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Hendrik Hakenes and Isabel Schnabel

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Johannes Gutenberg University Mainz
Gutenberg School of Management and Economics
Jakob-Welder-Weg 9
55128 Mainz
Germany
wiwi.uni-mainz.de

Contact details

Hendrik Hakenes
Finance Department
University of Bonn
Adenauerallee 24-42
53113 Bonn
Germany

hakenes@uni-bonn.de

Isabel Schnabel
Gutenberg School of Management and Economics
Chair of Financial Economics
Johannes Gutenberg University Mainz
Jakob Welder-Weg 4
55128 Mainz
Germany

isabel.schnabel@uni-mainz.de

Bank Bonuses and Bail-outs[*]

Hendrik Hakenes[†]

University of Bonn and MPI Bonn

Isabel Schnabel[‡]

Johannes Gutenberg University Mainz, CEPR, and MPI Bonn

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Abstract

This paper shows that bonus contracts may arise endogenously as a response to agency problems within banks, and analyzes how compensation schemes change in reaction to anticipated bail-outs. If there is a risk-shifting problem, bail-out expectations lead to steeper bonus schemes and even more risk-taking. If there is an effort problem, the compensation scheme becomes flatter and effort decreases. If both types of agency problems are present, a sufficiently large increase in bail-out perceptions makes it optimal for a welfare-maximizing regulator to impose caps on bank bonuses. In contrast, raising managers' liability is counterproductive.

Keywords: Bonus payments; bank bail-outs; bank management compensation; risk-shifting; underinvestment; limited and unlimited liability.

JEL-Classification: G21, G28, M52, J33.

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[†]Finance Department, University of Bonn, Adenauerallee 24-42, 53113 Bonn, Germany, hakenes@uni-bonn.de.

[‡]Gutenberg School of Management and Economics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany, isabel.schnabel@uni-mainz.de.

1 Introduction

In recent years, banks were harshly criticized for paying overly generous bonuses to bank managers. Much of the discussion focused on equity concerns. Many observers thought it unfair that banks paid out high bonuses after they had suffered unprecedented losses and had to be bailed out by the state. It seemed that bail-out money had been moved directly from the taxpayers' into the bank managers' pockets. Moreover, banks' profits had been boosted by favorable refinancing conditions due to public bail-out guarantees.

We present a simple model showing that steeper bonus schemes can be an optimal response of bank shareholders to increasing bail-out expectations, leading to higher risk-taking and a higher default probability of banks. This yields a rationale for imposing regulatory ceilings on bank bonuses, especially after a large-scale financial crisis. In contrast, raising managers' liability, as suggested in recent policy discussions, can be counterproductive because it raises risk-shifting incentives.

The underlying economic argument is intuitive. Shareholders design compensation schemes to influence bank managers' behavior. In a risk-shifting setup, bank shareholders with limited liability have an incentive to take excessive risk. Bonus schemes can be used to implement the desired risk level. Market discipline by (uninsured) lenders counteracts such incentives. However, bank bail-outs raise expected bail-out probabilities and thereby destroy market discipline. Therefore, shareholders react to an increase in bail-out expectations by designing steeper compensation (bonus) schemes to induce managers to take higher risk. In such a setup, ceilings on bonus payments are welfare-increasing, especially if bail-outs are expected with a high probability. In contrast, increasing the manager's liability lowers welfare: the manager can now be pushed to his participation constraint, hence it becomes cheaper to incentivize him. Therefore, the shareholder induces him to take even more risk.

But there may also be a downside to bonus restrictions: they curb managers' efforts. If there is an effort problem between the shareholder and the manager, steep compensation schemes can be used to induce effort by the bank manager. The anticipation of a bail-out generates a larger positive externality of effort on the deposit insurance and the taxpayer, and thus induces shareholders to offer a flatter compensation scheme. This leads to an inefficiently low effort by the manager. In such a setup, ceilings on bonus payments are either harmful or at best ineffective. Raising the manager's liability increases welfare. It becomes cheaper to incentivize the manager to exert effort, and the bank becomes safer in equilibrium.

In reality, both types of agency problems are likely to be present. We discuss the conditions under which a ceiling on bank bonuses raises welfare in a setup with a risk-shifting and an effort problem. Our analysis shows that a sufficiently large increase in bail-out perceptions *always* makes it optimal for a welfare-maximizing regulator to impose ceilings on bank bonuses. This implies that bonus restrictions are desirable especially for banks with high bail-out probabilities, that is for systemically important financial institutions (SIFIs). Introducing unlimited liability of the manager lowers welfare and strengthens the case for bonus restrictions.

The model enables us to evaluate recent reform proposals by the Financial Stability Board, which have become an integral part of the G20 recommendations (see Financial Stability Board, 2009). The most important suggestions are the enforced deferral of a significant portion of variable compensation to reward long-term success rather than short-term risk-taking; the introduction of claw-back clauses to make sure that money can be recouped if decisions turn bad later on; the payment of bonuses in stock options rather than cash; greater transparency; the establishment of a board remuneration committee to oversee compensation schemes on behalf of the board of directors; and finally, supervisory review of compensation structures. This list reveals that the main concern is an increase in bank managers' liability, which is believed to better align the incentives between managers and shareholders.[1]

Many countries have already started to implement a regulation of bank manager compensation. In Europe, immediate cash bonuses are restricted to 20 to 30 percent; the remaining bonus payment has to be deferred, with at least 50 percent to be paid in stocks. However, there are no outright size limitations on bonus payments. In the United States, regulation is expected to prescribe a deferral of only 50 percent, with a restriction of 20 percent on immediate cash bonuses. In addition, several countries, such as Germany and the United States, have introduced absolute compensation

[1]For an early statement of this view, see Macey and O'Hara (2001).

ceilings for managers at banks that benefited from government bail-outs. The United Kingdom introduced an ex-post tax on bonuses exceeding a certain amount.

