0, v)$$

For a normal distribution, it is:

$$\begin{aligned} & \left(1 - \Phi\left(\frac{-(v - D - z)}{\sigma}\right)\right) \cdot \frac{\int_0^\infty x \cdot \frac{1}{\sigma} \cdot \phi\left(\frac{x - (v - D - z)}{\sigma}\right) dx}{1 - \Phi\left(\frac{-(v - D - z)}{\sigma}\right)} = \\ & \int_0^\infty x \cdot \frac{1}{\sigma} \cdot \phi\left(\frac{x - (v - D - z)}{\sigma}\right) dx = \\ & (v - D - z) \cdot \Phi\left(\frac{v - D - z}{\sigma}\right) + \sigma \cdot \phi\left(\frac{v - D - z}{\sigma}\right) \end{aligned}$$

For a uniform distribution:

$$(1 - F(0, v)) \cdot \mathbf{E}(x|x > 0, v) = \int_0^\infty x \cdot \frac{1}{2\sigma\sqrt{3}} dx = \frac{(v - D - z + \sigma\sqrt{3})^2}{4\sigma\sqrt{3}}$$

The expected value of equity in the case of risky asset is by definition the sum of unconditional mean of the value of asset minus debt $v - D - z$ and the risk taking incentives $\Delta(v)$ (the put option enjoyed by shareholders). Normal distribution:

$$\begin{aligned} \Delta(v) = & (1 - F(0, v)) \cdot \mathbf{E}(x|x > 0, v) - (v - D - z) = \\ & (v - D - z) \cdot \left[\Phi\left(\frac{v - D - z}{\sigma}\right) - 1 \right] + \sigma \cdot \phi\left(\frac{v - D - z}{\sigma}\right) \end{aligned}$$

Uniform distribution:

$$\Delta(v) = (1 - F(0, v)) \cdot \mathbf{E}(x|x > 0, v) - (v - D - z) = \frac{(v - D - z - \sigma\sqrt{3})^2}{4\sigma\sqrt{3}}$$

Consider now how the risk shifting incentive changes with interim asset value v . It is easy to show that under these distributions the derivative of the risk shifting incentive function with respect to v is negative. Normal distribution:

$$\frac{\partial \Delta(v)}{\partial v} = \Phi\left(\frac{v - D - z}{\sigma}\right) - 1 \leq 0$$

Uniform distribution:

$$\frac{\partial \Delta(v)}{\partial v} = \frac{2(v - D - z - \sigma\sqrt{3})}{4\sigma\sqrt{3}} \leq 0$$

Thus, the risk shifting incentive decrease with asset value v , or capital $v - D$.

The second derivative of function $\Delta(v)$ with respect to v is positive. Normal distribution:

$$\frac{\partial^2 \Delta(v)}{\partial v^2} = \phi\left(\frac{v - D - z}{\sigma}\right) \cdot \frac{1}{\sigma} \geq 0$$

Uniform distribution:

$$\frac{\partial^2 \Delta(v)}{\partial v^2} = \frac{1}{2\sigma\sqrt{3}} \geq 0$$

Thus, risk shifting incentives fall in a convex fashion with bank capital $v - D$.

Proof of Statement about risk incentives and exogenous risk

We look at how risk incentives change when volatility of risky asset grows. The derivative of risk shifting function with respect to σ is positive.

Normal distribution:

$$\frac{\partial \Delta(v)}{\partial \sigma} = \phi \left(\frac{(v - D - z)}{\sigma} \right) \geq 0$$

Uniform distribution:

$$\frac{\partial \Delta(v)}{\partial \sigma} = - \frac{(v - D - z - \sigma\sqrt{3}) \cdot (v - D - z + \sigma\sqrt{3})}{4\sqrt{3} \cdot \sigma^2} \geq 0$$

Thus, the risk shifting incentives increase with volatility of the risky asset.

And finally, we find the effect of difference in means of payoffs from safe and risky assets z on the risk shifting incentives. The derivative of risk shifting function with respect to z is:

Normal distribution:

$$\frac{\partial \Delta(v)}{\partial z} = - \left[\Phi \left(\frac{v - D - z}{\sigma} \right) - 1 \right] \geq 0$$

Uniform distribution:

$$\frac{\partial \Delta(v)}{\partial z} = - \frac{2(v - D - z - \sigma\sqrt{3})}{4\sigma\sqrt{3}} \geq 0$$

So, higher z leads to higher risk shifting incentives.

Proof of Lemma 1

First, we show that indeed the banker with interim leverage $v > v^*$ exerts effort. The banker solves the problem (2.5). Her decision depends on the whether the risk shifting incentive is higher or lower than the difference in means from safe and risky payoff z . If $\Delta(v) \leq z$, the banker exerts effort. According to the Assumption 1, the risk shifting incentive function $\Delta(v)$ is decreasing in v . Then our condition $\Delta(v) \leq z$ implies that the banker with interim asset value $v \geq \Delta^{-1}(z) \equiv v^*$ exerts effort.

Next we show that the probability that the banker controls risk ($\frac{1-\delta-v^*}{2\delta}$) decreases with the volatility of risky asset σ . The probability of risk control negatively depends on the magnitude v^* . Remember that v^* is derived from the condition $G(v, z, \sigma) \equiv \Delta(v) - z = 0$. We find the effect of σ on the critical value v^* using the implicit function theorem and computing

$$\frac{\partial v}{\partial \sigma} = - \frac{\partial G / \partial \sigma}{\partial G / \partial v}$$

where

$$\partial G / \partial \sigma = \Delta'_\sigma(v) \geq 0$$

and

$$\partial G / \partial v = \Delta'_v(v) \leq 0$$

As a result the derivative is $\frac{\partial v}{\partial \sigma} \geq 0$. The critical asset value v^* becomes higher if σ increases, since higher higher volatility provides larger risk-shifting benefits. Thus, the probability that the banker controls risk diminishes with σ .

Finally, note that the revelation of information does not have any effect on the banker's incentives. The reason is that information revelation makes market participants informed about the interim asset v , but does not change the incentives of the banker, since market does not have an instrument to affect the banker's payoff in case of high or low risk choice.

Proof of Lemma 2

In general, the effort choice is the solution to (2.8) and is:

$$\begin{aligned} \text{If } v_C^* < v_T, e = & \begin{cases} 1 & \text{if } v^* \leq v \leq 1 + \delta \\ 0 & \text{if } v_T < v < v^* \\ 1 & \text{if } v_C^* \leq v \leq v_T \\ 0 & \text{if } 1 - \delta \leq v < v_C^* \end{cases} \\ \text{If } v_C^* \geq v_T, e = & \begin{cases} 1 & \text{if } v \geq v^* \\ 0 & \text{otherwise} \end{cases} \end{aligned} \quad (2.20)$$

where equation (2.9) defines the critical value v_C^* .

Proof of Proposition 3

We show how asset volatility affects the chosen trigger value schedule $v_T = v^*$. Remember that in the Proof of Lemma 1, we already demonstrated that critical value v^* increases with the volatility of the risky asset σ . This result implies that the trigger value $v_T = v^*$ should be raised when volatility grows in order to avoid increased risk-shifting incentives.

Proof of Proposition 2

We demonstrate the effect of the amount of CoCos on the risk choice. First, we define the risk improvement effect as a difference between banker's payoff from safe and risky strategies, i.e

$\frac{\text{Safe payoff}-\text{Risky payoff}}{d+1}$, where $d = \frac{C}{v^*-D}$ is a fixed conversion ratio. The difference is then:

$$\begin{aligned} & \frac{v-D+C}{d+1} - \frac{v-D-z+C+\Delta(v+C)}{d+1} = \\ & \frac{(v-D+C) \cdot (v^*-D)}{v_D^*+C} - \frac{(v-D-z+C+\Delta(v+C)) \cdot (v^*-D)}{v^*-D+C} = \\ & \frac{(z-\Delta(v+C)) \cdot (v^*-D)}{v^*-D+C} \end{aligned} \quad (2.21)$$

The effect of CoCos on risk improvement is:

$$\begin{aligned} \frac{\partial \frac{(\text{Safe-Risky})}{d+1}}{\partial C} &= \frac{(v^*-D)[- \Delta'_C(v+C) + \Delta(v+C) - z]}{(v^*-D+C)^2} \\ &= \begin{cases} \geq 0 & \text{if } \Delta'_C(v+C) \leq \frac{\Delta(v+C)-z}{(v^*-D+C)^2} \\ < 0 & \text{otherwise} \end{cases} \end{aligned} \quad (2.22)$$

Thus, the effect of CoCos on the risk incentives may be positive or negative. It increases as interim asset value goes down:

$$\frac{\partial \frac{(\text{Safe-Risky})^2}{d+1}}{\partial C \partial v} = \frac{(v^*-D)[- \Delta''_{Cv}(v+C) \cdot (v^*-D+C) + \Delta'_v(v+C)]}{(v^*-D+C)^2} \leq 0 \quad (2.23)$$

Moreover, effect is always positive if $\Delta(v+C) - z \geq 0$, i.e $v < v^* - C$ (since $\Delta'_C(v+C)$ is negative, inequality $\Delta'_C(v+C) \leq \frac{\Delta(v+C)-z}{(v^*-D+C)^2}$ always holds if the right hand side is positive).

To disentangle the risk reducing effect, we assume no value transfer between equity and CoCos. It is achieved only if dilution ratio depends on the asset value, i.e $d_C = \frac{C}{\mathbf{E}(V_2-D+C|V_2>D-C)}$:

$$d_C = \begin{cases} \frac{C}{v-D} & \text{if safe strategy} \\ \frac{C}{v-D-z+\Delta(V+C)} & \text{if risky strategy} \end{cases}$$

Given these dilution ratios, we demonstrate that the effect of CoCos on risk improvement

is always positive if there is no value transfer:

$$\frac{\text{Safe-Risky}}{d_C + 1} = v - D - (v - D - z + \Delta(v + C)) \quad (2.24)$$

$$\frac{\partial \frac{\text{Safe-Risky}}{d_C + 1}}{\partial C} = -\Delta'_C(v + C) \geq 0 \quad (2.25)$$

Indeed, without value transfer the effect of CoCos on the risk incentives is always positive. It decreases as the interim asset value grows:

$$\frac{\partial \frac{\text{Safe-Risky}^2}{d_C + 1}}{\partial C \partial v} = -\Delta''_{Cv}(v + C) \leq 0 \quad (2.26)$$

Only value transfer from CoCo to equity produces negative effect which is more pronounced for low levered banks (CoCo dilution effect is larger for banks with higher asset value):

$$\frac{\partial \left[\frac{\text{Safe-Risky}}{d+1} - \frac{\text{Safe-Risky}}{d_C+1} \right]}{\partial C} = \frac{C \Delta'_C(v + C)}{v^* - D + C} + \frac{(\Delta(v + C) - z) \cdot (v^* - D)}{(v^* - D + C)^2} \quad (2.27)$$

If v is high enough, i.e $v > v^* - C$ ($\Delta(v + C) - z < 0$), the effect is negative.

Equity Dilution and CoCo Dilution Effects: Numerical Example

Consider a bank with debt $D = 95$ and initial assets $V_0 = 100$. The risky asset return V_2 follows the binomial distribution:

$$V_2 = \begin{cases} v + 5 & \text{with prob } \frac{1}{2} \\ v - 10 & \text{with prob } \frac{1}{2} \end{cases}$$

Model parameters take values: $\varphi = 0.5$, $\delta = 5$, $z = 2.5$, $\sigma = 7.5$.

In the absence of CoCos bank with $v < v^* = 100$ does not control risk, i.e bank controls risk with probability 0.5.

Next we introduce CoCos of amount $C_L = 2.5$, and then show how the banker's incentives change if the amount of CoCos increases up to $C_H = 5$. The trigger value is $v^* = 100$.

First, consider the case of $C_L = 2.5$. The conversion ratio is $d_L = 0.5$. Payoff from $e = 1$ is:

$$\varphi \cdot \frac{v - D + C_L}{d_L + 1} + (1 - \varphi) \cdot (v - D) = 0.5 \cdot \frac{v - 92.5}{1.5} + 0.5 \cdot (v - 95)$$

Payoff from $e = 0$ is:

$$\varphi \cdot \frac{1}{2} \cdot \frac{v + 5 - D + C_L}{d_L + 1} + (1 - \varphi) \cdot \frac{1}{2} \cdot (v + 5 - D) = 0.25 \cdot \frac{v - 87.5}{1.5} + 0.25 \cdot (v - 90)$$

Bank with $v > v_C^* = 99$ chooses to control risk in the presence of CoCos $C_L = 2.5$, i.e bank controls risk with probability 0.6.

Second, consider the case of $C_H = 5$. The conversion ratio is $d_H = \frac{1}{2}$. Then the payoffs from safe and risky strategies are respectively:

Payoff from $e = 1$ is:

$$\varphi \cdot \frac{v - D + C_L}{d_L + 1} + (1 - \varphi) \cdot (v - D) = 0.5 \cdot \frac{v - 90}{2} + 0.5 \cdot (v - 95)$$

Payoff from $e = 0$ is:

$$\varphi \cdot \frac{1}{2} \cdot \frac{v + 5 - D + C_L}{d_L + 1} + (1 - \varphi) \cdot \frac{1}{2} \cdot (v + 5 - D) = 0.25 \cdot \frac{v - 85}{2} + 0.25 \cdot (v - 90)$$

Bank with $v > v_C^* = 98.33$ chooses to control risk when CoCos is $C_H = 5$.

Next, we disentangle equity dilution effect from the overall effect of CoCos increase. We make the conversion ratio such that it ensures no value transfer in order to disentangle equity dilution and CoCo dilution effects. Instead of $d_H = 1$ we use:

$$d_C = \begin{cases} \frac{C}{v-D} = \frac{5}{v-95} & \text{if safe strategy} \\ \frac{C}{\mathbb{E}(V_2 - D + C | V_2 > D - C) - C} = \frac{10}{v-95} & \text{if risky strategy} \end{cases}$$

Payoff from $e = 1$ is:

$$\varphi \cdot \frac{(v - D + C_H) \cdot (v - D)}{v - D + C_H} + (1 - \varphi) \cdot (v - D) = v - 95$$

Payoff from $e = 0$ is:

$$\varphi \cdot \frac{1}{2} \cdot \frac{(v + 5 - D + C_H)}{d_C + 1} + (1 - \varphi) \cdot \frac{1}{2} \cdot (v + 5 - D) = 0.25 \cdot (v - 95) + 0.25 \cdot (v - 90)$$

If there were no value transfer to shareholders, bank with $v > v_C^* = 97.5$ would choose to control risk in the presence of CoCos $C_H = 5$. The effort improvement would be 0.15 due to the increase in CoCos from 2.5 to 5. This risk reduction arises because equity dilution reduces attractiveness of the risky payoff. We refer to this effect as equity dilution effect.

Because of lower conversion ratio d_H , the dilution is at the disadvantage of CoCo holders and advantage of shareholders. The effort improvement becomes lower.

CoCo dilution effect disincentives the banker to control risk. This effect is measured as the reduction in effort improvement of 0.083.

Thus, equity dilution effect raises the probability of bank controlling risk to 0.75 (effort improvement of 0.25), whereas CoCo dilution effect reduces this probability to 0.667 (effort decrease by -0.083). Overall effect from increasing the amount of CoCos from 2.5 to 5 is the expected effort increase by 0.067.

Proof of Proposition 3

The maximum improvement in effort is achieved when threshold for bank with CoCos v_C^* reaches its minimum. The condition for optimal amount of CoCos generating minimum v_C^* (this increases the probability of bank exerting higher effort, and thus expected effort improvement) is:

$$\frac{\partial v_C^*}{\partial C} = 0$$

We use the implicit function theorem to compute this derivative:

$$\frac{\partial v_C^*}{\partial C} = - \frac{\partial F / \partial C}{\partial F / \partial v_C^*}$$

where²²

$$\frac{\partial F}{\partial C} = \frac{\varphi(v_T - D) (\Delta'_C(v + C) \cdot (C + v_T - D) - \Delta(v + C) + z)}{(C + v_T - D)^2}$$

$$\frac{\partial F}{\partial v} = \frac{\varphi(v_T - D)}{C + v_T - D} \cdot \Delta'_v(v + C) + (1 - \varphi) \cdot \Delta'(v)$$

The resulting condition is then:

$$\frac{\partial v_C^*}{\partial C} = - \frac{\varphi(v_T - D) (\Delta'_C(v + C) \cdot (C + v_T - D) - \Delta(v + C) + z)}{(C + v_T - D)^2 \cdot \left(\frac{\varphi(v_T - D)}{C + v_T - D} \cdot \Delta'_v(v + C) + (1 - \varphi) \cdot \Delta'(v) \right)} = 0$$

From here the condition for the amount of CoCos C guaranteeing the minimum v_C^* is:

$$\Delta'_C(v + C^*)(C^* + v_T - D) - \Delta(v + C^*) + z = 0$$

where $v_T = v^*$. Note that we treat the solution of this equation as the amount of CoCos providing the minimum v_C^* , since we know that at $C = 0$, the function $v_C^*(C)$ is decreasing,

²²Further we use just v instead of v_C^* .

and at $C = \infty$ it is constant. This suggests the existence of at least one minimum point.

$$\lim_{C \rightarrow 0} \frac{\partial v_C^*}{\partial C} = -\frac{\varphi (\Delta'_C(v) \cdot (v_T - D) - \Delta(v) + z)}{(v_T - D) \cdot \Delta'_v(v)} \leq 0$$

$$\lim_{C \rightarrow +\infty} \frac{\partial v_C^*}{\partial C} = 0$$

Proof of Lemma 4

The marginal rate of substitution between the optimal amount of CoCos and the optimal is positive:

$$\frac{\partial C^*}{\partial v_T} = -\frac{\Delta'_C(v + C)}{\Delta'_C(v + C)(C + v_T - D)} > 0 \quad (2.28)$$

Proof of Proposition 4

We show the effect of volatility σ on the effort improvement $\frac{v^* - v_C^*}{2\delta}$ upon assumption that the trigger value v_T is exogenous. We need to find the effect of σ on the critical value v_C^* , i.e. compute $\frac{\partial v_C^*}{\partial \sigma}$. Using the implicit function theorem, we define it as:

$$\frac{\partial v_C^*}{\partial \sigma} = -\frac{\partial F / \partial \sigma}{\partial F / \partial v}$$

where we use the result $\frac{\partial F}{\partial v} \leq 0$ from the proof of proposition 3, and

$$\frac{\partial F}{\partial \sigma} = \frac{\varphi}{d + 1} \cdot \Delta'_\sigma(v + C) + (1 - \varphi) \cdot \Delta'_\sigma(v) \geq 0$$

where we exploit the assumption 1 that $\Delta'_\sigma \geq 0$. Thus, $\frac{\partial v_C^*}{\partial \sigma} \geq 0$.

Consequently, the effect of the asset volatility on the expected effort improvement $\frac{v_T - v_C^*}{2\delta}$ is negative given that the trigger value is exogenously given.

Proof of Lemma 5

Next we examine the marginal effect from setting trigger value $v_T = v^*$ on effort. This effect consists of two: the effect on v^* as an upper bound of interim asset value for which the conversion takes place, and the effect of v^* on the v_C^* via dilution ratio d .

First effect is positive, as we already established in the proof of Lemma 1, that critical value v^* increases with the volatility of the risky asset σ .

Second effect is also positive for the expected effort:

$$\frac{\partial v_C^*}{\partial \sigma} = \frac{\partial v_C^*}{\partial d} \cdot \frac{\partial d}{\partial \sigma} = -\frac{\frac{\partial F}{\partial d}}{\frac{\partial F}{\partial v}} \cdot \frac{\partial d}{\partial \sigma} = -\underbrace{\frac{-\frac{\varphi(\Delta(v_C^*+C)-z)}{(d+1)^2}}{\frac{\varphi}{d+1} \cdot \Delta'_v(v+C) + (1-\varphi) \cdot \Delta'(v)}}_{\geq 0} \cdot \underbrace{\frac{-Cv_\sigma^*}{(v^*-D)^2}}_{\leq 0} \leq 0$$

Since volatility increases trigger value v^* , the dilution ratio diminishes. This leads to the lower critical value v_C^* .

Thus, the marginal effect is positive, and setting trigger value to be v^* reduces the negative effect of volatility on the expected effort (achieved with exogenous trigger price).

However, the sign of the overall effect is undefined and depends on the parameters:

$$\frac{\partial \frac{v^*-v_C^*}{2\delta}}{\partial \sigma} = \frac{1}{2\delta} \cdot \left[\underbrace{v_\sigma^* \cdot \left(1 + \frac{\varphi d(\Delta(v_C^*+C)-z)}{\frac{\partial F}{\partial v}(v^*-D)(d+1)^2} \right)}_{\geq 0} + \underbrace{\frac{\frac{\varphi \cdot \Delta'_\sigma(v_C^*+C)}{d+1} + (1-\varphi)\Delta'_\sigma(v)}{\frac{\partial F}{\partial v}}}_{\leq 0} \right]$$

As a result, the overall effect of σ on effort may also become positive.

Proof of Lemma 6

Here we look at the effect of the higher trigger precision on the expected effort $\frac{v^*-v_C^*}{2\delta}$. The sign of the effect is opposite to the sign of the derivative $\frac{\partial v_C^*}{\partial \varphi} = -\frac{\frac{\partial F}{\partial \varphi}}{\frac{\partial F}{\partial v_C^*}}$, where $\frac{\partial F}{\partial v_C^*} \leq 0$

$$\frac{\partial F}{\partial \varphi} = \underbrace{\frac{\Delta(v+C)-z}{d+1}}_{\leq 0} + \underbrace{(z-\Delta(v))}_{\leq 0} \leq 0$$

The derivative $\frac{\partial v_C^*}{\partial \varphi}$ is negative, therefore the effect of probability of information revelation on the expected effort is positive. Note that critical asset value v^* is not affected by φ according to the results of Lemma 1.

Proof of Proposition 5

In order to show that banker never chooses to issue CoCos voluntarily instead of deposits, we compare the price of CoCos P_C and the price of deposits. Thus, we show that funding with CoCos (face value C) is more expensive than with deposits of the same face value.

Price of deposits is equal to their face value C , since depositors get their money back with certainty and deposit rate is zero.

We show that priced of CoCos is lower than C , i.e $P_C \leq C$.

$$\begin{aligned}
P_C = & \underbrace{\varphi \cdot \left[\underbrace{Prob(v > v^*) \cdot C}_{\text{safe strategy, no conversion}} + \underbrace{Prob(v_C^* < v \leq v^*) \cdot \frac{d}{d+1} \cdot \mathbf{E}(v - D + C | v_C^* < v \leq v^*)}_{\text{safe strategy, conversion}} \right]}_{\text{if information is revealed}} + \\
& \underbrace{Prob(v \leq v_C^*) \cdot \frac{d}{d+1} \cdot Prob(V_2 > D - C) \cdot \mathbf{E}(V_2 - D + C | V_2 > D - C, v \leq v_C^*)}_{\text{if information is revealed}} + \\
& \underbrace{(1 - \varphi) \left[\underbrace{Prob(v \geq v_C^*) \cdot C}_{\text{safe strategy}} + \underbrace{Prob(v < v_C^*) \cdot \mathbf{E}(B | v < v_C^*)}_{\text{risky strategy}} \right]}_{\text{if information is not revealed}} \quad (2.29)
\end{aligned}$$

First, if information is not revealed, CoCos gets not higher than the face value, since in case of $D - C \leq V_2 \leq D$, they may get the value of the bond B , which is lower than face value C :

$$B = Prob(V_2 \geq D, v) \cdot C + Prob(D - C \leq V_2 < D, v) \cdot \mathbf{E}(V_2 - D + C | D - C \leq V_2 \leq D, v)$$

The reason is that $\mathbf{E}(V_2 - D + C | D - C \leq V_2 \leq D, v) \leq C$.

Second, if information is revealed and there is no conversion, CoCos receive the face value. If there is a conversion, and safe strategy is chosen by the banker, CoCos get for $v_C^* < v \leq v^*$

$$\frac{d}{d+1} \cdot (v - D + C) = \frac{\frac{C}{v^* - D}}{\frac{C}{v^* - D} + 1} \cdot (v - D + C) = C \cdot \frac{v - D + C}{v^* - D + C} \leq C \quad (2.30)$$

If banker chooses risky strategy and conversion occurs ($v \leq v_C^*$), CoCo's payoff is:

$$\begin{aligned}
& \frac{d}{d+1} \cdot Prob(V_2 > D - C) \cdot \mathbf{E}(V_2 - D + C | V_2 > D - C, v \leq v_C^*) = \\
& \frac{C}{v^* - D + C} \cdot (v - D - z + \Delta(v + C) + C) \leq C \quad (2.31)
\end{aligned}$$

since $v^* - D + C \geq v - D - z + \Delta(v + C) + C$ due to $\Delta(v + C) - z \leq v^* - v$.

Thus, in any possible case the value of CoCos does not exceed their face value C , and banker considers it more expensive funding option than deposits.

Proof of Proposition 6

The banker's program with extra equity is:

$$\begin{aligned} & \max_e e \cdot (v - D + \epsilon) + (1 - e) \cdot (v - D + \epsilon - z + \Delta(v + \epsilon)) \\ & \text{s.t. } e \in \{0, 1\} \end{aligned} \quad (2.32)$$

In order to compute the substitution ratio k , we use the condition for finding v_C^* :

$$G(v^* - \epsilon | k\epsilon, d) = 0$$

or equivalently

$$\frac{\varphi}{d+1} \cdot \Delta[v^* + \epsilon(k-1)] + (1-\varphi) \cdot \Delta[v^* - \epsilon] - z \left(1 - \varphi + \frac{\varphi}{d+1} \right) = 0 \quad (2.33)$$

Here we prove that $k \geq 1$. The proof is by contradiction. Assume that $k < 1$. We can rewrite condition (2.33) as

$$\frac{\varphi}{d+1} \cdot (\Delta[v^* + \epsilon(k-1)] - z) + (1-\varphi) \cdot (\Delta[v^* - \epsilon] - z) = 0$$

Note that $\Delta[v^* - \epsilon] \geq z$, since banker with $v < v^*$ does not exert effort. Since the whole expression is equal to zero, and the second term is non-negative, the first term should be non-positive. Hence,

$$\frac{\varphi}{d+1} \cdot (\Delta[v^* + \epsilon(k-1)] - z) \leq 0$$

The expression above is non-positive only if

$$\Delta[v^* + \epsilon(k-1)] - z \leq 0$$

The risk shifting incentive is smaller than or equal to z only if $v \geq v^*$. And if $k < 1$, then $v^* + \epsilon(k-1) < v^*$. This is a contradiction. Consequently, it always holds that $k \geq 1$, and higher amount of CoCos is required to provide the same effect as equity.

Proof of Lemma 7

In order to show the effect of the probability of information revelation on the substitution ratio k , we compute first and second derivatives of k with respect to φ : $\frac{\partial k}{\partial \varphi}$ and $\frac{\partial^2 k}{\partial \varphi^2}$. We apply the implicit function theorem to the condition $G(v^* - \epsilon | k\epsilon, d) = 0$. We rewrite it using the

fact that $d = \frac{k\epsilon}{v^* - D}$:

$$\frac{\varphi \cdot (v^* - D)}{k\epsilon + v^* - D} \cdot (\Delta[v^* + \epsilon(k - 1)] - z) + (1 - \varphi) \cdot (\Delta[v^* - \epsilon] - z) = 0$$

According to the implicit function theorem:

$$\frac{\partial k}{\partial \varphi} = - \frac{\partial G(v^* - \epsilon | k\epsilon, d) / \partial \varphi}{\partial G(v^* - \epsilon | k\epsilon, d) / \partial k}$$

where $\frac{\partial G(v^* - \epsilon | k\epsilon, d)}{\partial k}$ equals to

$$\frac{\varphi \cdot (v^* - D) \cdot \epsilon}{(k\epsilon + v^* - D)^2} \cdot \left(\underbrace{(k\epsilon + v^* - D) \cdot \Delta'_k[v^* + \epsilon(k - 1)]}_{\leq 0} - \underbrace{(\Delta[v^* + \epsilon(k - 1)] - z)}_{\leq 0} \right)$$

which is non-positive for infinitesimal ϵ .

$$\frac{\partial G(v^* - \epsilon | k\epsilon, d)}{\partial \varphi} = \underbrace{\frac{(v^* - D)}{k\epsilon + v^* - D} \cdot (\Delta[v^* + \epsilon(k - 1)] - z)}_{\leq 0} + \underbrace{(z - \Delta[v^* - \epsilon])}_{\leq 0} \leq 0$$

Thus, the substitution ratio falls as probability of revelation rises $\frac{\partial k}{\partial \varphi} \leq 0$.

Next, consider the second derivative of substitution ratio with respect to φ :

$$\frac{\partial^2 k}{\partial \varphi^2} = - \frac{(-1) \cdot \frac{\partial G}{\partial \varphi}}{\frac{(v^* - D) \cdot \epsilon}{(k\epsilon + v^* - D)^2} \cdot (\Delta'_k[v^* + \epsilon(k - 1)] \cdot (k\epsilon + v^* - D) - (\Delta[v^* + \epsilon(k - 1)] - z))} \geq 0$$

This result implies that the substitution ratio k is decreasing and convex function of the probability of information revelation φ .

Proof of Proposition 7

The banker's payoff from the risky strategy is lower than in the case of non-convertible debt by the value of the call option held by the bondholders, which we denote as $\frac{w}{w+1} \cdot \gamma(v + \epsilon)$:

$$v - z - D + \Delta(v) - \frac{w}{w+1} \cdot \gamma(v + \epsilon) \quad (2.34)$$

where the value of the call option:

$$\frac{w}{w+1} \cdot \gamma(v + \epsilon) = \frac{w}{w+1} \cdot (1 - F(D + \frac{\epsilon}{w} - v)) \cdot \mathbf{E}(V_2 - D | V_2 - D > \frac{\epsilon}{w}) \quad (2.35)$$

is positive and increasing in v .

If the interim asset value is high ($v > D + \frac{\epsilon}{w}$), shareholders will choose to convert at the final date. The banker's return from the safe strategy becomes then $\frac{v-D+\epsilon}{w+1}$. If $v \leq D + \frac{\epsilon}{w}$, the banker's payoff from the safe strategy is the same as in the case of non-convertible debt $v - D$.

The banker's problem is:

$$\begin{aligned} \max_e e \cdot \underbrace{\left[(v - D) \cdot I(v \leq D + \frac{\epsilon}{w}) \right]}_{\text{equity value if } e=1, \text{ no conversion}} + \underbrace{\left[\frac{v - D + \epsilon}{w + 1} \cdot I(v > D + \frac{\epsilon}{w}) \right]}_{\text{equity value if } e=1, \text{ conversion occurs}} + \\ (1 - e) \cdot \underbrace{\left[v - z - D + \Delta(v) - \frac{w}{w + 1} \cdot \gamma(v + \epsilon) \right]}_{\text{equity value if } e=0} \\ \text{s.t. } e \in \{0, 1\} \end{aligned} \quad (2.36)$$

The banker chooses effort according to the schedule:

$$\begin{aligned} \text{If } v_G^{**} > D + \frac{\epsilon}{w}, e = \begin{cases} 1 & \text{if } v \geq v_G^{**} \\ 0 & \text{if } D + \frac{\epsilon}{w} \leq v < v_G^{**} \\ 1 & \text{if } v_G^* \leq v < D + \frac{\epsilon}{w} \\ 0 & \text{if } v < v_G^* \end{cases} \\ \text{If } v_G^{**} < D + \frac{\epsilon}{w}, e = \begin{cases} 1 & \text{if } v \geq D + \frac{\epsilon}{w} \\ 0 & \text{if otherwise} \end{cases} \end{aligned} \quad (2.37)$$

We show here that the equivalence ratio between CoCos and Green's convertible bonds is lower than 1 ($k \leq 1$), which implies stronger effect on effort is produced by CoCos.

The condition for the equivalent effect from CoCos and Green's convertibles is:

$$G(D + \frac{\epsilon}{w} | k\epsilon, d) = 0 \quad (2.38)$$

or equivalently,

$$\frac{\varphi}{d+1} \cdot (\Delta[D + \epsilon(k + \frac{1}{w})] - z) + (1 - \varphi) \cdot (\Delta[D + \frac{\epsilon}{w}] - z) = 0 \quad (2.39)$$

Note that $D + \epsilon(k + \frac{1}{w}) \geq D + \frac{\epsilon}{w}$, when $k \geq 0$. For the equality (2.39) to hold, we need one part of the equation to be positive and another negative. $\Delta(v) - z$ is positive for $v < v^*$, and negative for $v > v^*$. This implies that $D + \epsilon(k + \frac{1}{w}) > v^*$ and $D + \frac{\epsilon}{w} < v^*$. This implies that for $\varphi = 1$, the equivalence condition is:

$$\begin{aligned}
v^* - k\epsilon &= D + \frac{\epsilon}{w} \\
k &\geq \frac{v^* - D}{\epsilon} - \frac{1}{w}
\end{aligned}
\tag{2.40}$$

We proof by contradiction. Assume that $k > 1$. Then it implies that $\frac{v^* - D}{\epsilon} - \frac{1}{w} > 1$, which is equivalent to $w(v^* - D - 1) < \epsilon$. This is contradiction, since $v^* < 1$ ($v_T < 1$), $v^* - D - 1 < 0$, but $\epsilon > 0$ by construction. As a result, $k \leq 1$ for $\varphi = 1$.

Chapter 3

Internal Asset Transfers and Risk-Taking in Financial Conglomerates

3.1 Introduction

The period preceding the financial crisis of 2007-2008 was characterized by large scale asset securitization and loose financial regulation (Kashyap et al., 2008, Brunnermeier, 2009). These two factors contributed to a credit expansion via loan securitization (Shin, 2009), facilitating the rapid growth of large banking groups. The size and interconnectedness of those groups made them systemically important, increasing the chance of government support in case of trouble.

During the crisis, many institutions which ran into trouble were financial conglomerates, i.e. holding companies comprised of banks and non-bank institutions such as investment or insurance companies (Squam Lake Report, 2010). In the US a number of financial conglomerates were rescued by the Troubled Asset Relief Program (TARP), whereas Citigroup and Bank of America received equity infusions. In Europe, large groups like Fortis, ING, ABN Amro, RBS and Lloyds Bank also had to be saved.

Many observers claim that loan securitization led to excessive risk taking by banks, as risky loans were sold by banks off balance sheet (Duffie, 2008).¹ In the case of internal transfers in financial conglomerates however, the effect of securitization on their risk profile is not obvious. After all, internal capital market should allow a monitored allocation of financial resources by reducing information asymmetry (Williamson, 1975; Gertner et al., 1994). In contrast, internal risk shifts in conglomerates may induce more risk-taking by banks due to the government guarantee on their deposits. A good example may be the intention of Morgan Stanley in May 2012 "to shift a large chunk of its \$52tn derivatives portfolio into the part of the group backed by customer deposits" (Financial Times, 2012). This could allow Morgan

¹Interestingly, banks retained a large fraction of originated loans (Acharya and Richardson, 2009).

Stanley to lower its funding cost and subsequently to boost its earnings by 5-25 cents per share.

This paper studies the effect of securitization on bank risk taking incentives in financial conglomerates², recognizing the government's implicit support granted to banks.

We compare the monitoring and risk allocation decisions in standalone banks and in financial conglomerates. Our model shows that bankers in financial conglomerates are tempted to transfer the safest assets to their non-bank counterpart, gambling on the riskiest assets. At the same time this value transfer encourages bankers to monitor assets better. Standalone banks hold the safest loans and sell the riskiest, but have lower incentives to monitor them. Based on these findings, the paper underlines implications for the regulation of standalone and conglomerate banks.

Our securitization model builds on Pennacchi (1988), where monitoring improves bank returns on loans and loan sale is limited by the degree of moral hazard. In our model, bank assets are opaque. A bank is subject to capital requirements and deposit insurance guarantee. Loan sale enables the bank to save on the cost of capital, but takes place under asymmetric information. Investors buying those assets are financed by debt and do not have access to the deposit insurance guarantee.

The model endogenizes the bank choice of risk control and its allocation across conglomerate affiliates via loan sales. It focuses on credit risk monitoring after loan origination. Monitoring can boost loan return and provides information about its quality.

The model shows that credit risk monitoring takes place only for sufficiently high capital requirement both in a conglomerate and in a standalone bank, without which either bank is tempted to gamble. This is the basic risk shifting result under deposit insurance, also known as the Merton put (Merton, 1977).

Next, the internal sale in the conglomerate is contrasted with conditions of the market sale by a standalone bank. A standalone bank sells the riskiest loans from the originated loan pool to rational market investors. It receives a fair price for arm-length sales of riskiest loans. To be able to sell loans to the market, a standalone bank must retain a fraction thereof to credibly commit to monitoring.³ In the case of low capital requirements, it cannot credibly commit to monitoring as it still has too little at stake. A standalone bank keeps its non-monitored loans to gamble on good outcome, as the market would discount its sales. Here the debt overhang effect reduces the gain to monitor and leads the bank to exploit its deposit insurance guarantee.

Our main result concerns the value transfer incentives in a conglomerate. A conglomerate bank cherry-picks the safest loans, and transfers them to its non-bank counterpart at the

²We define here a conglomerate as a bank holding where each member may fail independently, thus making it ring-fenced as suggested by Vickers' report (2011).

³The result is similar to Gorton and Pennacchi (1995), which shows that a loan sales contract requires a bank to maintain some share of loan risk.

market price. Unlike in an arm's length transaction, this price is below their fair value. As a result, a conglomerate bank transfers value to its affiliate. It is left with the riskiest assets and gambles on them, maximizing the value of deposit insurance subsidy. This is a *value transfer effect*.

In a financial conglomerate, monitoring incentives for loans sold internally are better than in a standalone bank. It monitors its loans even for low bank capital, when a standalone bank cannot commit to monitoring any more. Precisely because of the value transfer incentive, it always monitors the loans when selling them to its affiliate. Thus, the incentive to retain risk encourages a conglomerate bank to monitor its loans. This is termed as *monitoring effect*.

When capital requirement is high, all banks have enough incentives to monitor their loans, although a conglomerate bank retains worse assets. Setting a higher capital requirement decreases the value of a deposit insurance subsidy, but does not improve a conglomerate bank's value transfer incentives. If the capital requirement is low, a conglomerate bank may be safer than a standalone bank due to better monitoring incentives.

This paper can contribute to the debate on structural reforms, and specifically on the Vickers Commission's proposal that suggests to ring-fence retail banking activities, imposing higher bank capital requirements. Our model suggests that some risk incentives are not addressed in the proposal, highlighting the possible value transfer effect in conglomerate banks even when subject to ring-fencing. It also shows that a higher bank capital requirement cannot be used as the only tool to discourage conglomerates from transferring safer assets out of conglomerate banks. Specific restrictions on transfers in conglomerates are needed, in addition to the prudential regulation of financial conglomerates.

Section 2 provides a literature review. Section 3 presents the basic model setup. Section 4 studies the equilibrium in the market for securitized assets and the resulting monitoring and selling decisions of the standalone bank and the conglomerate bank. Section 5 explores the optimal regulatory policy. Section 6 concludes. All proofs are in the Appendix.

3.2 Literature Review

The paper refers to the theoretical literature on bank risk taking and the internal capital markets.

The models of financial conglomeration differentiate between integrated conglomerates and holding companies. Financial conglomerates with a holding structure consist of separate entities subject to different regulation. These entities can fail independently, and their activities are ring-fenced. Freixas et al. (2007) argue that capital arbitrage within the holding reduces the reach of the safety net, raises market discipline and thus increases welfare.

An integrated conglomerate operates as one legal entity and has a single balance sheet. As a consequence, regulatory bodies impose capital restrictions on the whole conglomerate, not

on its divisions. Integrated conglomerates can benefit from the risk reduction resulting from diversification. However, Dewatripont and Mitchell (2005) argue that extending the reach of the deposit insurance safety net to a non-bank division may increase risk incentives and reduce market discipline⁴.

In contrast to Dewatripont and Mitchell (2005), our paper abstracts from the diversification argument. Instead, it focuses on the internal transfer of risk in conglomerates with a holding structure as in Freixas et al. (2007).

Our model is close to Kahn and Winton (2004), who point to the incentives of financial institutions to separate risky assets from safe ones in different entities. The reason behind this is the reduction of the default costs. Their findings can be extended to the idea that the riskiest loans would be allocated to the financial institution with assets subject to deposit insurance.

Another effect highlighted in our model is the minimization of the cost of bank capital via its assets transfer. This effect resembles the finding by Kojien and Yogo (2013). They show that insurance companies transfer their liabilities to the affiliated reinsurer which operates under more favorable capital regulation. There the presence of a state-guaranteed fund encourages higher leverage in the insurance company, while such a transfer enables the increase in leverage.

We look at the value transfer from a bank with deposit insurance and higher capital requirement. A main contribution of our model is the interaction between a bank's monitoring choice and the risk allocation decision via loan sale, yielding the result that opportunistic value transfer helps improving monitoring incentives.

The literature on the internal capital markets focuses on the issues of investment efficiency and riskiness in non-financial conglomerates. Scharfstein and Stein (2000) emphasize the inefficiency of the internal capital market due to managerial rent-seeking, whereas Stein (1997) shows that better control by headquarters improves allocation of scarce resources among projects in conglomerates.

To the best of our knowledge, value transfers in financial conglomerates have not been studied empirically. The available empirical research studies the effect of internal capital markets on credit volume in headquarters and bank subsidiaries, as in Houston et al. (1997). However, there are some closely related studies on credit value transfer from banks to their asset-backed commercial paper conduits. Acharya et al. (2013) show that securitization provided little real value transfer, since the explicit guarantees on securitized assets provided recourse to banks' balance sheets. Such a transfer may eliminate the lemon premium in the market for securitized loans while saving on bank cost of capital (Duffie, 2008). However, this structure allows selective risk accumulation in banks. Similarly, in our model, the conglomerate bank shifts the worse risk to deposit insurance while its affiliate, which is

⁴This result is in line with Boot and Schmeits (2000), where in the absence of deposit insurance, higher diversification benefits decrease the sensitivity of a financial conglomerate's cash flows to the investment decisions of a conglomerate's divisions, and as a result, market discipline is reduced.

subject to market discipline, enjoys safer assets (in the case of conduits, guarantees).

3.3 Model

The model has two dates ($t = 0, 1$), no discounting, and universal risk neutrality. There are two active agents: bankers and investors.

The bank is funded by capital k and deposits $1 - k$. k is a capital requirement imposed by the regulator⁵. The banker invests his wealth k with opportunity cost δ in bank equity, and is the sole owner of the bank. Deposits are protected by deposit insurance.

At date $t = 0$ the banker originates loans of size 1. There are two types of loans: a fraction $\theta \in (0, 1]$ is risky, while $1 - \theta$ is safe. Loan credit risk can only be assessed after loan origination by monitoring to reveal the quality of each loan in the pool. The banker decides on monitoring at $t = 0$. Monitoring incurs non-pecuniary effort with cost c , also paid at $t = 0$.

Monitoring improves expected loan return. Under monitoring ($m = 1$), the risky loan repays R with probability p and 0 otherwise, whereas safe loan repays R with certainty. Risky loans have perfectly correlated outcomes. Expected return from the pool of loans is thus:

$$\Pi_1 \equiv R(1 - \theta + p\theta). \quad (3.1)$$

If the banker does not monitor ($m = 0$), risky loan repays less likely with probability βp , where $\beta < 1$, whereas safe loan return will remain the same. The expected return from all unmonitored pool is then:

$$\Pi_0 \equiv R(1 - \theta + \beta p\theta). \quad (3.2)$$

Net present value of a monitored risky loan is positive while if not monitored, it is negative for any θ :

$$\Pi_0 - 1 < 0 < \Pi_1 - 1 - c. \quad (3.3)$$

where monitoring cost is sufficiently high⁶:

$$c \geq \theta(1 - \theta)(1 - \beta p)R \quad (3.4)$$

After the monitoring decision is made, the banker chooses to keep a share $\alpha \geq 0$ of the loans, and sells the rest to investors. Investors are competitive. They are financed by debt. Investors do not observe the monitoring decision of the banker and the type of each loan,

⁵We assume that capital requirement is not based on the risk-weighted assets. Further on we shall discuss how our results change if this assumption is not valid.

⁶This is a simplifying assumption and it does not affect the basic result of the model.

since bank assets are opaque.

Loan sales reduce the scale of the bank balance sheet. Proceeds from sales are immediately used to repay a share $1 - \alpha$ of deposits, a share $1 - \alpha$ of equity to the banker, and the rest is captured by the banker in the form of a dividend. As a condition to operate and retain its charter, the bank is required to keep some minimal fraction s of originated loans.⁷ At $t = 1$ loan returns are realized.

The financial conglomerate (FC) is a holding company which comprises of a bank and a non-bank financial company (e.g. investment or insurance company). These entities are ring-fenced, so each can fail independently. The conglomerate shareholder maximizes the joint value of both intermediaries and shares all information from bank monitoring. A conglomerate bank can sell a fraction of loans to the bank's affiliate as long as this happens at the market price, as determined in an arm's-length transaction.

A non-bank affiliate is financed by debt. While a bank has a deposit insurance, the cost of funding by a non-bank affiliate depends on the risk born by capital market investors, who provide funding for the purchase price of securitized loans. The existing capital and asset structure of the non-bank intermediary is such that debtholders will get their investment back.⁸

The full list of model parameters is presented in the Appendix.

3.4 Results

3.4.1 Standalone Bank

This section finds an equilibrium price for arm-length transactions in the market for securitized loans, given the selling and monitoring decisions of a standalone bank.

First, we consider the selling and monitoring decisions of a standalone bank in the benchmark case in which there is not trade in the market for securitized loans. Secondly, we establish the conditions of trade in the market and find a standalone bank's choice when trade of loans is available.

If the banker originates and holds loans, the banker's payoff is:

$$\begin{cases} \Pi_1 - 1 - k\delta + DIS_1 - c & \text{if banker monitors} \\ \Pi_0 - 1 - k\delta + DIS_0 & \text{if not} \end{cases} \quad (3.5)$$

DIS_1 denotes the deposit insurance subsidy if the banker monitors, and DIS_0 is the deposit insurance subsidy if the banker does not monitor. Deposit insurance subsidy is the expected

⁷This rules out the case in which the bank ceases to exist at $t = 0$ by the complete sale of loans.

⁸The affiliate may have sufficient capital to offset any loss from assets transferred by the bank. Alternatively, it may hold assets that are non-negatively correlated with the bank assets.

value of the debt guarantee. If the capital requirement is sufficiently high $k > k_d$, where

$$k_d \equiv 1 - (1 - \theta)R, \quad (3.6)$$

there is no default even if risky loans are not repaid. In this case no deposit insurance subsidy is received and the banker internalizes the loss. For lower capital requirement $k \leq k_d$, if the banker monitors the loans, the deposit insurance subsidy is positive. As a result,

$$DIS_1 = \max[0, (1 - p)(k_d - k)] \quad (3.7)$$

$$DIS_0 = \max[0, (1 - \beta p)(k_d - k)] \quad (3.8)$$

Clearly, the deposit insurance subsidy is higher for banks with lower capital.

Consider the benchmark case when the market for securitized assets does not exist. Does the banker monitor loans?

Lemma 8. *If there is no market for securitized loans, a standalone bank originates loans if the cost of capital is sufficiently low, i.e. $\delta \leq \max[\delta_1^{PC}, \delta_0^{PC}]$, and monitors them if capital requirement exceeds a threshold, i.e. $k \geq k^*$, where*

$$\delta_1^{PC} = \frac{\Pi_1 - 1 - c + DIS_1}{k} \quad (3.9)$$

$$\delta_0^{PC} = \frac{\Pi_0 - 1 + DIS_0}{k} \quad (3.10)$$

$$k^* = 1 - R + \frac{c}{(1 - \beta)p} \quad (3.11)$$

The amount of bank capital k is crucial for the value of the deposit insurance subsidy in case of a partial default. A higher capital implies a lower subsidy, discourages the bank from gambling, and thus provides better monitoring incentives.

Figure 3.1 shows the banker's decision without the market for securitized loans.

We next consider the case in which there is a market for securitized loans. The market price is set by arm-length sale by the standalone bank, given that investors do not know the quality of loans.

If all the loans could be sold, the banker's payoff would be:

$$\begin{cases} P - 1 - c & \text{if she monitors} \\ P - 1 & \text{if not} \end{cases} \quad (3.12)$$

where P is the price of loans, which will be determined in the market equilibrium.

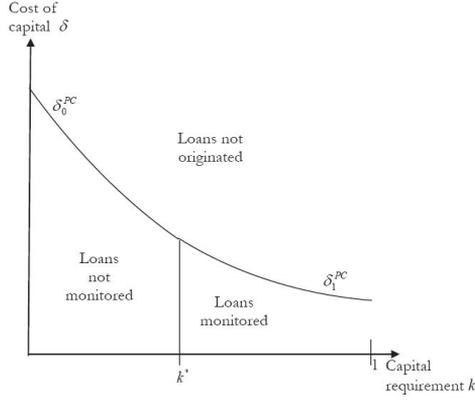


Figure 3.1: Standalone bank's monitoring decision without the market for securitized loans

The banker may sell non-monitored loans, safest monitored loans or riskiest monitored loans. The market anticipates the banker's decision and sets the price accordingly.

Under symmetric information, the banker sells the safest loans to maximize the value of the deposit insurance subsidy. However, in the presence of asymmetric information about heterogeneous loans, the banker can have an incentive to sell the less profitable, riskiest, monitored loans or non-monitored loans. Investors can infer whether loans had been monitored and if so, the quality of loans sold. The banker can never convince market investors that she sells the safest loans, since she always realizes the gain from deviating by selling the riskiest loans.

The incentive compatibility constraint of the banker that ensures monitoring is:

$$\underbrace{\alpha [\Pi^R - 1 + DIS_1^R - k\delta]}_{\text{payoff from keeping riskiest monitored loans}} - c \geq \underbrace{\alpha [\Pi_0 - 1 - k\delta + DIS_0]}_{\text{payoff from keeping non-monitored loans}} \quad (3.13)$$

where Π^R is the average value of loans kept in the bank if the banker sells the riskiest monitored loans:

$$\Pi^R = \begin{cases} \frac{(1-\theta)}{\alpha} R + (1 - \frac{1-\theta}{\alpha}) pR & \text{if } \alpha > 1 - \theta \\ R & \text{if } \alpha \leq 1 - \theta \end{cases},$$

and DIS_1^R is the average deposit insurance subsidy from selling riskiest monitored loans:

$$DIS_1^R = \begin{cases} (1-p) [(1-k) - \frac{1-\theta}{\alpha} R] & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \\ 0 & \text{if } \alpha \leq \frac{(1-\theta)R}{1-k} \end{cases}$$

Lemma 9. *If a standalone bank retains the minimum fraction of loans $\alpha^*(k)$, the market pays the fair price for the riskiest monitored loans. If it keeps less than $\alpha^*(k)$, it gets the fair price for non-monitored loans.*

$$P = \begin{cases} pR & \text{if } \alpha \geq \max[1 - \theta, \alpha^*(k)] \\ \frac{(1-\alpha-\theta)R + \theta pR}{1-\alpha} & \text{if } \alpha^*(k) < \alpha < 1 - \theta \\ (1 - \theta)R + \beta p\theta R & \text{if } \alpha < \alpha^*(k) \end{cases} \quad (3.14)$$

The retention share $\alpha^*(k)$ is monotone and non-increasing in k . If $k \leq k^*$, the bank cannot credibly commit to monitoring $\alpha^*(k) \geq 1$.

Keeping $\alpha^*(k)$ is necessary to guarantee monitoring of the loan pool. This restriction on loan sale reduces the banker's ability to economize on funding cost by paying $\delta\alpha^*(k)$, while it still allows to exploit deposit insurance subsidy $(1-p)[(1-k)\alpha^*(k) - (1-\theta)R]$ when capital is moderate. However, if capital is low $k \leq k^*$, the banker cannot commit to monitoring, since investors are certain that only non-monitored loans will be sold.

Finally, we examine the selling and monitoring decision of the banker.

Given the market price, the banker chooses the fraction of loans to keep α , and whether to monitor loans m by solving the problem.

$$\begin{aligned} \max_{m, \alpha} \quad & \alpha \left[m \left(\overbrace{\frac{\text{payoff from kept monitored loans}}{\Pi^R - 1 - c + DIS_1^R - k\delta}} \right) + (1 - m) \left(\overbrace{\frac{\text{payoff from kept non-monitored loans}}{\Pi_0 - 1 + DIS_0 - k\delta}} \right) \right] \\ & + (1 - \alpha) \left[m \left(\underbrace{P - 1 - c}_{\text{sold monitored loans}} \right) + (1 - m) \left(\underbrace{P - 1}_{\text{sold non-monitored loans}} \right) \right] \\ & \text{subject to the banker's participation constraint} \end{aligned} \quad (3.15)$$

Proposition 8. *For $k \geq k^*$, a banker in a standalone bank monitors loans. She sells the fraction $1 - \min[\alpha^*(k), s]$ loans if $\delta \geq \delta^S$, where*

$$\delta^S \equiv \begin{cases} \frac{(1-p)(1-k)}{k} & \text{if } k^* < k \leq 1 - \frac{(1-\theta)Rp(1-\beta)R}{c+R(1-\theta)p(1-\beta)} \equiv k^{**} \\ \frac{(1-p)(k_d-k)}{k(1-\alpha^*(k))} & \text{if } k^{**} < k \leq k_d \\ 0 & \text{if } k > k_d \end{cases} \quad (3.16)$$

If $\delta < \delta^S$, she keeps all loans. For $k < k^*$, she gives up on monitoring and keeps all loans.

If capital requirement is low $k \leq k^*$, the banker cannot credibly commit to monitoring. She prefers to keep all loans rather than selling any amount for the price Π_0 , which gives her a negative payoff from loan sale. The monitoring decision of the banker is the same as when the market for securitized loans is closed.

For high capital requirement $k > k^*$, the sale takes place when the value of the deposit insurance subsidy is lower than the savings on the cost of capital the banker receives from the loan sale ($\delta > \delta^S$). The amount of loans sold is the maximum for which investors pay the higher price of monitored loans, and it increases with the capital requirement until k becomes so high that the bank's loss in case of risky loans failure is internalized.

Lemma 10. *The incentive to sell loans increases with a higher cost of capital δ and capital requirements k .*

Selling loans has the advantage of reducing funding costs. Keeping loans enables the banker to exploit the deposit insurance guarantee associated with lower capital requirements.

The asset sale also produces an extra effect on the loan origination decision of the banker summarized in the Lemma 11:

Lemma 11. *Trading in the market for securitized loans enables banks to originate loans for $k > k^*$, even when the cost of capital is high:*

$$\delta_1^{PC} < \delta \leq \frac{\Pi_1 - c - 1}{k\alpha^*(k)} + \frac{\max[0, (1 - p)((\alpha^*(k)(1 - k) - (1 - \theta)R)]}{k} \equiv \delta_{1,\alpha=\alpha^*}^{PC} \quad (3.17)$$

Thus, the market sale releases the participation constraint of the banker by reducing the bank's cost of financing.

The banker's selling and monitoring decisions are illustrated in Figure 3.2.

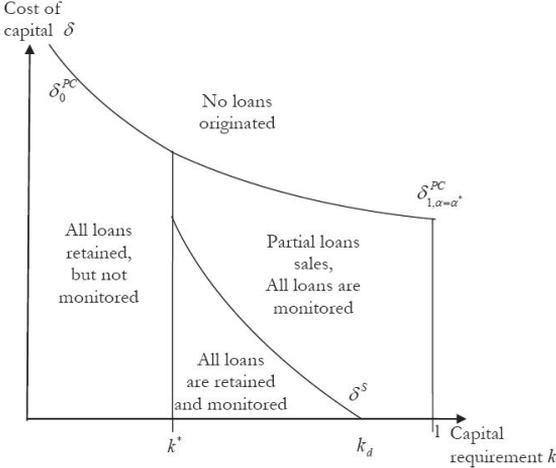


Figure 3.2: Standalone bank's monitoring and selling decision

3.4.2 Financial Conglomerate

This section studies the various aspects of the internal sale of securitized loans in financial conglomerates.

The payoff from the sale at a market price P for the conglomerate is:

$$\begin{cases} \underbrace{P - 1 - c}_{\text{bank's payoff}} + \underbrace{\Pi_T - P}_{\text{investment company's payoff}} & \text{if } m = 1 \\ \underbrace{P - 1}_{\text{bank's payoff}} + \underbrace{\Pi_0 - P}_{\text{investment company's payoff}} & \text{if } m = 0 \end{cases} \quad (3.18)$$

where Π_T is the value of the loans transferred.

Consider the banker's selling and monitoring decisions in case of an internal loan transfer.

The banker makes the decision about monitoring, the amount and the quality of loans sold, solving the problem:

$$\begin{aligned} \max_{m, \alpha, \alpha^S} & m \underbrace{[\Pi_1 - c - 1 + (DIS_{FC}(\alpha^S) - k\delta)\alpha]}_{\text{payoff under monitoring}} + (1 - m) \underbrace{[\Pi_0 - 1 + (DIS_0 - k\delta)\alpha]}_{\text{payoff under no monitoring}} \\ \text{s.t. } & PC_{FC} \end{aligned} \quad (3.19)$$

where α^S is the share of safe loans kept, and DIS_{FC} is value of the deposit insurance subsidy on the kept loans.

Proposition 9. *A banker in a financial conglomerate does not monitor and keeps all loans if $\delta < \delta^M$:*

$$\delta^M = \begin{cases} \frac{-[\Pi_1 - \Pi_0 - c] + [DIS_0 - sDIS_{FC}]}{k(1-s)} & \text{if } k < k^* - \frac{R(1-p)(1-\theta)}{p(1-\beta)} \\ \frac{-[\Pi_1 - \Pi_0 - c] + [DIS_0 - \theta DIS_{FC}]}{k(1-\theta)} & \text{otherwise} \end{cases} \quad (3.20)$$

where $DIS_{FC} = (1 - p)(1 - k)$. If $\delta \geq \delta^M$, a banker monitors loans and sells $1 - \alpha_{FC}^*$ to its affiliate company.

$$\alpha_{FC}^* = \begin{cases} \theta & \text{if } \delta^M \leq \delta < \delta^* \equiv \frac{(1-p)(1-k)}{k} \\ s & \text{if } \delta \geq \max[\delta^M, \delta^*] \end{cases} \quad (3.21)$$

In the case of an internal sale, the information structure of the conglomerate eliminates asymmetric information, which is inherent to the market for securitized assets. First, both parties observe the quality of transferred assets perfectly. Second, incentives of the banker and investor are now aligned, since one shareholder maximizes the joint conglomerate value.

The banker sells safer loans internally to her counterpart. The bank is then left with the

risky loans and gambles.⁹

The reason for such a transfer in our model is to maximize the value of the deposit insurance subsidy per loan kept in the bank. If the bank keeps the pool, a safe loans return will offset the losses from risky loans, reducing the cost of the deposit insurance fund $(1 - p)[1 - k - (1 - \theta)R]$. If the bank retains only risky loans, the value of the deposit insurance subsidy increases to $DIS_{FC} = (1 - p)(1 - k)$. The deposit insurance fund must repay all depositors, since upon default the bank value is zero. This is a *value transfer effect*. The incentive to transfer value from the bank subject to the deposit insurance guarantee exists even for higher capital requirement.

The ability to transfer risk stimulates a higher incentive to monitor loans, since monitoring provides information about loan quality. The conglomerate bank always monitors loans when it sells them to its counterpart. If there is no monitoring, the value of the loan pool is Π_0 , and such a sale produces a negative NPV for the bank affiliate. This is a *monitoring effect*.

As a result, the bank's moral hazard in risk allocation leads to the reduction of the moral hazard in risk control.

Proposition 10. *A conglomerate bank does not sell loans to the market, but only internally. This reduces the cost of financing and increases the deposit insurance subsidy.*

Since the banker in the conglomerate does not need to keep a fraction of her loans to commit to their monitoring, she can transfer the securitized assets internally even when capital requirement is low $k < k^*$, whereas market sale is more restrictive on the amount of loans sold. As a result, internal sale allows the cost of bank financing to be reduced by downsizing the bank balance sheet more than in market sale.

Moreover, in internal sale, the banker can keep riskier assets than in market sale. This accumulation of risk in the bank increases the value of the deposit insurance subsidy, and thus the attractiveness of internal sale.

The following table summarizes the banker's decisions in a financial conglomerate:

Condition	Fraction kept	Monitoring	Quality of loans kept
$\delta < \delta^M$	$\alpha = 1, \alpha = 1$	not monitor	Pool
$\delta^M \leq \delta < \delta^*$	$\alpha = 1, \alpha = \theta$	monitor	Risky
$\max[\delta^*, \delta^M] \leq \delta \leq \delta_{1,\alpha=s}^{PC}$	$\alpha = 1, \alpha = s$	monitor	Risky

Figure 3.3 shows the set of possible equilibria.

⁹The incentive to allocate risky and safe loans in two different entities is natural as shown in Kahn and Winton (2004).

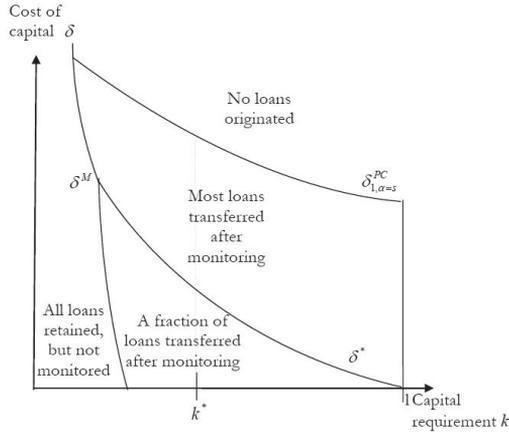


Figure 3.3: Banker's monitoring and selling decisions in a financial conglomerate.

3.5 Bank Regulation

This section studies the effect of bank regulation, in particular capital requirements and restrictions on the volume of asset transfer.

Social welfare is the sum of bank profit, market investors' payoff and expected social cost of bank failure. Assume that the social cost of failure equals total losses to the deposit insurance fund, plus a fixed cost F (representing the economic damage caused by reduced confidence after bank failure).

When assets are monitored and default is possible, the social welfare is $\Pi_1 - c - 1 - (1 - p)F$ otherwise $\Pi_0 - 1 - (1 - \beta p)F < 0$. When default is not possible, for example due to a high capital requirement, the social welfare is $\Pi_1 - 1 - c$. Assume that social welfare is positive when loans are monitored:

$$F < \frac{\Pi_1 - 1 - c}{1 - p} \tag{3.22}$$

There are three effects of asset risk choices on social welfare. First, asset monitoring boosts welfare, since projects gain in value. Secondly, asset transfer may affect bank asset risk and thus the expected cost of bank failure. Finally, asset transfer increases the incentive to originate loans, since it reduces the cost of the bank's funding.

3.5.1 Bank Capital Requirement

What is the optimal minimum capital requirement the regulator should set for both types of bank to maximize social welfare?

Proposition 11. *The minimum capital requirements for a conglomerate bank and a standalone bank are:*

$$k_{SB}^* = \begin{cases} k^* & \text{if } \delta \geq \delta_{1,\alpha=\alpha^*}^{PC}(k^{**}) \\ k^{**} & \text{if } \delta_{1,\alpha=\alpha^*}^{PC}(k^{**}) < \delta \leq \delta^S(k^{**}) \\ k^{-1}(\delta^S) & \text{otherwise} \end{cases} \quad (3.23)$$

$$k_{FC}^* = k^{-1}(\delta^M) \quad (3.24)$$

Setting a higher capital requirement for a conglomerate bank than for a standalone bank would not reduce the risk of failure of the former.

Capital requirement reflects three effects of financial conglomeration. First, for a low capital requirement $k < k^*$ and $\delta^M \leq \delta < \delta_0^{PC}$, the default risk of the conglomerate bank is lower and the value of originated loans is higher than of the standalone bank. The conglomerate bank monitors its loans as opposed to the standalone bank due to the monitoring effect of conglomeration. The social welfare from the conglomerate is higher than from the standalone bank:

$$\Pi_1 - 1 - c - F(1 - p) > \Pi_0 - 1 - F(1 - \beta p). \quad (3.25)$$

Secondly, the risk of default in the conglomerate bank is higher than in the standalone bank, if capital requirement is high $k \geq k^{**}$ and cost of capital is sufficiently low $\delta^S < \delta \leq \delta_{1,\alpha=\alpha^*}^{PC}$. In this case, both banks monitor their loans. However, the conglomerate bank's loans are riskier due to the value transfer effect even for such a high capital requirement. In the standalone bank, default on the loan pool is not possible. The social welfare from the conglomerate is lower than from the standalone bank:

$$\Pi_1 - c - 1 - F(1 - p) < \Pi_1 - 1 - c. \quad (3.26)$$

Finally, a financial conglomerate has higher incentives to originate loans than a standalone bank, due to a higher sale and a larger deposit insurance subsidy. When the cost of capital is sufficiently high $\delta > \max[\delta_0^{PC}, \delta_{1,\alpha=\alpha^*}^{PC}]$, the conglomerate bank originates and monitors loans, whereas the standalone bank gives up on origination. The reason is too high funding costs for the standalone bank as compared to the deposit insurance subsidy it receives. In this case, the social welfare from the conglomerate is higher than from the standalone bank:

$$\Pi_1 - 1 - c - F(1 - p) > 0. \quad (3.27)$$

Figure 3.4 summarizes the difference between the default risk and the value of originated loans between the standalone bank and the conglomerate bank.

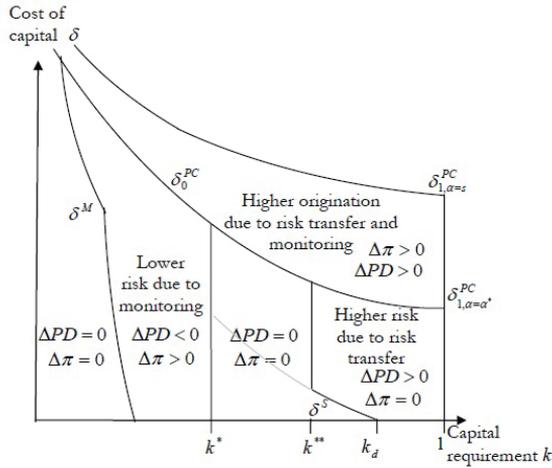


Figure 3.4: Difference in originated loans' value $\Delta\pi$ and default probabilities ΔPD of a conglomerate bank and a standalone bank.

As a result of these three effects, the regulator must set a high capital requirement for the standalone bank in order to make the banker internalize all losses. However, when the cost of capital is sufficiently high, the banker may give up on loan origination. To induce origination, the regulator must reduce the requirement to k^* , thus increasing the probability of default, but still encouraging monitoring.

The relative costs of keeping loans in a conglomerate bank as opposed to its non-bank affiliate are:

$$\Delta Cost = \delta k - (1 - p)(1 - k) \quad (3.28)$$

The effect of capital k on those costs is defined by:

$$\frac{\partial \Delta Cost}{\partial k} = \delta + 1 - p \geq 0. \quad (3.29)$$

A higher capital requirement in the conglomerate bank merely increases the cost of bank funding, since it reduces the value of the deposit insurance guarantee and raises the cost of capital. Thus, setting a higher capital requirement for the conglomerate bank stimulates larger asset transfer, but does not affect bank risk.

Even for a capital requirement close to 1, the banker in the conglomerate will prefer value transfer. As a result, the probability of a bank's default is positive for any capital requirement. The regulator then chooses the minimum capital requirement, which is even lower than requirement of the standalone bank, in order to guarantee monitoring.

Figure 3.5 summarizes the optimal minimum capital requirements.

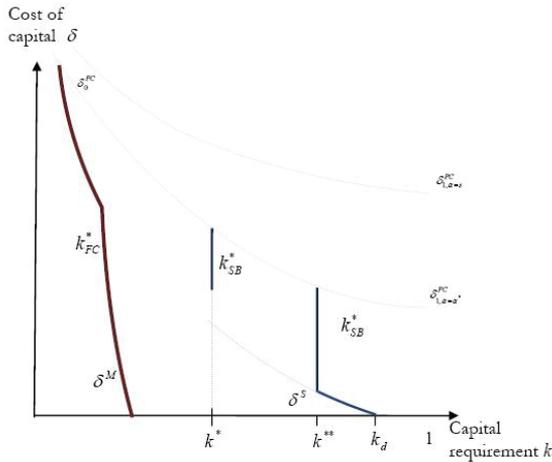


Figure 3.5: Optimal capital requirements for a standalone bank and a conglomerate bank.

Note that if the capital requirement is based on the risk-weighted assets, the result may still hold. There are three cases.

First, asset risk is perfectly observed, and capital surcharge reflects this risk. Then the bank will be indifferent as to which assets to transfer, since in the absence of asset opacity deposit insurance is also priced fairly. The only reason for the asset transfer is the cost of capital minimization.

Second, asset risk is not well observed, and some assets have a too high capital surcharge compared to their risk. Then the banker has a higher incentive to transfer those assets. Still the banker will prioritize the transfer of the safest assets with a higher capital surcharge.

Third, asset risk is not well observed, and some assets have a too low capital surcharge relative to their risk. Then the banker has a stronger incentive to keep those assets on her balance sheet. Yet, the banker will aim to hold the riskiest assets with a lower capital surcharge.

As a result, under regulation with risk-weighted assets, imposing a sufficiently high capital requirement also encourages asset transfer. However, the nature of such a transfer will remain the same, unless asset risk is perfectly observed by the regulator.

3.5.2 "Skin in the Game" Requirement

Next, consider a regulation restricting the amount of loans sold by the bank. Equivalently, the regulator decides on the minimum requirement to retain a fraction of loans $s \in [0, 1]$.

Proposition 12. *The optimal requirement to retain a fraction of loans for a standalone bank is $s_{SB}^* = 0$, whereas for a conglomerate bank it is higher and equal to:*

$$s_{FC}^* = \begin{cases} 0 & \text{if } k < k_d \\ \frac{\theta R}{R-(1-k)} & \text{if } k > k_d \end{cases}$$

When s is set optimally and $k > k_d$, a conglomerate bank will never default.

In the standalone bank, the market disciplines the bank, requiring it to retain a fraction $\alpha^*(k)$ of loans. Therefore, imposing restrictions to have "skin in the game" would not affect a standalone bank's monitoring decision, but would merely raise its funding cost. This may reduce her incentives to originate loans for high δ .

In a financial conglomerate, setting a sufficiently high minimum retention requirement together with a high capital requirement may result in internalizing the cost of default.

Although for $k > k_d$, there exists an optimal s that guarantees the absence of default, imposing such restrictions on the conglomerate bank's activities deprives the banker from any incentive to form a conglomerate, since there may be no benefits in terms of lower funding cost or a higher deposit insurance subsidy.

Lemma 12. *If $k > k_d$, the optimal holding requirement for a conglomerate bank decreases with higher capital requirement. Retention share and capital requirement act here as regulatory substitutes.*

3.6 Conclusion

This paper studies how internal transfer of securitized assets in conglomerates may affect risk in conglomerate banks. Bank monitoring and risk allocation choices are endogenized while on the other hand market discipline is imposed on a conglomerate's affiliate.

Our model contributes to the debate on structural reforms, focusing on the unfavorable risk incentives arising from ring-fencing. In the United Kingdom, the "Vickers Commission" proposed to ring-fence retail banking activities, imposing higher capital requirements on banks. In the US, the "Volcker rule" bans proprietary trading by banks. In Europe, the "Liikanen plan" suggests a separation of investment banking from traditional banking activities. The positive risk reduction effect from such reforms is highlighted in Boot and Ratnoski (2012). However, under such structural reform, banks' affiliates may experience higher funding cost (Goodhart, 2012), as they are not subject to the government bailout guarantee anymore.

This paper points to the effect that is not be fully addressed by the Vickers proposal on financial stability. First, the model shows how the holding structure of conglomerates affects their risk choice. Conglomerate banks can sell their loans internally more easily than

standalone banks, due to the absence of asymmetric information. This enables them to cherry pick the safest assets for transfer, while taking advantage of the deposit insurance guarantee on the kept assets. Thus, conglomerate banks accumulate the riskiest assets, gambling on a good outcome, as its funding has the lowest risk charge. However, this risk shifting in conglomerates produces higher incentives to monitor assets than in standalone banks, which may enhance the quality of conglomerates' loans.

Secondly, the model demonstrates that higher capital requirements (as proposed by the Vickers Commission) may not improve the value transfer decisions of conglomerates¹⁰. This implies that a different instrument must be found to offset the value transfer incentive. A possible candidate is the restriction on the amount of transferred assets in conglomerates. Results suggest that the regulator must apply a higher minimum requirement to retain securitized assets to conglomerate banks than to standalone banks, in combination with a higher capital requirement.

Thirdly, the model explains the ability of financial conglomerates to grow faster by means of securitization. For financial conglomerates it is easier to sell more loans internally, due to the absence of asymmetric information between the counterparties. Standalone banks on the contrary face the restrictions on the sold amount in market sales due to asymmetric information. Since the loan sale releases the capital that can be used for more loan origination, financial conglomerates have a higher ability to originate and sell more loans.

In conclusion, although ring-fencing makes it possible to limit the exposure of the safety net (Duffie, 2012), it may overlook conglomerates' opportunistic incentives to accumulate risk on their banks' balance sheets arising from the conglomerate structure. Regulation should take into account both beneficial and unfavorable effects of conglomeration.

¹⁰A higher capital requirement for conglomerate banks may merely affect their funding costs

3.7 Appendix

The List of Model Parameters

Parameter	Interpretation
α	an amount of loans kept in the bank after sale
k	bank capital requirement
δ	opportunity cost of capital
θ	fraction of low type loans in the pool
R	(gross) return on loans
p	the probability of repayment by risky loans
c	non-pecuniary cost of effort
m	monitoring decision $\in \{0, 1\}$
β	the severity of moral hazard
s	required minimal fraction of loans held in the bank

Proof of Lemma 8

Consider banker's monitoring decision when trade in loans is not available. The banker monitors if:

$$pR\theta - c + DIS_1 \geq \beta pR\theta + DIS_0 \quad (3.30)$$

For $k > k_d$, the banker always monitors loans due to (3.3). For $k < k_d$, the banker monitors if

$$(1 - \beta)pR\theta - c \geq p(1 - \beta)(k_d - k) \quad (3.31)$$

From (3.6), this condition is equivalent to

$$(1 - \beta)p[R - (1 - k)] \geq c \quad (3.32)$$

As a result, the banker monitors loans when (3.11) holds.

Banker's participation constraint if she does not monitor loans ($k < k^*$) is:

$$\beta pR\theta - 1 + (1 - \beta p)(k_d - k) \geq 0 \quad (3.33)$$

or equivalently, when $\delta \leq \delta_0^{PC}$ from (3.11).

If the banker monitors loans ($k \geq k^*$), her participation constraint is:

$$\Pi_1 - 1 - c - k\delta + DIS_1 \geq 0 \quad (3.34)$$

or equivalently, when $\delta \leq \delta_1^{PC}$ from (3.10).

Note that $\delta_1^{PC} = \delta_0^{PC}$ when $k = k^*$, since those two functions intersect when

$$pR - 1 - c + (1 - p)(1 - k) = \beta pR - 1 + (1 - \beta p)(1 - k)$$

For $k > k^*$, $\delta_1^{PC} > \delta_0^{PC}$. It is easy to show since the functions are monotone and $\delta_1^{PC}|_{k=1} > \delta_0^{PC}|_{k=1}$:

$$\begin{aligned}\delta_1^{PC}|_{k=1} &= \beta pR - 1 < 0 \\ \delta_0^{PC}|_{k=1} &= pR - 1 - c > 0\end{aligned}\tag{3.35}$$

As a result, the banker makes the following monitoring decision:

$$\begin{cases} \text{No loan origination} & \text{if } \delta > \max[\delta_1^{PC}, \delta_0^{PC}] \\ \text{No loan monitoring} & \text{if } \delta \leq \delta_0^{PC} \& k \leq k^* \\ \text{Loan monitoring} & \text{otherwise} \end{cases}$$

Proof of Lemma 9

This proposition establishes the equilibrium in the market for securitized assets. The payoff of the banker if she sells the safest monitored loans is:

$$(1 - \alpha)P + \alpha\Pi^S - 1 - c + \alpha DIS_1^S - k\delta\alpha\tag{3.36}$$

Π^S is the value of kept loans in the bank when the safest loans are sold:

$$\Pi^S = \begin{cases} \frac{\theta}{\alpha}pR + (1 - \frac{\theta}{\alpha})R & \text{if } \alpha > \theta \\ pR & \text{if } \alpha \leq \theta \end{cases}$$

DIS_1^S is deposit insurance subsidy from selling safest monitored loans:

$$DIS_1^S = \begin{cases} (1 - p)(1 - k) & \text{if } \alpha \leq \theta \\ (1 - p)[(1 - k) - (1 - \frac{\theta}{\alpha})R] & \text{if } \theta < \alpha < \frac{\theta R}{R - (1 - k)} \\ 0 & \text{if } \alpha \geq \frac{\theta R}{R - (1 - k)} \end{cases}$$

The banker's payoff from selling the riskiest loans from monitored pool using Π^R is from (3.14), and DIS_1^R is from (3.14) is:

$$(1 - \alpha)P + \alpha\Pi^R - 1 - c + \alpha DIS_1^R - k\delta\alpha\tag{3.37}$$

If the banker sells non-monitored loans, using DIS_0 is from (3.8) her payoff is:

$$(1 - \alpha)P + \alpha\Pi_0 - 1 + \alpha DIS_0 - k\delta\alpha \quad (3.38)$$

The banker prefers selling safest monitored loans rather than riskiest monitored if:

$$\alpha(\Pi^S - \Pi^R + DIS_1^S - DIS_1^R) > 0 \quad (3.39)$$

Consider two cases:

1. First, $\theta < \frac{1}{2}$ (i.e when the amount of risky loans is higher than of safe $\theta < 1 - \theta$), The difference in the value of kept loans when selling safest and selling riskiest loans is:

$$\alpha(\Pi^S - \Pi^R) = \begin{cases} -\alpha R(1 - p) & \text{if } \alpha \leq \theta \\ -\theta R(1 - p) & \text{if } \theta < \alpha \leq 1 - \theta \\ -(1 - \alpha)R(1 - p) & \text{if } \alpha < 1 - \theta \end{cases}$$

Consider the thresholds for α , which affect the payoff: $\theta, 1 - \theta, \frac{(1-\theta)R}{(1-k)}, \frac{\theta R}{R-(1-k)}$. If $\theta < \frac{1}{2}$, thresholds have the following structure:

$$\begin{cases} \theta < 1 - \theta < \frac{(1-\theta)R}{(1-k)} < 1 < \frac{\theta R}{R-(1-k)} & \text{if } k < k_d \\ \theta < 1 - \theta < \frac{\theta R}{R-(1-k)} < 1 < \frac{(1-\theta)R}{(1-k)} & \text{if } k_d \leq k < 1 - \frac{R(1-2\theta)}{1-\theta} \\ \theta < \frac{\theta R}{R-(1-k)} < 1 - \theta < 1 < \frac{(1-\theta)R}{(1-k)} & \text{if } k \geq 1 - \frac{R(1-2\theta)}{1-\theta} \end{cases}$$

The difference in deposit insurance subsidy from selling the riskiest and safest loans for $k \leq k_d$ is:

$$\alpha(DIS_1^S - DIS_1^R) = \begin{cases} (1 - p)(1 - k)\alpha & \text{if } \alpha \leq \theta \\ (1 - p)[\alpha(1 - k) - (\alpha - \theta)R] & \text{if } \theta < \alpha \leq \frac{(1-\theta)R}{1-k} \\ (1 - p)R(1 - \alpha) & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \end{cases}$$

and for $k > k_d$:

$$\alpha(DIS_1^S - DIS_1^R) = \begin{cases} (1 - p)(1 - k)\alpha & \text{if } \alpha \leq \theta \\ (1 - p)[\alpha(1 - k) - (\alpha - \theta)R] & \text{if } \theta < \alpha \leq \frac{(1-\theta)R}{1-k} \\ 0 & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \end{cases}$$

The difference in overall gain from selling the riskiest and safest loans is for $k < k_d$:

$$\begin{cases} -\alpha(1-p)[R - (1-k)] < 0 & \text{if } \alpha \leq 1 - \theta \\ -(1-p)[(1-\theta)R - \alpha(1-k)] < 0 & \text{if } 1 - \theta < \alpha \leq \frac{(1-\theta)R}{1-k} \\ 0 & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \end{cases}$$

for $k_d \leq k < 1 - \frac{R(1-2\theta)}{1-\theta}$:

$$\begin{cases} -\alpha(1-p)[R - (1-k)] < 0 & \text{if } \alpha \leq 1 - \theta \\ -(1-p)[(1-\theta)R - \alpha(1-k)] < 0 & \text{if } 1 - \theta < \alpha \leq \frac{\theta R}{R-(1-k)} \\ -(1-\alpha)(1-p)R < 0 & \text{if } \alpha > \frac{\theta R}{R-(1-k)} \end{cases}$$

and for $k \geq 1 - \frac{R(1-2\theta)}{1-\theta}$:

$$\begin{cases} -\alpha(1-p)[R - (1-k)] < 0 & \text{if } \alpha \leq \frac{\theta R}{R-(1-k)} \\ -\theta R(1-p) < 0 & \text{if } \frac{\theta R}{R-(1-k)} < \alpha \leq 1 - \theta \\ -(1-\alpha)(1-p)R < 0 & \text{if } \alpha > 1 - \theta \end{cases}$$

Overall gain from selling riskiest loans is higher, and bank sells riskiest loans.

2. Next, $\theta \geq \frac{1}{2}$. The difference in the value of kept loans from selling safe and risky loans:

$$\alpha(\Pi^S - \Pi^R) = \begin{cases} -\alpha R(1-p) & \text{if } \alpha \leq 1 - \theta \\ -(1-\theta)R(1-p) & \text{if } 1 - \theta < \alpha \leq \theta \\ -(1-\alpha)R(1-p) & \text{if } \alpha > \theta \end{cases}$$

Thresholds of α have the following structure:

$$\begin{cases} 1 - \theta < \frac{(1-\theta)R}{(1-k)} < \theta < 1 < \frac{\theta R}{R-(1-k)} & \text{if } k < 1 - \frac{R(1-\theta)}{\theta} \\ 1 - \theta < \theta < \frac{(1-\theta)R}{(1-k)} < 1 < \frac{\theta R}{R-(1-k)} & \text{if } 1 - \frac{R(1-\theta)}{\theta} \leq k < k_d \\ 1 - \theta < \theta < \frac{\theta R}{R-(1-k)} < 1 < \frac{(1-\theta)R}{(1-k)} & \text{if } k \geq k_d \end{cases}$$

The difference in deposit insurance subsidy for $k < 1 - \frac{R(1-\theta)}{\theta}$ is:

$$\alpha(DIS_1^S - DIS_1^R) = \begin{cases} (1-p)(1-k)\alpha & \text{if } \alpha \leq \frac{(1-\theta)R}{1-k} \\ (1-p)(1-\theta)R & \text{if } \frac{(1-\theta)R}{1-k} < \alpha \leq \theta \\ (1-p)R(1-\alpha) & \text{if } \alpha > \theta \end{cases}$$

for $1 - \frac{R(1-\theta)}{\theta} \leq k < k_d$:

$$\alpha(DIS_1^S - DIS_1^R) = \begin{cases} (1-p)(1-k)\alpha & \text{if } \alpha \leq \theta \\ (1-p)[(1-k)\alpha - (\alpha - \theta)R] & \text{if } \theta < \alpha \leq \frac{(1-\theta)R}{1-k} \\ (1-p)R(1-\alpha) & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \end{cases}$$

and for $k \geq k_d$:

$$\alpha(DIS_1^S - DIS_1^R) = \begin{cases} (1-p)(1-k)\alpha & \text{if } \alpha \leq \theta \\ (1-p)[(1-k)\alpha - (\alpha - \theta)R] & \text{if } \theta < \alpha \leq \frac{\theta R}{R-(1-k)} \\ 0 & \text{if } \alpha > \frac{\theta R}{R-(1-k)} \end{cases}$$

The overall difference in payoff from selling safest and riskiest loans for $k < k_d$:

$$\begin{cases} -\alpha(1-p)[R - (1-k)] < 0 & \text{if } \alpha \leq 1 - \theta \\ -(1-p)[(1-\theta)R - \alpha(1-k)] < 0 & \text{if } 1 - \theta < \alpha \leq \frac{(1-\theta)R}{1-k} \\ 0 & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \end{cases}$$

and for $k \geq k_d$ it is identical to the case of $\theta < \frac{1}{2}$. Thus, the banker sells the riskiest loans for any θ .

Next, consider the banker's monitoring decision. She sells riskiest monitored loans if:

$$\alpha(\Pi^R - \Pi_0 + DIS_1^R - DIS_0) - c > 0 \quad (3.40)$$

The difference in values of kept loans is:

$$\alpha(\Pi^R - \Pi_0) = \begin{cases} \alpha R \theta (1 - \beta p) > 0 & \text{if } \alpha \leq 1 - \theta \\ R(1 - \theta)(1 - p) + \alpha R[\theta(1 - \beta p) - (1 - p)] > 0 & \text{if } \alpha > 1 - \theta \end{cases}$$

Next compare deposit insurance subsidies. If $k < k_d$, the difference in subsidies is:

$$\alpha(DIS_1^R - DIS_0) = -\alpha p(1 - \beta)[(1 - k) - (1 - \theta)R] - (1 - p)(1 - \theta)R(1 - \alpha) < 0$$

if $\alpha > \frac{(1-\theta)R}{1-k}$, and

$$\alpha(DIS_1^R - DIS_0) = -(1 - \beta p)\alpha[1 - k - (1 - \theta)R] < 0 \quad (3.41)$$

if $\alpha \leq \frac{(1-\theta)R}{1-k}$.

For $k \geq k_d$:

$$\alpha(DIS_1^R - DIS_0) = \begin{cases} (1-p)[\alpha(1-k) - (1-\theta)R] > 0 & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \\ 0 & \text{if } \alpha \leq \frac{(1-\theta)R}{1-k} \end{cases}$$

Thus, the difference in overall payoffs is for $k < k_d$:

$$\begin{cases} \alpha(1-\beta p)[R - (1-k)] - c & \text{if } \alpha \leq 1-\theta \\ R(1-p)(1-\theta-\alpha) + (1-\beta p)\alpha[R - (1-k)] - c & \text{if } 1-\theta < \alpha \leq \frac{(1-\theta)R}{1-k} \\ \alpha p(1-\beta)[R - (1-k)] - c & \text{if } \alpha > \frac{(1-\theta)R}{1-k} \end{cases}$$

and for $k \geq k_d$:

$$\begin{cases} \alpha(1-\beta p)\theta R - c & \text{if } \alpha \leq 1-\theta \\ R(1-\theta)(1-p) + \alpha R[(1-\beta p)\theta - (1-p)] - c & \text{if } \alpha > 1-\theta \end{cases}$$

The banker sells monitored loans if difference in overall payoffs is positive.

1. Consider the case when $k < k_d$. If $\alpha \leq 1-\theta$, to guarantee monitoring bank must retain

$$\alpha \geq \frac{c}{(1-\beta p)[R - (1-k)]}.$$

Note that the threshold α is lower than $1-\theta$ if $k > 1 - R + \frac{c}{(1-\theta)(1-\beta p)}$, which is not feasible given (3.4) and condition $k < k_d$.

If $1-\theta < \alpha \leq \frac{(1-\theta)R}{1-k}$, α that guarantees monitoring is:

$$\alpha \geq \frac{c - R(1-\theta)(1-p)}{pR(1-\beta) - (1-\beta p)(1-k)} \equiv \alpha_1 \quad (3.42)$$

Note that $\alpha_1 > 1-\theta$ if $k > k^{***}$ and $\alpha_1 \leq \frac{(1-\theta)R}{1-k}$ if

$$k \geq 1 - \frac{(1-\theta)Rp(1-\beta)R}{c + R(1-\theta)p(1-\beta)} \equiv k^{**} \quad (3.43)$$

If $\alpha > \frac{(1-\theta)R}{1-k}$, the share of loans to keep is:

$$\alpha \geq \frac{c}{p(1-\beta)[R - (1-k)]} \equiv \alpha_2, \quad (3.44)$$

which is feasible when $k^* \leq k < k^{**}$ (equivalent to $\frac{(1-\theta)R}{1-k} < \alpha_2 \leq 1$).

2. Next consider the case $k \geq k_d$. Then if $\alpha < 1-\theta$, the minimum share is $\alpha \geq \frac{c}{\theta R(1-\beta p)}$ which is not feasible given (3.4) and the condition $\alpha < 1-\theta$.

If $\alpha > 1 - \theta$, the banker must retain the share which satisfies:

$$\alpha R[\theta(1 - \beta p) - (1 - p)] > c - R(1 - \theta)(1 - p). \quad (3.45)$$

Next, show that right hand side of the inequality is positive. Monitoring cost c satisfies (3.3) and (3.4) if:

$$\Pi_1 - \Pi_0 > \theta(1 - \theta)(1 - \beta p)R \quad (3.46)$$

implying that

$$R[\theta(1 - \beta p) - (1 - p)] > 0. \quad (3.47)$$

Thus, the banker must retain:

$$\alpha \geq \frac{c - R(1 - \theta)(1 - p)}{R[\theta(1 - \beta p) - (1 - p)]} \equiv \alpha_3 \quad (3.48)$$

The nominator is positive, if $c > R(1 - \theta)(1 - p)$. It always holds since this threshold of c is lower than the minimum c from (3.4):

$$R(1 - \theta)(1 - p) < R(1 - \theta)\theta(1 - \beta p) \quad (3.49)$$

which is true if (3.47). It is shown above that (3.47) holds.

Let $\alpha^*(k)$ be the loan share the banker must retain to sell loans for the price of monitored.

$$\alpha^*(k) = \begin{cases} 1 & \text{if } k < k^* \\ \frac{c}{p(1-\beta)[R-(1-k)]} & \text{if } k^* \leq k < k^{**} \\ \frac{c-R(1-\theta)(1-p)}{pR(1-\beta)-(1-\beta p)(1-k)} & \text{if } k^{**} \leq k < k_d \\ \frac{c-R(1-\theta)(1-p)}{R[\theta(1-\beta p)-(1-p)]} & \text{if } k \geq k_d \\ 0 & \text{otherwise} \end{cases} \quad (3.50)$$

Next, we show that $\alpha^*(k)$ is monotone in k and not increasing in k . First, to prove monotonicity, we show that at the threshold levels $\alpha^*(k)$ does not have a jump. It is monotone at $k = k^{**}$ if:

$$\frac{c}{p(1-\beta)[R-(1-k)]} = \frac{c - R(1 - \theta)(1 - p)}{pR(1 - \beta) - (1 - \beta p)(1 - k)}$$

holds at $k = k^{**}$, which is indeed equivalent to:

$$k = 1 - \frac{(1 - \theta)Rp(1 - \beta)}{c + (1 - \theta)p(1 - \beta)} = k^{**}$$

Next, we check whether there is no jump in $\alpha^*(k)$ function at $k = k_d$. The function is monotone if equality holds at $k = k_d$:

$$\frac{c - R(1 - \theta)(1 - p)}{pR(1 - \beta) - (1 - \beta p)(1 - k)} = \frac{c - R(1 - \theta)(1 - p)}{R[\theta(1 - \beta p) - (1 - p)]}$$

which is again equivalent to the equality $k = k_d$.

The final step is to show that for $k < k_d$, $\alpha^*(k)$ is non-increasing in k , whereas for $k \geq k_d$, it does not depend on k . For $k^* \leq k < k^{**}$, the derivative of α^* with respect to k is negative:

$$\frac{\partial \alpha^*}{\partial k} = -\frac{c}{p(1 - \beta)[R - (1 - k)]^2} < 0 \quad (3.51)$$

For $k^{**} \leq k < k_d$, the derivative of α^* with respect to k is also negative:

$$\frac{\partial \alpha^*}{\partial k} = -\frac{(1 - \beta p)[c - R(1 - \theta)(1 - p)]}{[pR(1 - \beta) - (1 - \beta p)(1 - k)]^2} < 0 \quad (3.52)$$

The derivative of α^* with respect to k is zero for $k > k_d$ independent of cost c .

Thus, the banker must retain less loans if she has higher capital. If $\alpha \geq \alpha^*(k)$, the banker sells the riskiest monitored loans. If $\alpha < \alpha^*(k)$, the banker sells non-monitored loans. The market price is then:

$$P = \begin{cases} pR & \text{if } \alpha \geq \max[1 - \theta, \alpha^*(k)] \\ \frac{(1 - \alpha - \theta)R + \theta pR}{1 - \alpha} & \text{if } \alpha^*(k) < \alpha < 1 - \theta \\ (1 - \theta)R + \beta p \theta R & \text{if } \alpha < \alpha^*(k) \end{cases}$$

Proof of Proposition 8

Consider banker's selling and monitoring decision. Lemma 8 shows the monitoring decision of the banker if she keeps all loans. From Lemma 9, the price of loans is established. Here we establish whether the banker sells non-monitored loans. If price is Π_0 , the banker does sell loans only if:

$$\Pi_0 - 1 + DIS_0 \alpha - k \delta \alpha \geq 0 \quad (3.53)$$

Rearranging items gives the condition for α :

$$\alpha(k\delta - DIS_0) \leq \Pi_0 - 1 \quad (3.54)$$

which is satisfied only if $\delta < \frac{DIS_0}{k}$, since the right hand side is negative.

The banker maximizes her return by choosing α . First order condition is:

$$DIS_0 - k\delta \quad (3.55)$$

For $k \geq k_d$, $DIS_0 = 0$, thus the banker minimizes the amount of loans kept and can choose s under the price Π_0 . For $k < k_d$, the banker keeps maximum $\alpha = 1$ if $\delta \leq \frac{(1-\beta p)(k_d-k)}{k}$. She sells maximum $\alpha = s$ only if $\delta > \frac{(1-\beta p)(k_d-k)}{k}$. Then participation constraint is not satisfied. Thus, the banker never sells non-monitored loans for the price Π_0 , since it generates a negative payoff.

From Lemma 9, the banker cannot sell loans for the price higher than Π if $k \leq k^*$. Lemma 8 shows that under no sale, for $k \leq k^*$ the banker does not monitor loans and keeps them all.

Consider banker's selling decision when $k > k^*$. When the banker sells riskiest monitored loans (incentive compatible α^* ensures this), her payoff is then:

$$\Pi_1 - 1 - c + \alpha DIS_1^R - k\delta\alpha \quad (3.56)$$

where

$$DIS_1^R = \begin{cases} 0 & \text{if } k > k^{**} \\ (1-p)[(1-k) - \frac{1-\theta}{\alpha}R] & \text{if } k \leq k^{**} \end{cases} \quad (3.57)$$

Maximizing the payoff, the banker chooses minimum possible α in two cases. First, if $(1)\alpha^* < \frac{(1-\theta)R}{1-k}$ i.e when $k > k^{**}$, deposit insurance subsidy is zero, so α is minimized. Second, if $k^* < k \leq k^{**}$ and

$$\delta > \frac{(1-p)(1-k)}{k}, \quad (3.58)$$

the banker chooses minimum α , since the cost of capital higher than the deposit insurance subsidy.

If $k \leq k^{**}$ and $\delta \leq \frac{(1-p)(1-k)}{k}$, the banker keeps all monitored loans. Thus, the banker sells $1 - \alpha^*$ loans if $k \geq k^{**}$ and if $k^* < k < k^{**}$ and $\delta \geq \frac{(1-p)(1-k)}{k}$.

For $k > k^{**}$, can the banker still choose to keep loans? If $k^{**} < k < k_d$, the deposit insurance subsidy from keeping all loans is positive, whereas it is zero when selling riskiest

loans. The banker sells loans if

$$\delta > \frac{(1-p)(k_d - k)}{k(1-\alpha^*)} \quad (3.59)$$

There is a threshold cost of capital δ from (3.16) above which the banker sells loans. Does this threshold δ (3.16) satisfy the participation constraint of the banker when selling?

$$\Pi_1 - 1 - c + \alpha DIS_1^R - k\delta\alpha \geq 0 \quad (3.60)$$

equivalent to the constraint on δ :

$$\delta < \frac{\Pi_1 - 1 - c}{k\alpha^*} + \frac{DIS_1^R}{k} \equiv \delta_{1,\alpha=\alpha^*}^{PC} \quad (3.61)$$

If cost of capital is higher than the threshold above, the banker does not originate loans at all.

The selling region is then exists for $k \geq k_d$, since $\delta^S = 0$. Next show that it also exists for $k^{**} < k < k_d$. Since both thresholds for δ are monotone, we can easily show that $\delta^S < \delta_{1,\alpha=\alpha^*}^{PC}$ by comparing those thresholds at k^{**} and k_d . It is clear that $k = k_d$, the banker can sell for low cost of capital δ : $\delta^S(k_d) < \delta_{1,\alpha=\alpha^*}^{PC}(k_d)$. At k^{**} , the banker chooses $\alpha^* = \frac{(1-\theta)R}{1-k}$. Thus,

$$\delta^S(k^{**}) = \frac{(1-p)(1-k^{**} - (1-\theta)R)}{k \frac{1-k^{**} - (1-\theta)R}{1-k^{**}}} = \frac{(1-p)(1-k^{**})}{k^{**}}, \quad (3.62)$$

and

$$\delta_{1,\alpha=\alpha^*}^{PC}(k^{**}) = \frac{(\Pi_1 - 1 - c)(1-k^{**})}{k^{**}(1-\theta)R} \quad (3.63)$$

The condition for $\delta^S(k^{**}) < \delta_{1,\alpha=\alpha^*}^{PC}(k^{**})$ to hold is $pR - 1 - c > 0$ which holds based on the assumption.

In the same fashion we can show that the participation constraint is not binding for $k^* < k \leq k^{**}$. Since for $k = k^*$ $\alpha^* = 1$, $DIS_1^R = DIS_1$, and thus $\delta^S(k^*) = \frac{(1-p)(1-k^*)}{k^*} < \delta_{1,\alpha=\alpha^*}^{PC}(k^*) = \frac{pR-1-c+(1-p)(1-k^*)}{k^*}$.

Note also that at $k = k^*$, the threshold cost of capital arising from participation constraints in case of monitoring and not monitoring are equal, i.e $\delta_0^{PC} = \delta_{1,\alpha=\alpha^*}^{PC}$, since at $k = k^*$, $\alpha^* = 1$, and thus:

$$\begin{aligned} \frac{\beta pR - 1 + (1 - \beta p)(1 - k)}{k} &= \frac{\Pi_1 - 1 - c}{k} + \frac{DIS_1}{k} \\ k[1 - \beta p - (1 - p)] &= pR\theta + (1 - \theta)R - 1 - c - (1 - p)(1 - \theta)R - (\beta pR - 1) \\ k &= 1 - R + \frac{c}{(1 - \beta)p} \end{aligned} \quad (3.64)$$

This ensures the monotonicity of origination incentives.

Proof of Lemma 10

The selling incentive of the banker (denote as SI) can be measured as the difference between the payoff from selling and payoff from keeping loans, i.e

$$SI \equiv (1 - \alpha^*)k\delta + (\alpha^*DIS_1^R - DIS_1) = \begin{cases} k\delta(1 - \alpha^*) & \text{if } k^{**} < k < k_d \\ k\delta(1 - \alpha^*) - (1 - p)(k_d - k) & \text{if } k^{**} < k < k_d \\ (1 - \alpha^*)[k\delta - (1 - p)(1 - k)] & \text{if } k^* < k \leq k^{**} \end{cases}$$

The derivatives of SI with respect to δ and k are:

$$\begin{aligned} \frac{\partial SI}{\partial \delta} &= k(1 - \alpha) \geq 0 & (3.65) \\ \frac{\partial SI}{\partial k} &= \begin{cases} \delta[(1 - \alpha^* - k\frac{\partial \alpha^*}{\partial k})] \geq 0 & \text{if } k \geq k_d \\ \delta[(1 - \alpha^* - k\frac{\partial \alpha^*}{\partial k}) + (1 - p)] \geq 0 & \text{if } k^{**} < k < k_d \\ -\frac{\partial \alpha^*}{\partial k}[k\delta - (1 - p)(1 - k)] + (\delta + 1 - p)(1 - \alpha^*) \geq 0 & \text{if } k^* < k \leq k^{**} \end{cases} \end{aligned}$$

where $\frac{\partial \alpha^*}{\partial k} < 0$ from Lemma 9. Thus, higher selling incentive corresponds to the lower value of deposit insurance guarantee and higher cost of capital.

Proof of Lemma 11

When market for securitized loans is closed, for $k > k^*$, the banker does not originate loans when $\delta > \delta_1^{PC}$. When market for securitized loans is open, for $k > k^*$, the banker does not originate loans when

$$\Pi_1 - 1 - c + \alpha^*DIS_1^R - k\delta\alpha^* \leq 0 \quad (3.66)$$

This condition is equivalent to the constraint on the cost of capital δ :

$$\delta \leq \delta_{1, \alpha = \alpha^*}^{PC} = \begin{cases} \frac{\Pi_1 - 1 - c}{k\alpha^*} & \text{if } k > k^{**} \\ \frac{pR - 1 - c}{k\alpha^*} + \frac{(1-p)(1-k)}{k} & \text{if } k \leq k^{**} \end{cases} \quad (3.67)$$

Compare the threshold δ from participation constraint with and without trade. For $k > k_d$, $\delta_{1, \alpha = \alpha^*}^{PC} > \delta_1^{PC}$, since:

$$\frac{\Pi_1 - 1 - c}{k\alpha^*} \geq \frac{\Pi_1 - 1 - c}{k} \quad (3.68)$$

For $k < k^{**}$, the banker has higher origination incentives, since

$$\frac{pR - 1 - c}{k\alpha^*} + \frac{(1-p)(1-k)}{k} > \frac{pR - 1 - c + (1-p)(1-k)}{k} = \delta_1^{PC} \quad (3.69)$$

Since the origination incentives are monotone, we can expect that for $k^{**} < k \leq k_d$, $\delta_{1,\alpha=\alpha^*}^{PC} > \delta_1^{PC}$:

$$\frac{\Pi_1 - 1 - c}{k\alpha^*} \geq \frac{pR - 1 - c + (1-p)(1-k)}{k} \quad (3.70)$$

Note that at $k = k^{**}$ and at $k = k_d$, $\delta_{1,\alpha=\alpha^*}^{PC} > \delta_1^{PC}$. Thus, due to monotonicity of banker's origination incentives for $k^{**} < k \leq k_d$, $\delta_{1,\alpha=\alpha^*}^{PC} > \delta_1^{PC}$.

The participation constraint of the bank not selling loans is tighter than for the one selling. This implies that opening the market for securitized loans enables banks to originate loans even with more expensive capital.

Proof of Proposition 9

First, the solution to the problem of financial conglomerate is presented. Second, the mechanism and condition for the information transfer is explained.

We solve the problem of the banker (3.19) by backward induction. First, we solve for the selling decision of the banker given that she does not monitor loans. Then banker's payoff is:

$$\alpha[\Pi_0 - 1 - k\delta + DIS_0] + (1-\alpha)[\Pi_0 - 1] \quad (3.71)$$

where deposit insurance subsidy DIS_0 is the same as in the standalone bank case. The banker decides on α , but not the quality, since she does not learn the type of each loan.

$$\begin{aligned} & \max_{\alpha} \Pi_0 - 1 - \alpha[k\delta - DIS_0] \\ & \text{s.t. PC: } \Pi_0 - 1 - \alpha[k\delta - DIS_0] \geq 0 \end{aligned} \quad (3.72)$$

First order condition for the objective function leads to the two possible candidates for α :

$$\alpha = \begin{cases} 1 & \text{if } \delta \leq \frac{DIS_0}{k} = \frac{(1-\beta p) \max[0, k_d - k]}{k} \\ s & \text{otherwise} \end{cases}$$

Under the participation constraint

$$\delta \leq \frac{(1-\beta p) \max[0, k_d - k]}{k} + \frac{\Pi_0 - 1}{k\alpha} \quad (3.73)$$

If $\alpha = s$, the participation constraint is not satisfied, since

$$\frac{(1 - \beta p) \max[0, k_d - k]}{k} + \frac{\Pi_0 - 1}{ks} < \frac{(1 - \beta p) \max[0, k_d - k]}{k} \quad (3.74)$$

The participation constraint is binding for the banker. She chooses $\alpha = 1$.

If the banker does not monitor its loans, it keeps them all if:

$$\delta \leq \frac{(1 - \beta p) \max[0, k_d - k]}{k} + \frac{\Pi_0 - 1}{k} \quad (3.75)$$

Otherwise, it does not originate loans at all.

Second, we solve for the selling decision of the banker given that she monitors loans. Banker's payoff if she monitors:

$$\Pi_1 - c - 1 + (DIS_{FC}(\alpha^S) - k\delta)\alpha \quad (3.76)$$

where

$$DIS_{FC}(\alpha^S) = (1 - p) \max \left[0, 1 - k - \frac{\alpha^S}{\alpha} R \right] \quad (3.77)$$

Maximizing banker's payoff with respect to α^S gives the optimal amount of safe loans to keep $\alpha^S = \max[0, \alpha - \theta]$. The banker keeps the riskiest loans and transfers the safest.

What is the optimal amount of loans to transfer? Banker maximizes her payoff:

$$\Pi_1 - c - 1 + (1 - p)(1 - k)\alpha - (1 - p) \max[0, \alpha - \theta]R - k\delta\alpha. \quad (3.78)$$

If $\alpha > \theta$, she optimally sets $\alpha = \theta$. If $\alpha \leq \theta$,

$$\alpha = \begin{cases} \theta & \text{if } \delta < \frac{(1-p)(1-k)}{k} \equiv \delta^* \\ s & \text{otherwise} \end{cases} \quad (3.79)$$

The value of deposit insurance subsidy is $DIS_{FC} = (1 - p)(1 - k)$ per unit of loans kept. Banker sells only if she monitors loans.

Is the banker's participation constraint for this selling choice satisfied? The constraint is:

$$\begin{cases} \Pi_1 - c - 1 + (1 - p)(1 - k)\theta - k\delta\theta \geq 0 & \text{if } \alpha = \theta \\ \Pi_1 - c - 1 + (1 - p)(1 - k)s - k\delta s \geq 0 & \text{if } \alpha = s \end{cases} \quad (3.80)$$

equivalent to the constraint on δ :

$$\begin{cases} \delta \leq \frac{(1-p)(1-k)}{k} + \frac{\Pi_1 - c - 1}{k\theta} & \text{if } \alpha = \theta \\ \delta \leq \frac{(1-p)(1-k)}{k} + \frac{\Pi_1 - c - 1}{ks} & \text{if } \alpha = s \end{cases} \quad (3.81)$$

Thus, both participation constraints are not binding.

What is the monitoring decision of the banker? Consider the choice of the banker between selling θ monitored loans and keeping all non-monitored loans. The banker chooses the former if:

$$\Pi_1 - c - 1 + DIS_{FC}\theta - k\delta\theta \geq \Pi_0 - 1 - [k\delta - DIS_0] \quad (3.82)$$

This constraint is equivalent to:

$$\delta \geq \frac{-[(1-\beta)pR\theta - c] + [DIS_0 - \theta DIS_{FC}]}{k(1-\theta)} \equiv \delta^M(\theta) \quad (3.83)$$

Next check the feasibility of this threshold. Threshold $\delta^M(\theta)$ must be lower than δ^* . To understand the characteristics of $\delta^M(\theta)$, find the condition when $\delta^M(\theta) = 0$:

$$-[(1-\beta)pR\theta - c] - \theta(1-p)(1-k) = 0 \quad (3.84)$$

which implies

$$k = 1 - R + \frac{c}{1 - \beta p - \theta(1-p)} \equiv k' \quad (3.85)$$

Note that $k' < k^* = 1 - R + \frac{c}{p(1-\beta)}$, since $1 - \beta p - \theta(1-p) > p(1-\beta)$. Given that, $\delta^M(\theta)$ cross δ^* if:

$$\frac{(1-p)(1-k)}{k} - \frac{-[(1-\beta)pR\theta - c] + [DIS_0 - \theta(1-p)(1-k)]}{k(1-\theta)} = 0 \quad (3.86)$$

which implies

$$k = 1 - \frac{R(1 - \beta p - \theta(1-p))}{p(1-\beta)} + \frac{c}{p(1-\beta)} \equiv k'' \quad (3.87)$$

Note that $k'' < k^*$. Moreover, $\delta^M(\theta)$ is decreasing, since $k'' < k'$. Thus, for $\delta < \delta^*$ and $\delta > \delta^M$, the banker transfers $1 - \theta$ of safest monitored loans.

Now consider the monitoring choice between selling s monitored loans and keeping all

non-monitored. The banker chooses the former if:

$$\Pi_1 - c - 1 + DIS_{FC} s - k\delta s \geq \Pi_0 - 1 - [k\delta - DIS_0] \quad (3.88)$$

This constraint is equivalent to:

$$\delta \geq \frac{-[(1-\beta)pR\theta - c] + [DIS_0 - sDIS_{FC}]}{k(1-s)} \equiv \delta^M(s) \quad (3.89)$$

Check the feasibility constraint, i.e. $\delta_0^{PC} > \delta^*$, and $\delta^M(s) > \delta^*$. Consider the difference $\delta_0^{PC} - \delta^*$ for $k < k_d$:

$$\frac{\beta p R - 1 + (1 - \beta p)(1 - k)}{k} - \frac{(1 - p)(1 - k)}{k} > 0 \quad (3.90)$$

$$k < 1 + \frac{\beta p R - 1}{(1 - \beta)p} \quad (3.91)$$

So for $k < 1 + \frac{\beta p R - 1}{(1 - \beta)p}$ (note that $1 + \frac{\beta p R - 1}{(1 - \beta)p} > k^*$), the banker chooses whether to sell $1 - s$ monitored loans or keep non-monitored. Next, check whether $\delta^M(s) > \delta^*$.

$$-[(1 - \beta)pR\theta - c] - (1 - \beta p)(1 - \theta)R + p(1 - \beta)(1 - k) > 0 \quad (3.92)$$

equivalent to the range of k :

$$k < 1 - \frac{R(1 - \beta p - \theta(1 - p))}{p(1 - \beta)} + \frac{c}{(1 - \beta)p} \quad (3.93)$$

Note that $1 - \frac{R(1 - \beta p - \theta(1 - p))}{p(1 - \beta)} + \frac{c}{(1 - \beta)p} < k^*$. As a result, the banker sells $1 - s$ of monitored loans if $\delta > \delta^M(s)$.

To sum up, the banker does not monitor loans if $\delta < \delta^M$ from (3.20). The overall solution: the banker does not monitor loans if $\delta < \delta^M$ and keeps them all. If $\delta \geq \delta^M$, the banker monitors loans. Under monitoring, she always sells $1 - \alpha_{FC}^*$:

$$\alpha_{FC}^* = \begin{cases} 1 & \text{if } \delta < \delta^M \\ \theta & \text{if } \delta^M < \delta^* \\ s & \text{if } \delta^M < \delta < \delta_{1,\alpha=s}^{PC} \end{cases} \quad (3.94)$$

For high cost of capital $\delta > \delta_{1,\alpha=s}^{PC}$, the banker does not originate loans.

Proof of Proposition 10

If the conglomerate bank sells assets to the market, it must retain the share α^* shown in Proposition 8.

First, consider the case when $\delta \geq \delta^*$, where the conglomerate bank sells $1 - s$ of the safest loans, whereas the standalone bank sells $1 - \alpha^*$ of riskiest monitored loans. Financial conglomerate prefers internal sale if:

$$\Pi_1 - 1 - c + (1 - p)(1 - k)s - k\delta s \geq \Pi_1 - 1 - c + DIS_1^R - \alpha^*k\delta \quad (3.95)$$

or equivalently

$$\begin{cases} \delta \geq \frac{(1-p)(1-k)}{k} - \frac{(1-p)(1-\theta)R}{k(\alpha^*-s)} & \text{if } k < k^{**} \\ \delta \geq -\frac{(1-p)(1-k)s}{k(\alpha^*-s)} & \text{if } k \geq k^{**} \end{cases} \quad (3.96)$$

Considering $\delta > \delta^* = \frac{(1-k)(1-p)}{k}$, implies that for this range of δ , FC prefers internal asset sale.

Second, look at the range of $\delta < \delta^*$. The standalone bank keeps α^* of loans, and the conglomerate bank keeps θ loans. Thus, the conglomerate prefers internal sale if:

$$\Pi_1 - 1 - c + (1 - p)(1 - k)\theta - k\delta\theta \geq \Pi_1 - 1 - c + DIS_1^R - \alpha^*k\delta \quad (3.97)$$

If $\alpha^* > \theta$, this condition is equivalent to:

$$\begin{cases} \delta \geq \frac{(1-p)(1-k)}{k} - \frac{(1-p)(1-\theta)R}{k(\alpha^*-\theta)} & \text{if } k < k^{**} \\ \delta \geq -\frac{(1-p)(1-k)\theta}{k(\alpha^*-\theta)} & \text{if } k \geq k^{**} \end{cases} \quad (3.98)$$

Note that both thresholds are lower than 0. The first threshold is negative because:

$$-[R(1 - \theta) - (1 - k)(\alpha^* - \theta)] < 0 \quad (3.99)$$

Recall that $R > (1 - k)$. Then since $1 - \theta > \alpha^* - \theta$, the threshold is negative.

Since keeping θ is chosen only for $\delta < \delta^*$ and the conditions above fall in this range of δ , the banker prefers internal sale if $\alpha^* > \theta$.

If $\alpha^* < \theta$, then:

$$\begin{cases} \delta \leq \frac{(1-p)(1-k)}{k} + \frac{(1-p)(1-\theta)R}{k(\theta-\alpha^*)} & \text{if } k < k^{**} \\ \delta \leq \frac{(1-p)(1-k)\theta}{k(\theta-\alpha^*)} & \text{if } k \geq k^{**} \end{cases} \quad (3.100)$$

Both thresholds are higher than δ^* . The second threshold is higher, because $\frac{(1-p)(1-k)\theta}{k(\theta-\alpha^*)} < \frac{(1-p)(1-k)}{k}$ due to $\frac{\theta}{\theta-\alpha^*} > 1$. If $\delta < \delta^*$ and $\alpha^* < \theta$, the banker sells loans internally. Conglomerate only sells loans internally.

Proof of Proposition 11

First, we derive the optimal capital requirements for the standalone bank. There are four cases when decisions of the standalone bank result in different welfare (see Table below).

Condition	Social welfare
Case 1: $k < k^*$ and $\delta \leq \delta_0^{PC}$	$\Pi_0 - 1 - (1 - \beta p)F$
Case 2: $k^* \leq k < k^{**}$ and $\delta \leq \delta_{1,\alpha=\alpha^*}^{PC}$; $k^{**} \leq k < k_d$ and $\delta < \delta^S$	$\Pi_1 - 1 - c - (1 - p)F$
Case 3: $k \geq k^{**}$ $\delta^S \leq \delta \leq \delta_{1,\alpha=\alpha^*}^{PC}$	$\Pi_1 - 1 - c$
Case 4: $\delta > \max[\delta_{1,\alpha=\alpha^*}^{PC}, \delta_0^{PC}]$	0

Table 3.1: Social welfare in the case of a standalone bank

There are two components that contribute to the social welfare. First, the NPV of the financed loans. Second, expected cost of bank's failure.

When $k < k^*$, NPV from originated loans is negative, since for non-monitored loans $\Pi_0 - 1 < 0$. Thus, regulator prefers to close the bank than allow bank to continue operating even if $F = 0$. For $k^* \leq k < k^{**}$ as well as for the range of $k^{**} \leq k < k_d$ when $\delta < \delta^S$, the banker monitors loans, and NPV from financed loans is positive $\Pi_1 - 1 - c > 0$. However, originated loans have a positive probability of default $1 - p$, incurring the social loss of $(1 - p)F$. If $k \geq k^{**}$ and $\delta^S \leq \delta \leq \delta_{1,\alpha=\alpha^*}^{PC}$, the banker monitors loans yielding positive NPV and bank is default free, since capital is enough to repay all depositors in case of risky assets failure.

The regulator maximizes social welfare for the range of $k \geq k^{**}$ and $\delta \geq \delta^S$, i.e minimum capital requirement is:

$$\begin{cases} k^{**} & \text{if } \delta_{1,\alpha=\alpha^*}^{PC}(k^{**}) < \delta \leq \delta^S(k^{**}) \\ k^{-1}(\delta^S) & \text{otherwise} \end{cases} \quad (3.101)$$

However, if cost of capital is high $\delta > \delta_{1,\alpha=\alpha^*}^{PC}(k^{**})$, the regulator reduces capital requirement to k^* . In this case the banker does not originate loans any more due to the expensive bank financing. Then the social welfare is 0. Thus, the regulator prefers that the banker originates loans and upon default deposit insurance fund compensates depositors.

As a result, optimal capital requirement for the standalone bank is:

$$k_{SB}^* = \begin{cases} k^* & \text{if } \delta \geq \delta_{1,\alpha=\alpha^*}^{PC}(k^{**}) \\ k^{**} & \text{if } \delta_{1,\alpha=\alpha^*}^{PC}(k^{**}) < \delta \leq \delta^S(k^{**}) \\ k^{-1}(\delta^S) & \text{otherwise} \end{cases} \quad (3.102)$$

Next, solve for the optimal capital requirement for the conglomerate bank. Then there are three cases when the conglomerate bank's choice results in different social welfare.

Condition	Social welfare
Case 1: $\delta < \delta^M$	$\Pi_0 - 1 - (1 - \beta p)F$
Case 2: $\delta^M \leq \delta \leq \delta_{1,\alpha=s}^{PC}$	$\Pi_1 - 1 - c - (1 - p)F$
Case 3: $\delta > \delta_{1,\alpha=s}^{PC}$	0

Table 3.2: Social welfare in the case of financial conglomerate

Regulator never sets such capital requirement that results in non-monitored assets, i.e when $\delta < \delta^M$, since this yields negative social welfare due to the origination of negative NPV assets. Regulator prefers to close the bank rather than to set too low capital requirement and deprive bank from monitoring incentives. If $\delta^M \leq \delta \leq \delta_{1,\alpha=s}^{PC}$, the banker monitors assets yielding positive NPV loans. However, kept loans have a positive probability of failure $1 - p$. Thus, the optimal minimum capital requirement is $k_{FC}^* = k^{-1}(\delta^M)$.

Proof of Proposition 12

First, consider the standalone bank. If the capital requirement is optimal, there is no need in restricting the market sale of bank loans. Social welfare does not depend on the amount of loans sold. Optimal asset sale restriction s is zero for the standalone bank.

Next, consider the conglomerate bank. To improve the welfare, the regulator eliminates any chance of bank default. For a given capital requirement k , the required requirement to keep loans must be such that the expected value of deposit insurance subsidy is not larger than zero, i.e

$$(s - \theta)R - (1 - k)s \geq 0 \quad (3.103)$$

Minimum holding requirement is $s_{FC}^* = \frac{\theta R}{R - (1 - k)}$. Note that $s_{FC}^* \leq 1$ if $k \geq 1 - (1 - \theta)R = k_d$. Thus, both high capital requirement and high retention share must be set to maximize social welfare.

Proof of Lemma 12

This lemma describes the comparative statics for the optimal retention requirement for bank in an FC if $k > k_d$.

The derivative of s_{FC}^* with respect to k :

$$\frac{\partial s_{FC}^*|_{k>k_d}}{\partial k} = -\frac{\theta R}{[R - (1 - k)]^2} < 0$$

Optimal skin in the game requirement decreases with k .

The derivative of s_{FC}^* with respect to θ :

$$\frac{\partial s_{FC}^*|_{k>k_d}}{\partial \theta} = \frac{R}{[R - (1 - k)]} > 0$$

If the share θ of risky assets in the pool increases, the retention requirement increases to offset banker's risk incentives.

Chapter 4

Franchise Value and Risk-Taking in Modern Banks

4.1 Introduction

The recent crisis revealed a surprising amount of risk-taking in financial institutions with exceptionally valuable franchises. Before the crisis, AIG was one of only three AAA-rated companies in the U.S. It started selling credit default swap (CDS) protection on senior tranches of collateralized debt obligation in 2005 and lost over \$100 billion – 10% of assets – in 2008 (AIG Annual Report, 2007), wiping out shareholder equity and triggering a bailout. UBS in Switzerland had a unique wealth management franchise, with a stable return on allocated capital in excess of 30% (UBS Annual Report, 2007). It rapidly, over just two years, accumulated a large portfolio of CDS, lost over \$50 billion in 2008, and had to be rescued. Washington Mutual, once called “The Walmart of Banking”, lost \$22 billion on subprime exposures and was liquidated. Similar investments-related disasters occurred in many other previously-profitable banks in U.S. and Europe.

Significant risk-taking in institutions with a high franchise value seems to contradict the traditional predictions of corporate finance models.¹ Shareholders are protected by limited liability and have incentives to take risk to maximize their option-like payoff (Jensen and Meckling, 1976). But as the shareholder value increases, shareholders internalize more of the downside, so their risk-taking incentives decline. A bank’s franchise value belongs to its shareholders and is lost in the bankruptcy, so a high franchise value should reduce bank risk-taking. Therefore it is puzzling why profitable banks chose to become exposed to risky and untested market-based instruments and on such a large scale.

This paper attempts to reconcile theory and evidence. Our key observation is that in Jensen and Meckling-type models, firms choose the risk of a portfolio of a given size. Yet bank

¹We understand franchise value as long term bank profitability (a ratio of a discounted stream of future bank profits to bank size).

risk-taking in the run-up to the crisis took a different form. Banks levered up – expanded the balance sheet – to undertake additional, risky market-based investments. The investments had skewed returns: they offered modest gains (“alpha”) in normal times, but incurred significant and correlated losses in downturns.² The risks were accumulated alongside banks’ traditional ‘core’ business, which remained stable and prudent.

We show that when banks take risk by leveraging up to take *additional risk*, rather than by manipulating their core portfolio, the traditional result that high franchise value reduces bank risk-taking incentives does not always hold. The reason is that high franchise value allows the bank to borrow more and take risk on a larger scale. Larger scale offsets lower incentives to take risk of given size. As a result, a bank with a high franchise value may have higher – not lower – incentives to take risk.

The novel effect where franchise value contributes to bank risk-taking holds for a range of parameter values. It is more likely to arise when it is easier for banks to lever up. This may be a result of better institutional environment with more protection of creditor rights. This could explain why most banks affected by the crisis were in advanced economies. And the effect is more likely to arise when the funding for banks’ market-based investments is senior to the funding for their core business. This highlights the role of repo market arrangements in pre-crisis vulnerability (repos are senior to the rest of bank funding; Gorton and Metrick, 2012; Acharya and Öncü, 2013). Thus, the comparative statics of our model are consistent with the stylized patterns of bank risk-taking in the run-up to the crisis.

Our analysis lends itself to a number of extensions. In one extension, we show that a bank may strategically exert effort to increase the value of its core business in order to take large market-based gambles alongside it. A bank then combines prudent risk management in its core activity (e.g., lending or wealth management) with risky market-based activities. While the literature has often associated this seeming inconsistency with a “clash of cultures” between conservative bankers and risk-loving traders (Froot and Stein, 1998), we explain it based purely on shareholder value maximization.

In another extension, we consider the effects of bank capital and capital requirements. We find that higher capital *per se* does not necessarily reduce bank risk-taking, because higher capital today may allow the bank to borrow more in the future. Binding capital requirements may reduce bank risk-taking, but only if they include a sufficiently high capital charge on market-based investments, or a leverage ratio.

The paper relates to the literature on the link between bank franchise value and risk-taking. The accepted first-order effect is that franchise value reduces bank risk-taking incentives (Keeley, 1990; Demsetz et al., 1996; Repullo, 2004; among others). But a number of papers

²The risky investments included carry trade reliant on short term wholesale funding (Gorton, 2010), selling protection on senior tranches of asset backed securities through CDS contracts (Acharya and Richardson, 2009), undiversified exposures to housing (Shin, 2009), etc. Acharya et al. (2009) call these investments “the manufacturing of tail risk”.

caution that the relationship is more complex. First, there are dynamic effects where banks take risk in order to generate franchise value (Blum, 1999; Hellmann et al., 2000; Matutes and Vives, 2000). Second, high franchise value makes capital requirements less binding, so that the bank is less averse to occasional losses (Calem and Rob, 1999; Perotti et al., 2011). Our model proposes a novel effect, closely linked to the pre-crisis experience, where franchise value enables banks to borrow and take risk on a larger scale.

It is notable that the emerging empirical literature on bank performance around the 2008 crisis is not conclusive on the effects of bank capital. On the one hand, Beltratti and Stulz (2012) find in a sample of banks from advanced and emerging economies that, in most but not all specifications, higher pre-crisis capital improved bank performance during the 2008 crisis. And Berger and Bouwman (2013) show that higher capital improved U.S. banks' performance during multiple banking crises (but not specifically during the 2008 crisis, for which the results are nuanced). On the other hand, studies that focus on banks in advanced economies during the 2008 crisis only offer different insights. Huang and Ratnovski (2009) use OECD data and find no relationship between pre-crisis bank capital and performance during the crisis. They suggest that any positive impact of bank capital on performance is driven by banks with extremely low capital, and any equity above 4% of assets did not improve bank stability. Camara et al. (2010) use European data and verify that well-capitalized banks took more risk before the 2008 crisis. IMF's GFSR (2009) uses a sample of 36 major global banks and finds that banks that were intervened in during the crisis had statistically higher capital metrics (risk-weighted or not) before the crisis. All the latter effects are consistent with the main message of our paper.³

Our paper also relates to the literature on the effect of institutional environment on risk-taking. The positive relationship between the quality of institutional environment and the severity of crises was recently documented in the international economics literature (Giannone et al., 2011; Gourinchas et al., 2011). We explain why this may be the case. Stronger institutional environment offers better protection to creditor rights (Laeven, 2001; La Porta et al., 2003; Boyd and Hakenes, 2012) and thus allows banks to become more levered, with higher incentives to take risk.

There are parallels between our analysis and those of Myers and Rajan (1998) and Adrian and Shin (2014). Myers and Rajan (1998) point to an unintended effect of asset liquidity, which creates moral hazard by increasing managers' ability to trade assets in their own interest. Our framework points to an unintended effect of bank franchise value: it enables bankers to borrow more and take more risk. Adrian and Shin (2014) offer a framework where the leverage of financial intermediaries is procyclical: the level of bank equity is fixed, but banks can borrow more during upturns, thanks to lower risk weights. Our paper expands on this,

³Also, on pre-crisis data, Barth et al. (2006) find no relationship between bank capital ratios and stability. Bichsel and Blum (2004), Lindquist (2004), Jokipii and Milne (2008), and Angora et al. (2009) also find no or negative relationship between bank capital and performance pre-crisis.

suggesting that the expansion of bank balance sheets during upturns may take form of risky market-based gambles, consistent with the evidence from the financial crisis.⁴

Finally, it is useful to elaborate why the effects identified in our paper apply primarily to “modern” banks, i.e., may have come to the fore only recently. In the past, financial markets were not as developed, which limited the size of market-based gambles that banks could engage in. Only since the 1990s, with the deepening of financial markets that followed deregulation and financial innovation revolution, have the problems of risky market-based activities of banks become acute (Morrison and Wilhelm, 2007; Boot, 2014).

The paper is structured as follows. Section 2 sets up the model. Section 3 solves the model with an exogenous cost of funding. Section 4 endogenizes the cost of funding. Section 5 offers extensions. Section 6 discusses implications. Section 7 concludes.

4.2 The Model

Consider a bank which operates in a risk-neutral economy with three dates (0, 1, 2) and no discounting. The bank has no initial capital, has to borrow in order to invest, and maximizes its expected profit.

The bank is endowed with access to a valuable *core* project. This project is profitable, not scalable, and safe. Think about this as the relationship banking business. For 1 unit invested at date 0, the core project produces $R > 1$ with certainty at date 2. We call the NPV of the core project, $R - 1$, its *franchise value*.⁵

At date 1, the bank may in addition undertake a risky market-based investment. Think about this as carry trade (e.g., the accumulation of a portfolio of senior collateralized debt obligation using wholesale funding). The investment is scalable and has binary returns. For X units invested at date 1, it produces at date 2 a positive return $(1 + \alpha)X$ with probability p (where $\alpha > 0$), and 0 with probability $1 - p$. The risky investment has a negative NPV, so the bank would only engage in it for the purpose of risk-shifting:

$$p(1 + \alpha) < 1. \tag{4.1}$$

And even for a successful risky investment, the return obtained is lower than the return on the

⁴Another related paper is Boot and Ratnovski (2014). They also consider the interaction between relationship banking and market-based bank activities. Boot and Ratnovski study how banks may opportunistically misallocate capital to market-based “trading”, as a consequence of a conflict between the long-term nature of banking and the short-term nature of trading. Our paper focuses on a different issue: how market-based activities can be used for risk-shifting, depending on the value of the relationship banking business.

⁵Since the size of the core project is normalized to 1, $R - 1$ represents the project’s profitability (a ratio of profit to project size), consistent with our definition of franchise value. Note that franchise value is not related to bank size.

core project:

$$\alpha < R - 1. \tag{4.2}$$

This setup mimics real-world bank risk-taking strategies which generate a small positive return most of the time, but can lead to catastrophic losses with a small probability. The bank's project choice is not verifiable; as a result, the bank cannot commit not to undertake the risky value-destroying investment.⁶

The bank funds itself with debt. It attracts 1 unit of funds for the core project at date 0 against the interest rate r_0 , and may attract X units of funds for the market-based investment at date 1 against the interest rate r_1 . We call the two groups of creditors "date 0" and "date 1" creditors. All funds are repaid at date 2 if the bank is solvent (the payoff from projects exceeds the total amount owed). If the bank is insolvent, it is liquidated and all assets go to creditors. In Section 3, we solve a simplified version of the model setting $r_0 = r_1 = 0$. This allows us to showcase our main result most immediately. Exogenous interest rates can be rationalized through deposit insurance with risk-insensitive premiums, or through "too-big-to-fail" implicit government guarantees on the debt of large banks (O'Hara and Shaw, 1990). In Section 4, we solve the model with endogenous interest rates, and verify that our results hold.

The final ingredient of the model is that the bank is subject to a leverage constraint, driven by the owner-manager's incentives to engage in moral hazard. We use the Holmstrom and Tirole (1997) formulation, where the owner-manager can run the bank normally or, immediately after date 1, convert the bank's assets into private benefits. The manager would run the bank normally when:

$$\Pi \geq b(1 + X), \tag{4.3}$$

where Π is the shareholder return when assets are employed for normal business, and $b(1 + X)$ is the initial value of assets $1 + X$ multiplied by the conversion factor b ($0 < b < 1$) of assets

⁶It is useful to describe the relevance of these assumptions. In practice some market-based investments may be valuable or have different return distributions. But in this model we focus on the bank's incentives to opportunistically undertake value-destroying, tail risk-like projects. The assumption that the market-based investment has a negative NPV is convenient for exposition purposes. We can obtain similar results in a set-up where the risky investment has a positive NPV, but bank failures have negative externalities (e.g., 'systemic risk'). Banks' traditional lending is indeed usually more profitable than market-based investments. For example, in 2000-2007, the U.S. banks' net interest rate margin on lending was 3.25%, while gross returns on trading assets were 2% (and negative during the crisis; NY Fed, 2012). This is probably because banks enjoy some market power in lending due to asymmetric information (Petersen and Rajan, 1995; Dell'Ariccia and Marquez, 2006). The bank's investment decision may be not verifiable when it is difficult to write contracts limiting investments in innovative financial products (commitments in such contracts are easy to evade by designing new, previously unspecified products).

into private benefits.⁷ We assume that:

$$R - 1 \geq b, \tag{4.4}$$

so that the leverage constraint (4.3) is not binding when the bank engages only in the core project, and:

$$p\alpha < b, \tag{4.5}$$

so that the constraint becomes more binding in higher X .⁸

The timeline is summarized in Figure 4.1.

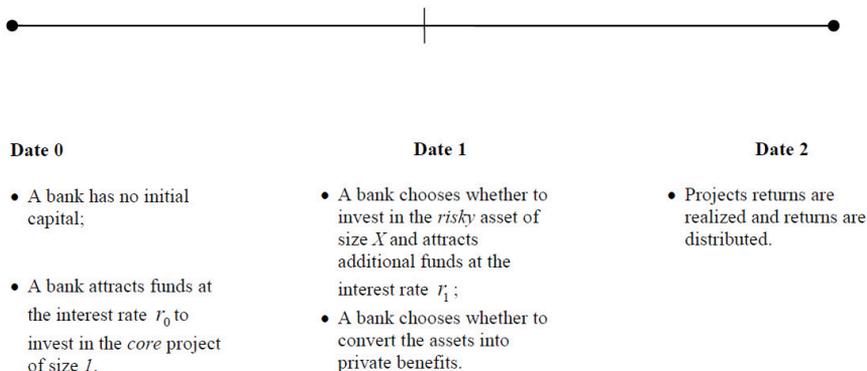


Figure 4.1: The Timeline

⁷The fact that firms can borrow only a certain fraction of their net worth is a standard feature of corporate finance models. For banks, this can be thought of as an economic capital requirement (Allen et al., 2011). There are many ways to interpret the payoff to moral hazard $b(1 + X)$. It can represent savings on abstaining from the owner-manager’s effort, limits on the pledgeability of revenues (Holmstrom and Tirole, 1998), the possibility of absconding (Calomiris and Kahn, 2001; Martin and Parigi, 2011), cash diversion (Hart, 1995; Burkart and Ellingsen, 2004), or even looting (Akerlof and Romer, 1993; Boyd and Hakenes, 2012). Bank creditors anticipate that the bank may engage in moral hazard and limit the amount of money that they are willing to lend to the bank.

⁸These assumptions are based on the observation that traditional banks (with relationship rents and a fixed customer base) are often not capital constrained, while market-based activities require a substantial equity commitment (as obtained through partnerships in early investment banking, or from full partners in hedge funds). A lower b ($b < p\alpha$) would enable the bank to undertake the market-based risky investment on an infinite scale, while a higher b ($b > R - 1$) would make the bank unable to raise funds even for its core lending activity.

4.3 Exogenous Cost of Bank Funding

4.3.1 Bank Strategy

Assume that $r_0 = r_1 = 0$ (we relax this assumption in the next section). Consider the bank's incentives to undertake the risky investment alongside its core project. The bank's profit when it invests only in the core project is $\Pi_0 = R - 1$, where R is the return of the core project and 1 is the repayment to creditors. When the bank undertakes the risky investment on a small scale, $X \leq R - 1$, it always repays its creditors in full at date 2 from the returns on the core project. The bank's expected profit is:

$$\Pi_1^{X \leq R-1} = R + p(1 + \alpha)X - (1 + X) = R - 1 + X[p(1 + \alpha) - 1], \quad (4.6)$$

where R is the return on the core project, $p(1 + \alpha)X$ is the return from the risky investment, and $1 + X$ is repayment to date 0 and date 1 creditors. From (4.1), $\Pi_1^{X \leq R-1} < \Pi_0$: since the risky investment has negative NPV, the bank has no incentives to undertake it when it fully internalizes the downside.

When the bank undertakes the risky investment on a larger scale, $X > R - 1$, the bank's profit is:

$$\Pi_1 = p[R + (1 + \alpha)X - (1 + X)] = p(R - 1 + \alpha X), \quad (4.7)$$

where p is the probability of success of the risky investment, $R - 1$ is the return on the core project, and αX is the return on the risky investment when it succeeds. With additional probability $1 - p$ the risky investment fails, the bank cannot repay its creditors in full, and the value of equity is zero.

The bank has incentives to undertake the risky investment when $\Pi_1 > \Pi_0$, corresponding to:

$$X > X_{\min} = \frac{(1 - p)(R - 1)}{p\alpha}. \quad (4.8)$$

This implies that the bank only undertakes the risky investment if it can do that on a sufficient scale. The intuition is that risk-taking has a fixed cost (i.e., the loss of the core project's franchise value $R - 1$ in bankruptcy with probability $1 - p$), while the benefits of risk-taking (i.e., the additional return α) are proportional to the scale of the risky investment. (Note that from (4.1) $X_{\min} > R - 1$).

Now consider the bank's ability to lever up to undertake the risky investment. When the bank undertakes the risky investment on scale X , the leverage constraint (4.3) becomes:

$$p(R - 1 + \alpha X) \geq b(1 + X), \quad (4.9)$$

where $p(R - 1 + \alpha X)$ is the bank's profit (same as Π_1 in (4.7)) and $b(1 + X)$ is the payoff

from moral hazard. This gives the maximum scale of the bank's risky investment:

$$X \leq X_{\max} = \frac{p(R-1) - b}{b - p\alpha}. \quad (4.10)$$

We can now summarize the bank's strategy as follows:

Lemma 13. *The bank undertakes risky investment when $X_{\min} < X_{\max}$. The interval $(X_{\min}, X_{\max}]$ is non-empty when b is low:*

$$b < b_{\max} = \frac{p\alpha(R-1)}{p\alpha + (1-p)(R-1)}. \quad (4.11)$$

Whenever the bank undertakes the risky investment, it does so at its maximum possible scale X_{\max} , since $\partial\Pi_1/\partial X > 0$.

Proof. See Appendix. □

Figure 4.2 illustrates the bank's strategy.

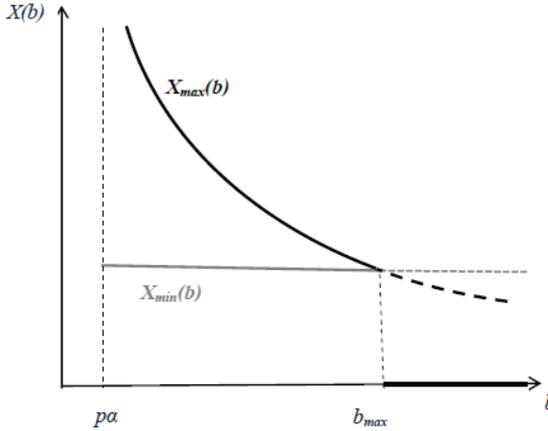


Figure 4.2: The scale of risky investment as a function of private benefits b

4.3.2 Franchise Value and Bank Risk-Taking

We now ask how franchise value affects bank risk-taking in our framework. Consider the effects on bank risk-taking of R , where $R - 1$ represents the franchise value of the bank's core project. Note that:

$$\frac{\partial b_{\max}}{\partial R} = \frac{p^2\alpha^2}{[p\alpha + (1-p)(R-1)]^2} > 0, \quad (4.12)$$

meaning that with a higher R the bank can undertake the risky investment for a wider range of parameter values. Note also that:

$$\frac{\partial X_{\max}}{\partial R} = \frac{p}{b - p\alpha} > 0, \quad (4.13)$$

from (4.5). This means that with a higher R the bank can undertake the risky investment on a larger scale.

We can now summarize with our first main result.

Proposition 13. *The bank undertakes risky investment when the leverage constraint is sufficiently lax, corresponding to low private benefits of moral hazard: $b < b_{\max}$. Higher franchise value expands the range of parameter values where the bank undertakes risky investment ($\partial b_{\max}/\partial R > 0$) and increases the scale of the risky investment ($\partial X_{\max}/\partial R > 0$).*

Figure 4.3 illustrates the relationship between franchise value and bank risk-taking.

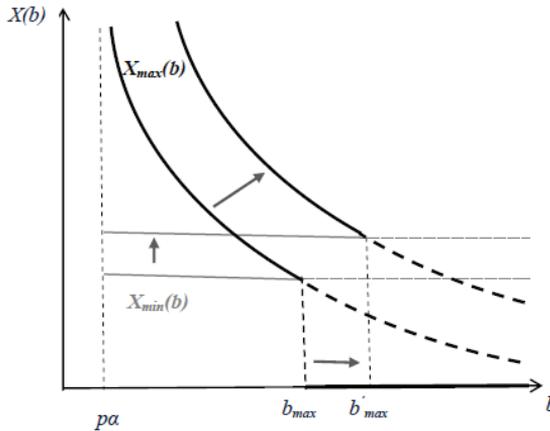


Figure 4.3: Risk incentives: comparative statics with respect to the franchise value R

The intuition is that when b is small, the leverage constraint is less binding, so an increase in the bank's franchise value increases its ability to borrow substantially. Then, the possibility to undertake the risky investment on a larger scale (higher X_{\max}) offsets lower incentives to take risk of given size (higher X_{\min}).⁹ This result sheds light on the reasons why banks with exceptionally high franchise value were in the center of the universe of new and risky financial instruments before the recent crisis. The high franchise value allowed such banks to borrow and take market-based exposures at an exceedingly large scale, which was sufficient to compensate for the risk of a loss of a core franchise.

⁹Note that from (4.8), $\frac{\partial X_{\min}}{\partial R} = \frac{1-p}{p\alpha} > 0$.

4.4 Endogenous Cost of Bank Funding

This section introduces risk-sensitive debt and shows that the results of Proposition 13 continue to hold. We also obtain new results on the effects of debt seniority on bank risk-taking.

4.4.1 Setup

Consider two tranches of bank debt: the tranche attracted for the core project at date 0 against the interest rate r_0 and the tranche attracted for the risky investment at date 1 against the interest rate r_1 . The interest rates are not anymore exogenous, but determined by the creditors' break even conditions, which depend on date 2 repayments.

When the bank is solvent, the creditors are repaid in full. When the bank is insolvent (which happens when the risky investment fails), it is liquidated and the remaining assets R are distributed among the creditors according to their seniority. The two tranches of debt may have different seniority. We capture the seniority of date 1 creditors by a parameter θ : the share of their investment that they receive in bankruptcy. That is, in bankruptcy, date 1 creditors are repaid θX and date 0 creditors $R - \theta X$, where $0 < \theta < \min[R/X, 1]$ ($\theta > R/X$ is not credible). A higher θ represents more senior date 1 debt.

In practice, θ is determined by contractual arrangements between the bank and its creditors. For example, if date 1 debt is secured (as in repos), or is scheduled to be repaid immediately before date 0 debt, it would be more senior (Brunnermeier and Oehmke, 2013). In the analysis, we treat θ as exogenous. As will become apparent, making θ endogenous, when the bank is able to set θ after date 0 debt is attracted, would lead the bank to choose the highest possible θ (e.g., attract all new funding in the form of repos), and thus make our risk-taking results even more pronounced.

4.4.2 Bank Strategy

We start by replicating the results of Proposition 13. When the bank undertakes the risky investment on a low scale, $X \leq \frac{R-1}{\theta}$, it internalizes the losses and as a result has no incentives for risk-taking.¹⁰ When the bank undertakes the risky investment on a larger scale, $X > \frac{R-1}{\theta}$, its profit is (similar to (4.7)):

$$\begin{aligned}\Pi_1 &= p\{R - (1 + r_0) + X[(1 + \alpha) - (1 + r_1)]\} = \\ &= p[R - (1 + r_0) + X(\alpha - r_1)],\end{aligned}\tag{4.14}$$

¹⁰Date 0 creditors' claim on the bank is risk-free since the bank is able to repay them in full at date 2 from the returns of the core project upon the failure of risky investment: $R - 1 - \theta X > 0$. However, from (4.1): $\Pi_1^{X \leq \frac{R-1}{\theta}} = R - 1 + p(1 + \alpha)X - (1 + r_1)X < R - 1 = \Pi_0$, which means that there is no risk-shifting.

where p is the probability of success of the risky investment, and $[R - (1 + r_0) + X(\alpha - r_1)]$ is the payoff in case of success. With additional probability $1 - p$ the risky investment fails, the bank cannot repay creditors in full, and the value of equity is zero. The bank has incentives to undertake the risky investment when $\Pi_1 > \Pi_0 = R - (1 + r_0)$, corresponding to:

$$X > X_{\min}^{\theta} = (1 - p) \frac{R - (1 + r_0)}{p(\alpha - r_1)}. \quad (4.15)$$

We now derive the bank's ability to lever up to undertake the risky investment. The leverage constraint (4.3) takes the form (similar to (4.9)):

$$p[R - (1 + r_0) + X(\alpha - r_1)] \geq b(1 + X), \quad (4.16)$$

where $[R - (1 + r_0) + X(\alpha - r_1)]$ is the payoff in case of success, and $b(1 + X)$ is the payoff to moral hazard. This limits the scale of the risky investment to:

$$X \leq X_{\max}^{\theta} = \frac{p(R - 1 - r_0) - b}{b - p(\alpha - r_1)}. \quad (4.17)$$

The interest rate r_1 is obtained from the break-even condition for date 1 bank creditors:

$$p(1 + r_1)X + (1 - p)\theta X = X, \quad (4.18)$$

giving:

$$r_1 = \frac{(1 - p)(1 - \theta)}{p}. \quad (4.19)$$

By substituting the value for r_1 from (4.19) into (4.15) and (4.17), we obtain:

$$X_{\min}^{\theta} = (1 - p) \frac{R - (1 + r_0)}{p\alpha - (1 - p)(1 - \theta)}, \quad (4.20)$$

$$X_{\max}^{\theta} = \frac{p[R - (1 + r_0)] - b}{b - [p\alpha - (1 - p)(1 - \theta)]}. \quad (4.21)$$

We can show the following:

Lemma 14. *The bank undertakes risky investment when $X_{\min}^{\theta} < X_{\max}^{\theta}$, and it does that at the maximum possible scale X_{\max}^{θ} . The interval $(X_{\min}^{\theta}, X_{\max}^{\theta}]$ is non-empty when b is low and θ is high:*

$$\theta > \theta_{\min} = 1 - \frac{p\alpha}{1 - p}, \text{ and} \quad (4.22)$$

$$b < b_{\max}^{\theta} = \frac{(R - 1 - r_0)(\theta - \theta_{\min})}{R - 1 - r_0 + \theta - \theta_{\min}}. \quad (4.23)$$

Proof. See Appendix. □

As before, the bank undertakes the risky investment when the private benefits b are small. Observe that $b_{\max}^{\theta} < b_{\max}$, where b_{\max} is given in (4.11). Endogenous funding rates reduce the bank's ability to lever up, since the bank's cost of debt is no longer subsidized. In addition, the incentives to undertake the risky investment depend on the seniority θ of date 1 creditors. A high θ reduces the interest rate r_1 , making the risky investment more attractive.¹¹

To complete the model, we endogenize the interest rate required by date 0 creditors. They receive only a share of the bank's liquidation value R when the risky investment fails. Anticipating that, they choose $r_0 > 0$ whenever they expect the bank to undertake at date 1 the risky investment financed by senior debt. Alternative $r_0 = 0$ is based on the belief that only core investment is made. Since the lower interest rate only increases incentives to take risk, $r_0 = 0$ provides negative payoff for date 0 creditors, and is out of equilibrium. Formally, from the date 0 creditors' break-even condition:

$$p(1 + r_0) + (1 - p)(R - \theta X) = 1, \quad (4.24)$$

we obtain:

$$r_0 = \frac{1 - p}{p} \cdot \frac{(R - 1)[\theta - (1 - p)\theta_{\min} - b] - b\theta}{(1 - p)\theta_{\min} + b}, \quad (4.25)$$

with θ_{\min} given in (4.22). Note that the franchise value is sufficient to repay date 0 creditors: $R - 1 - r_0 \geq 0$. For a detailed derivation of r_0 , see Appendix.

4.4.3 Franchise Value and Bank Risk-Taking

Consider again the effect of R , where $R - 1$ represents the franchise value of the bank's core project, on bank risk-taking. From (4.23):

$$\frac{\partial b_{\max}^{\theta}}{\partial R} = \frac{\left(1 - \frac{\partial r_0}{\partial R}\right) (\theta - \theta_{\min})^2}{(R - 1 - r_0 + \theta - \theta_{\min})^2}, \quad (4.26)$$

where:

$$\frac{\partial r_0}{\partial R} = \frac{1 - p}{p} \cdot \frac{\theta - (1 - p)\theta_{\min} - b}{(1 - p)\theta_{\min} + b} > 0. \quad (4.27)$$

This implies that $\frac{\partial b_{\max}^{\theta}}{\partial R} > 0$. Recall that the bank undertakes the risky investment for $b < b_{\max}^{\theta}$. Thus, high franchise value makes the bank more likely to engage in risky investment. Note also that:

$$\frac{\partial X_{\max}^{\theta}}{\partial R} = \frac{p \left(1 - \frac{\partial r_0}{\partial R}\right)}{b - (1 - p)(\theta - \theta_{\min})} > 0, \quad (4.28)$$

¹¹Note that repaying interest r_1 upon success is feasible ($r_1 < \alpha$) when $\theta > \theta_{\min}$. When seniority of new funds θ is low, the bank cannot attract funds for the risky investment.

meaning that the scale of the risky investment increases in bank franchise value R .¹² These replicate the result of Proposition 13.

Proposition 14. *The bank undertakes risky investment when the leverage constraint is sufficiently lax, corresponding to low private benefits of moral hazard: $b < b_{\max}^{\theta}$, and the cost of attracting new funds is sufficiently low, corresponding to high seniority of date 1 creditors: $\theta > \theta_{\min}$. Higher franchise value expands the range of parameter values where the bank undertakes risky investment ($\partial b_{\max}^{\theta}/\partial R > 0$) and increases the scale of the risky investment ($\partial X_{\max}^{\theta}/\partial R > 0$).*

Proof. See Appendix. □

4.4.4 Debt Seniority and Bank Risk-Taking

Consider now the effects on bank risk-taking of θ , the seniority of date 1 creditors. A higher θ reduces the interest rate required by date 1 creditors:

$$\frac{\partial r_1}{\partial \theta} = -\frac{1-p}{p} < 0, \quad (4.29)$$

and increases the interest rate required by date 0 creditors:

$$\frac{\partial r_0}{\partial \theta} = \frac{1-p}{p} \cdot \frac{R-1-b}{(1-p)\theta_{\min} + b} > 0. \quad (4.30)$$

From (4.23):

$$\frac{\partial b_{\max}^{\theta}}{\partial \theta} = \frac{(R-1-r_0)^2 - \frac{\partial r_0}{\partial \theta} \cdot (\theta - \theta_{\min})^2}{(R-1-r_0 + \theta - \theta_{\min})^2} > 0. \quad (4.31)$$

Higher r_0 lowers the cost of losing the value of the core project in case of bank failure. Lower r_1 means that the bank can get higher return from the risky investment, which enhances its attractiveness. Thus, higher debt seniority makes the bank more likely to engage in risky investment.

Also note that:

$$\frac{\partial X_{\max}^{\theta}}{\partial \theta} = \frac{-p \frac{\partial r_0}{\partial \theta} [b - (1-p)(\theta - \theta_{\min})] + p(1-p)(R-1-r_0)}{[b - (1-p)(\theta - \theta_{\min})]^2} > 0. \quad (4.32)$$

A higher r_0 lowers, while a lower r_1 increases the bank's ability to lever up. We find that, overall, the latter effect dominates: a higher θ increases the scale at which the bank can undertake the risky investment.

We can now summarize our second main result:

¹²From (4.20) note also that: $\frac{\partial X_{\min}^{\theta}}{\partial R} = \frac{1 - \frac{\partial r_0}{\partial R}}{\theta - \theta_{\min}} > 0$. However, the possibility to undertake the risky investment on a larger scale (higher X_{\max}^{θ}) offsets lower incentives to take risk of given size (higher X_{\min}^{θ}).

Proposition 15. *When the leverage constraint is sufficiently lax, corresponding to low private benefits of moral hazard ($b < b_{max}^\theta$), higher seniority of date 1 creditors expands the range of parameter values where the bank undertakes risky investment ($\partial b_{max}^\theta / \partial \theta > 0$) and increases the scale of the risky investment ($\partial X_{max}^\theta / \partial \theta > 0$).*

Proof. See Appendix. □

Figure 4.4 illustrates the relationship between date 1 debt seniority and bank risk-taking.

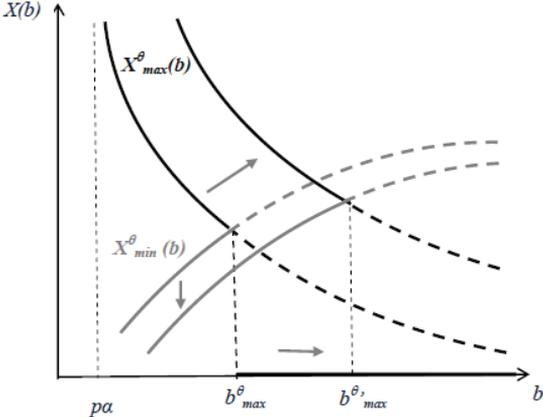


Figure 4.4: Risk incentives: comparative statics with respect to the debt seniority θ

Proposition 15 highlights the role of bank funding arrangements in creating incentives for risk-shifting. When a bank can make new funding senior (e.g., through the use of repos), it increases the incentives to use new funds for large market-based gambles. There are two reasons: First, higher seniority of new funds makes pre-existing bank funding more expensive, reducing the cost of putting the bank’s franchise value at risk. Second, higher seniority makes the new funds cheaper, increasing the returns to the market-based investment.

4.5 Extensions

In the previous sections we showed how franchise value can increase bank risk-taking incentives by increasing the bank’s ability to borrow. Here we offer two extensions of our model to deepen the intuition. First, we consider the case when the bank has to exert effort to improve the performance of the core project (which can also be interpreted as effort to decrease risk in the core project). Second, we consider the role of bank capital. To simplify exposition, we go back to the assumption of exogenous interest rates on bank funding: $r_0 = r_1 = 0$. (Endogenizing the interest rates would not affect the results.)

4.5.1 Effort in the Core Project

Consider the case when the bank’s core project is also risky, and the bank needs to exert effort to increase the probability of its success. We analyze how the presence of the risky market-based investment opportunity affects the bank’s incentives to exert such effort.

Formally, assume that the return on the core project is R with probability e and 0 otherwise (as opposed to a certain return R in the main model). The probability e corresponds to the bank’s effort, which carries a private cost $ce^2/2$, with $c > R - 1$ to ensure interior solution. The bank exerts effort at date 0, and the date 2 realization of the core project (whether it will succeed or not) becomes known immediately afterwards. The timeline is summarized in Figure 4.5.

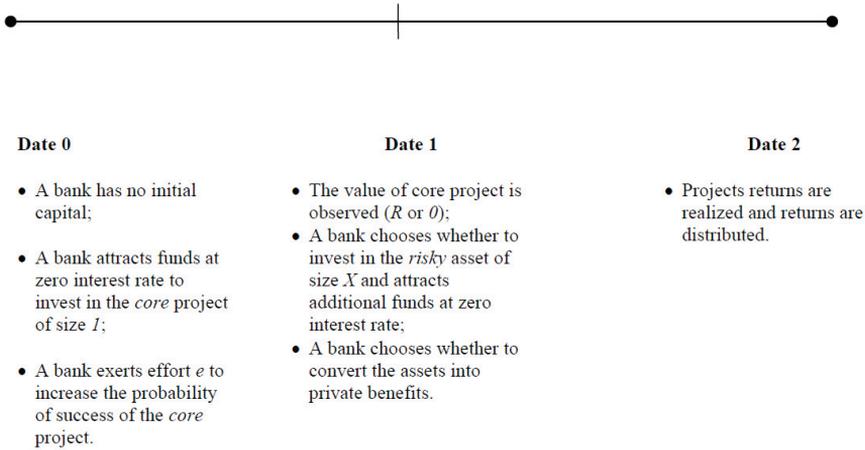


Figure 4.5: Effort in the core project: The timeline

We first derive the bank’s optimal effort in the absence of the risky market-based investment. The bank’s payoff from investing in the core project only:

$$\Pi_0^e = e(R - 1) - ce^2/2$$

is maximized for:

$$e = e_0 = \frac{R - 1}{c}. \tag{4.33}$$

Consider now the case when, at date 1, the bank may undertake a risky investment in addition to the core project. Recall that at date 1 the cost of effort for the core project is sunk, and the future realization of the core project is known. Then, the bank’s investment strategy is as follows. If the core project’s observed returns are R , the incentive problem of the bank is identical to the one in the basic model. When $b < b_{\max}$, the bank makes a risky investment of

size X_{\max} , with X_{\max} and b_{\max} given in (4.10) and (4.11), respectively. If the core project fails, the bank cannot raise funds for the risky investment and has zero payoff.

At date 0, the bank chooses e to maximize the expected joint payoff from the core and risky investments:

$$\Pi_1^e = ep(R - 1 + \alpha X_{\max}) - \frac{ce^2}{2}, \quad (4.34)$$

giving:

$$e = e_1 = \frac{p(R - 1 + \alpha X_{\max})}{c}, \quad (4.35)$$

where $\partial e_1 / \partial X_{\max} > 0$.

Proposition 16. *When the leverage constraint is sufficiently lax, corresponding to low private benefits of moral hazard ($b < b_{\max}$), the presence of the risky market-based investment opportunity increases bank incentives to exert effort in the core project: $e_1 > e_0$.*

Proof. See Appendix. □

The intuition for this result is as follows. The bank's effort increases the expected value of the core project, and through this the borrowing capacity. This allows the bank to gamble with the risky investment on a larger scale. Therefore, access to risky market-based investments increases the bank's incentives to exert effort. In equilibrium, a bank runs a deliberately safe (and profitable) core project, which enables it to take risk on a larger scale in market-based activities.

4.5.2 Bank Capital

Our model did not have explicit bank capital. The bank was financed entirely with debt, and derived implicit equity from the NPV of its core project. Now we allow the bank to be financed with both debt and inside equity. Formally, assume that at date 0 the owner-manager is endowed with wealth $k < 1$, which he puts as equity into the bank, and only finances the rest ($1 - k$ for the core project and X for the market-based investment) with debt.

As before, when the bank undertakes the risky investment on a sufficient scale, $X > R + k - 1$, it can shift some of the losses to the creditors. We can rewrite X_{\min} and X_{\max} (from (4.8) and (4.10), respectively) to account for explicit equity:

$$X_{\min}^k = \frac{(1 - p)(R + k - 1)}{p\alpha}, \quad (4.36)$$

$$X_{\max}^k = \frac{p(R + k - 1) - b(1 - k)}{b - p\alpha}. \quad (4.37)$$

We can characterize the bank's strategy as follows:

Lemma 15. *The bank undertakes risky investment when $X_{\min}^k < X_{\max}^k$, and it does that at the maximum possible scale X_{\max}^k . The interval $(X_{\min}^k, X_{\max}^k]$ is non-empty when b is low:*

$$b < b_{\max}^k = \frac{p\alpha(R+k-1)}{p\alpha(1-k) + (1-p)(R+k-1)}. \quad (4.38)$$

Proof. Similar to that of Lemma 13. □

Observe from (4.8) and (4.10) that $X_{\min} < X_{\min}^k$ and $X_{\max} < X_{\max}^k$. Capital k reduces the bank's incentives to take risks of a given scale, but allows the bank to borrow more and make larger bets. As with the franchise value, higher capital enables the bank to undertake the risky investment for a wider range of parameter values:

$$\frac{\partial b_{\max}^k}{\partial k} = \frac{(p\alpha)^2 R}{[p\alpha(1-k) + (1-p)(R+k-1)]^2} > 0. \quad (4.39)$$

Also the scale of the risky investment X_{\max}^k is increasing in bank capital k (from (4.5)):

$$\frac{\partial X_{\max}^k}{\partial k} = \frac{p+b}{b-p\alpha} > 0. \quad (4.40)$$

In addition, $b_{\max}^k > b_{\max}$, with b_{\max} given in (4.11), meaning that when the bank is partially funded with capital, it can achieve leverage sufficient for risk-taking for a more binding leverage constraint.

We can summarize the results on bank capital as follows:

Proposition 17. *The bank undertakes risky investment when the leverage constraint is sufficiently lax, corresponding to low private benefits of moral hazard: $b < b_{\max}^k$. Higher bank capital expands the range of parameter values for which the bank undertakes risky investment ($\partial b_{\max}^k / \partial k > 0$) and increases the scale of the risky investment ($\partial X_{\max}^k / \partial k > 0$).*

One way to interpret this result is as follows. In static frameworks that focus on the risk of a given portfolio, high capital reduces bank risk-taking incentives. But in a dynamic context, more equity today may enable the bank to borrow more tomorrow to gamble on a larger scale. Then, higher bank capital increases rather than mitigates banks risk-taking incentives. This relates to the assertions of practitioners that banks face pressure to “put to risk” their “unused” capital.

Note that the observation of possible unintended effects concerns capital levels, not capital requirements. In the context of our model, binding capital requirements (such as a leverage ratio) would play a role similar to an increased b , reducing the ability of a bank to lever up. As a result, high enough capital requirements, which make $b > b_{\max}^k$, would be effective in removing from the bank the ability to undertake risky market-based investments.

4.6 Discussion

Our analysis offers useful insights into risk-taking incentives of modern banks and their impact on financial stability.

(i) Higher franchise value and more capital are not panacea against bank risk-taking. Banks with a high franchise value or high capital can borrow and rapidly accumulate new risks. Therefore, bank risk-taking should be thought of as a dynamic concept. Regulators need to consider not only bank risk today, but also the ability of a bank to increase risk going forward. Such “dynamic” effects become particularly relevant when banks have better access to market-based investment opportunities.¹³

(ii) The bank’s ability to lever up for risky investments can be limited through capital requirements. But to the extent that risk in market-based investments may be underestimated, e.g. when investments with skewed returns have little observable risk in good times, capital requirements may need to include a high enough charge on market-based assets, or a not risk-weighted leverage ratio.

(iii) Better institutional environment does not guarantee prudent behavior of banks. In particular, better protection of creditor rights enables banks to borrow more, which can lead to more risk-taking.

(iv) The banks’ incentives to undertake risky market-based investments depend on the funding options available to them. When banks have access to senior funding (such as repos), these incentives are higher. This points to the importance of repo market reforms (such as possible limitations on the use of repos, Acharya and Öncü, 2013; or taxes on repos to make them less attractive, Perotti and Suarez, 2011).

(v) Our analysis also offers insights into the relationship between bank competition and financial stability. A common view is that low competition increases franchise value and reduces bank risk-taking incentives. But there are also counterarguments, based on general equilibrium effects (Boyd and De Nicolo, 2005), or that absent competition banks become less efficient and as a result unstable (Carlson and Mitchener, 2006; Calomiris and Haber, 2013). Our paper suggests another reason why restricting competition may not make banks safer. Lack of competition enables banks to accumulate franchise value, and at the same time prevents them from expanding their core business by poaching customers of other banks. Our results suggest that this may push banks to “use” their high franchise value by borrowing and investing in potentially risky, market-based activities.¹⁴

¹³This implies the need for the better control of a rapid asset growth also for the banking system as a whole, which is the focus of the macroprudential policy. One of the recent proposals aiming at limiting bank assets growth is made by Gersbach and Hahn (2010). It suggests the introduction of an average leverage ratio for the overall banking system (bank’s required level of equity capital depends on the equity capital of its peers).

¹⁴This is reminiscent of the reasons that drove German *Landesbanken*, which had a protected by limited-in-scope business model, to become exposed to structured credit securities originated in U.S. prior to the crisis. See Hufner (2010) for a discussion of the underlying causes of the German banking sector problems. Also see Akins et al. (2014) who show that a lack of competition increased bank fragility during the recent crisis.

(vi) An important observation is that our results do not rely on the too-big-to-fail (TBTF) effects. A common argument is that implicit bailout guarantees for large banks insulate their shareholders from downside risk realizations and give them incentives to take more risk. However one can be somewhat skeptical that TBTF drove much of bank risk-taking in the run-up to the crisis. TBTF guarantees affect mostly bank debt; during the crisis, bank shareholders lost a lot of value. Our results explain how excessive risk-taking in valuable (but not necessarily large) banks can arise even absent TBTF, as a result of their higher capacity to borrow.

4.7 Conclusion

This paper examined the relationship between bank franchise value and risk-taking. We showed that when banks take risk by leveraging up rather than altering their core portfolio, the traditional result that high franchise value reduces bank risk-taking incentives does not always hold. The reason is that high franchise value allows the bank to borrow more, so it can take risk on a larger scale. Larger scale offsets lower incentives to take risk of given size. As a result, a bank with a high franchise value may have higher – not lower – risk-taking incentives.

Our results highlight that neither high franchise value or capital, nor a good institutional environment are panacea against bank risk-taking. In fact, they may enable banks to borrow more and take risk on a larger scale, especially when banks have access to cheap senior funding such as repos. The paper fits well stylized patterns of bank risk-taking in the run-up to the crisis. Fundamentally, we also highlight that regulators should consider bank risk in a dynamic context, with a special focus on the potential for rapid asset growth.

4.8 Appendix

Proof of Lemma 13

The bank has incentives and ability to undertake the risky investment when $X_{\min} < X_{\max}$. Substituting from (4.8) and (4.10) and rearranging terms gives immediately:

$$b < \frac{p\alpha(R-1)}{p\alpha+(1-p)(R-1)}.$$

The bank's profit is increasing in X ($\frac{\partial \Pi_1(X)}{\partial X} = p\alpha > 0$), so the bank chooses $X = X_{\max}$ whenever $X_{\min} < X_{\max}$.

Proof of Lemma 14

The bank undertakes the risky investment when $X_{\min}^{\theta} < X_{\max}^{\theta}$. From (4.15) $X_{\min}^{\theta} > 0$ when:

$$\theta > \theta_{\min} = 1 - \frac{p\alpha}{1-p}. \quad (4.41)$$

For $\theta \leq \theta_{\min}$, $X = 0$. Further we focus on the case $\theta > \theta_{\min}$.

The denominator of X_{\max}^{θ} (from (4.21)) is positive given (4.5). The nominator of X_{\max}^{θ} is positive, if $b < p(R - 1 - r_0)$. From (4.20), (4.21), and (4.22), $X_{\min}^{\theta} < X_{\max}^{\theta}$ gives:

$$\frac{R - 1 - r_0}{\theta - \theta_{\min}} < \frac{p(R - 1 - r_0) - b}{b - (1-p)(\theta - \theta_{\min})},$$

which implies:

$$b < \frac{(R - 1 - r_0)(\theta - \theta_{\min})}{R - 1 - r_0 + \theta - \theta_{\min}} = b_{\max}^{\theta}. \quad (4.42)$$

Thus, when $\theta > \theta_{\min}$ and $b < b_{\max}^{\theta}$, $X_{\min}^{\theta} < X_{\max}^{\theta}$ implying that $X_{\max} > 0$. X_{\max} is the scale of risky investment (profit function in (4.14) increases with X). Otherwise, the bank invests only in the core project.

Next, we show that $b_{\max}^{\theta} < b_{\max}$, where b_{\max} is given in (4.11). From (4.11), (4.22), and (4.23), $b_{\max}^{\theta} < b_{\max}$ if:

$$\frac{(R - 1 - r_0)(\theta - \theta_{\min})}{R - 1 - r_0 + \theta - \theta_{\min}} < \frac{(1 - \theta_{\min})(R - 1)}{R - 1 + 1 - \theta_{\min}}. \quad (4.43)$$

Rearranging terms, we obtain:

$$(R - \theta_{\min})[(1 - \theta)(R - 1) + r_0(\theta - \theta_{\min})] > (1 - \theta_{\min})(R - 1)(1 - \theta + r_0),$$

or equivalently

$$(1 - \theta)[(R - 1)^2 - r_0(R - \theta_{\min})] > -r_0(1 - \theta_{\min})^2. \quad (4.44)$$

If $(R - 1)^2 - r_0(R - \theta_{\min}) > 0$, the inequality holds for any $\theta < 1$ (the left-hand side is positive, whereas the right-hand side is negative). If $(R - 1)^2 - r_0(R - \theta_{\min}) < 0$, it holds for:

$$\theta > 1 - \frac{r_0(1 - \theta_{\min})^2}{r_0(R - \theta_{\min}) - (R - 1)^2}.$$

The inequality above is binding if the right-hand side is larger than θ_{\min} :

$$(1 - \theta_{\min})r_0 < r_0(R - \theta_{\min}) - (R - 1)^2,$$

implying $R - 1 - r_0 < 0$ which is not feasible. Thus, inequality (4.44) holds, and $b_{\max}^{\theta} < b_{\max}$.

Derivation of r_0 (equation (4.25))

First, we derive r_0 . Using (4.21), the break-even condition (4.24) is:

$$p(1 + r_0) + (1 - p) \left[R - \frac{p\theta(R - 1 - r_0) - b\theta}{b - (1 - p)(\theta - \theta_{\min})} \right] = 1.$$

Rearranging the items, we get r_0 as in (4.25).

Next, we show that $R - 1 - r_0 \geq 0$. Substituting r_0 from (4.25), the inequality becomes:

$$\frac{1 - p}{p} \cdot \frac{(R - 1)[\theta - (1 - p)\theta_{\min} - b] - b\theta}{(1 - p)\theta_{\min} + b} \leq R - 1,$$

implying that:

$$\theta \leq \frac{(R - 1)[b + (1 - p)\theta_{\min}]}{(1 - p)(R - 1 - b)}. \quad (4.45)$$

This constraint on θ is binding if it is lower than 1, or equivalently:

$$(R - 1)[b - (1 - p)(1 - \theta_{\min})] > -b(1 - p),$$

yielding:

$$b < (1 - p)(1 - \theta_{\min}).$$

Substituting θ_{\min} from (4.22), we obtain $b < p\alpha$, which contradicts (4.5). Thus, (4.45) is not binding, implying $R - 1 - r_0 > 0$.

Proof of Proposition 14

To show the effect of R on risk incentives, we consider $\frac{\partial b_{\max}^{\theta}}{\partial R}$:

$$\begin{aligned} \frac{\partial b_{\max}^{\theta}}{\partial R} &= \frac{\left(1 - \frac{\partial r_0}{\partial R}\right) (\theta - \theta_{\min})(R - 1 - r_0 + \theta - \theta_{\min}) - \left(1 - \frac{\partial r_0}{\partial R}\right) (R - 1 - r_0)(\theta - \theta_{\min})}{(R - 1 - r_0 + \theta - \theta_{\min})^2} \\ &= \frac{\left(1 - \frac{\partial r_0}{\partial R}\right) (\theta - \theta_{\min})^2}{(R - 1 - r_0 + \theta - \theta_{\min})^2}, \end{aligned} \quad (4.46)$$

where $\frac{\partial r_0}{\partial R}$ is given in (4.27). Note that $\frac{\partial r_0}{\partial R} > 0$, since $\theta > (1 - p)\theta_{\min} + b$ from $r_0 \geq 0$.

Next, we sign $\frac{\partial b_{\max}^{\theta}}{\partial R}$. First item in the nominator $\left(1 - \frac{\partial r_0}{\partial R}\right)$ is positive if:

$$(1 - p)[\theta - (1 - p)\theta_{\min} - b] < p[(1 - p)\theta_{\min} + b],$$

which is equivalent to:

$$b > p\alpha - (1 - p)(1 - \theta).$$

Note that $p\alpha - (1 - p)(1 - \theta)$ is lower than $p\alpha$, implying that for any $b > p\alpha$, $1 - \frac{\partial r_0}{\partial R} > 0$.

Thus, $\frac{\partial b_{\max}^{\theta}}{\partial R} > 0$.

Finally, $\frac{\partial X_{\max}^{\theta}}{\partial R}$ from (4.28) is positive since $1 - \frac{\partial r_0}{\partial R} > 0$ and $b > (1-p)(\theta - \theta_{\min})$.

Proof of Proposition 15

First, we show that X_{\max}^{θ} increases with θ . Using (4.25), (4.30), and (4.32), $\frac{\partial X_{\max}^{\theta}}{\partial \theta} > 0$ if:

$$-\frac{(1-p)(R-1-b)}{p[(1-p)\theta_{\min}+b]} \cdot [b - (1-p)(\theta - \theta_{\min})] + (1-p)(R-1) - \theta \cdot \frac{(1-p)^2(R-1-b)}{p[(1-p)\theta_{\min}+b]} + \frac{(1-p)^2(R-1)[(1-p)\theta_{\min}+b]}{p[(1-p)\theta_{\min}+b]} > 0,$$

where the expressions with θ cancel out yielding:

$$R-1 + \frac{[(1-p)\theta_{\min}+b][(1-p)(R-1) - (R-1-b)]}{p[(1-p)\theta_{\min}+b]} > 0.$$

Rearranging items, we obtain $b > 0$. Thus, X_{\max}^{θ} increases with θ .

Next, we show that $\frac{\partial b_{\max}^{\theta}}{\partial \theta} > 0$. From above, $\frac{\partial X_{\max}^{\theta}}{\partial \theta} > 0$. Note also that from (4.20),

$$\frac{\partial X_{\min}^{\theta}}{\partial \theta} = \frac{-\frac{\partial r_0}{\partial \theta}(\theta - \theta_{\min}) - (R-1-r_0)}{(\theta - \theta_{\min})^2} < 0, \quad (4.47)$$

implying that $\frac{\partial b_{\max}^{\theta}}{\partial \theta} > 0$ as long as $\frac{\partial X_{\min}^{\theta}}{\partial b} > 0$ and $\frac{\partial X_{\max}^{\theta}}{\partial b} < 0$.

Indeed

$$\frac{\partial X_{\min}^{\theta}}{\partial b} = -\frac{\partial r_0 / \partial b}{\theta - \theta_{\min}} > 0,$$

where

$$\frac{\partial r_0}{\partial b} = -\frac{1-p}{p} \cdot \frac{\theta[R-1+(1-p)\theta_{\min}]}{[(1-p)\theta_{\min}+b]^2} < 0. \quad (4.48)$$

And also from (4.21), (4.25), and (4.48),

$$\begin{aligned} \frac{\partial X_{\max}^{\theta}}{\partial b} &= \frac{(1-p)(\theta - \theta_{\min}) - p(R-1-r_0)}{[b - (1-p)(\theta - \theta_{\min})]^2} + \frac{(1-p)\theta[R-1+(1-p)\theta_{\min}]}{[b - (1-p)(\theta - \theta_{\min})][(1-p)\theta_{\min}+b]^2} \\ &= -\frac{(1-p)\theta_{\min}[1 - (1-p)\theta] + (R-1)[b - (1-p)(\theta - \theta_{\min})]}{[(1-p)\theta_{\min}+b]^2} < 0. \end{aligned} \quad (4.49)$$

As a result, b_{\max}^{θ} increases with θ , and so do risk incentives.

Proof of Proposition 16

The presence of market-based activities increases effort, i.e. $e_1 > e_0$, if:

$$\frac{p(R - 1 + \alpha X_{\max})}{c} > \frac{R - 1}{c},$$

yielding:

$$X_{\max} > \frac{(1 - p)(R - 1)}{p\alpha}.$$

Next, we verify if indeed X_{\max} is above this threshold:

$$X_{\max} = \frac{p(R - 1) - b}{b - p\alpha} > \frac{(1 - p)(R - 1)}{p\alpha},$$

implying:

$$b < \frac{p\alpha(R - 1)}{(1 - p)(R - 1) + p\alpha} = b_{\max}.$$

Thus, if $b < b_{\max}$, bank increases effort in the presence of market-based investments.

Also note, that there is an interior solution for effort $e_1 < 1$ if:

$$c > pb(R - 1 - \alpha).$$

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Chapter 5

Nederlandse Samenvatting (Summary in Dutch)

Deze thesis bestaat uit drie papers over het bankwezen.

Het eerste paper, "Converteerbare Obligaties en het Nemen van Risico's door Banken", (in samenwerking met Enrico Perotti) bestudeert het effect van voorwaardelijk kapitaal (Contingent Capital, oftewel CoCo's) op de prikkels voor banken om risico's te nemen. CoCo's zijn schuldinstrumenten die omgezet worden in aandelen indien de bank slecht presteert. Wij vinden dat optimale conversie voor een faillissement afdwingt dat de kapitaalstructuur meer eigen vermogen bevat op momenten waarop de prikkels om risico te nemen sterker zijn. De kapitaalbreng vermindert endogene risicoverschuiving door verwatering van het rendement in hoge toestanden. Interessant genoeg kan voorwaardelijk kapitaal in de evenwichtssituatie minder riskant zijn dan traditionele schuldvormen, indien de lagere prioriteit wordt gecompenseerd door verminderd endogeen risico.

Mijn tweede paper, "Interne Overdrachten van Financiële Activa en het Nemen van Risico in Financiële Conglomeraten", bestudeert het effect van securitisatie in financiële conglomeraten op hun risicokeuze, en vergelijkt deze met de keuzes van de standalone banken. Doordat de interne verkoop van leningen binnen financiële conglomeraten niet onderhevig is aan asymmetrische informatie, zijn banken in financiële conglomeraten in staat om het risico op slechte leningen over te laten gaan op het depositogarantiestelsel door de beste leningen te verkopen aan andere onderdelen van het conglomeraat. Een dergelijke waarde-overdracht leidt echter tot betere monitoring door de conglomeraten. Als gevolg daarvan kunnen, bij lage kapitaaleisen, banken die onderdeel zijn van een financieel conglomeraat veiliger zijn dan standalone banken, door sterkere prikkels om te monitoren.

Het derde paper, "De Franchise Waarde en het Nemen van Risico in Moderne Banken", (in samenwerking met Lev Ratnovski en Razvan Vlahu) onderzoekt het effect van de franchisewaarde van de bank op haar prikkels om risico te nemen. We beschouwen een opzet waarin een bank risico neemt door meer schuld op te nemen in de kapitaalstructuur, om zo

te kunnen investeren in risicovolle marktinstrumenten. Een hoge franchise-waarde staat de bank toe om meer te lenen, zodat zij risico kan nemen op een grotere schaal. Dit compenseert zwakkere prikkels om risico's van een bepaalde grootte te nemen. Als gevolg daarvan kan een bank met een hogere franchisewaarde sterkere prikkels hebben om risico's te nemen. Het voorgestelde effect is sterker bij een bank die haar balans kan uitbreiden met behulp van goedkope financiering door niet-achtergestelde schuld, en wanneer zij meer schuld kan opnemen in haar kapitaalstructuur door een betere institutionele omgeving (met betere bescherming van de rechten van crediteuren).

The Tinbergen Institute is the Institute for Economic Research, which was founded in 1987 by the Faculties of Economics and Econometrics of the Erasmus University Rotterdam, University of Amsterdam and VU University Amsterdam. The Institute is named after the late Professor Jan Tinbergen, Dutch Nobel Prize laureate in economics in 1969. The Tinbergen Institute is located in Amsterdam and Rotterdam. The following books recently appeared in the Tinbergen Institute Research Series:

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