Our analysis supports the view that ceilings on bonus payments are appropriate to prevent excessive risk-taking. This is especially true for SIFIs (systemically important financial institutions), for which (implicit) bail-out guarantees—and thus risk-shifting incentives—are strongest. However, we also show that an increase in bank managers' liability may backfire and raise risk-taking rather than curbing it. Therefore, measures increasing managers' liability, such as a deferral of bonuses and claw-back clauses, are questionable. Moreover, a better alignment of managers' and shareholders' interests does not solve the problem if the dominant agency problem is between the bank and the deposit insurance or the taxpayer. If it is in the shareholders' interest to take higher risks, an alignment of interests does not help.[2]

While the literature on the corporate governance of non-financial firms is very broad,[3] the literature on the corporate governance of banks is still small, but developing quickly. Caprio and Levine (2002) stress two differences between banks and non-financial firms: the greater opaqueness of banks, which exacerbates agency problems, and the safety net, which affects the governance of banks in various ways, most importantly by increasing risk-shifting incentives.

The relationship between agency problems and management compensation in banking was hardly analyzed before the financial crisis, but is now on the top of the agenda of both academics and policy makers. Early work by John and John (1993) shows that a bank owner can commit to a certain level of risk-taking by setting management compensation schemes. This allows the shareholders to reestablish full market discipline, yielding the first-best level of risk (see also John, Saunders, and Senbet, 2000). The model implies that the risk sensitivity of bank manager compensation is lower when the risk-shifting problem is severe. In a similar vein, John, Mehran, and Qian (2011) argue that risk sensitivity should be low when monitoring

[2]We abstract from dynamic aspects in our model. Acharya, Pagano, and Volpin (2010) show that bank manager compensation based on short-term performance (leading to excessive risk-taking) may arise endogenously if there is competition for managers. Such aspects cannot be studied in our static setup.

[3]See Shleifer and Vishny (1997), Prendergast (1999), and Becht, Bolton, and Röell (2003) for excellent surveys.

by subordinated debt holders or the regulator is weak. Empirical results confirm that the performance-sensitivity of bank CEO contracts is low when a bank's leverage is high and outside monitoring is not very intense (John, Mehran, and Qian, 2011). In light of the recent crisis, the presumption that bank manager compensation reestablishes market discipline seems questionable. In our model, the main results are driven by the *lack* of market discipline.[4]

Several papers empirically analyze the relationship between management compensation and bank risk-taking. Early evidence by Houston and James (1995) suggests that compensation schemes in the banking sector did not promote risk-taking more than in other sectors. More recent evidence points in the opposite direction. Cheng, Hong, and Scheinkman (2010) document a close connection between bank compensation and risk-taking. Bebchuk, Cohen, and Spamann (2010) find that compensation schemes at Bear Stearns and Lehman promoted excessive risk-taking in the run-up to the financial crisis. Chesney, Stromberg, and Wagner (2010) show that higher risk-taking incentives for managers translated into higher bank losses in the United States. Interestingly, banks with a better alignment of interests between managers and shareholders performed worse than others in the financial crisis (see Fahlenbrach and Stulz, 2011; Gropp and Köhler, 2010). In the same vein, Laeven and Levine (2009) find that banks with more powerful shareholders take higher risks.[5] These findings are consistent with the idea that better aligned interests raised incentives to take risks, which then materialized in the crisis.

The earlier literature—and much of the policy discussion—focuses on the agency problem between shareholders and managers, rather than on that between shareholders and debt holders. Therefore, many policy suggestions aim at aligning the interests of shareholders and managers, which may come at the price of raising risk-shifting incentives. Our paper considers both agency conflicts: bank shareholders use bonus payments as an instrument to incentivize managers to exert effort (thus mitigating the agency problem between managers and shareholders) and to take risk

[4]Bannier, Feess, and Packham (2012) show that socially excessive risk-taking may arise even if banks themselves are not subject to a risk-shifting problem because bonus contracts may be used as screening devices to distinguish low and high ability workers.

[5]Moreover, they show that the effects of banking regulation depend on corporate governance structures.

(thereby exacerbating the agency problem between shareholders and debt holders or the deposit insurance). We then show which agency problem dominates under which conditions.

The importance of the safety net for banks' risk-taking behavior is a recurrent theme in the literature on the role of market discipline in banking (see, e. g., Demirgüç-Kunt and Huizinga, 2004; Gropp, Hakenes, and Schnabel, 2010). However, the relationship between the safety net and bank manager compensation schemes has hardly been analyzed. The extension of the safety net, especially for SIFIs, is one of the most important consequences of the crisis. In order to design proper bank management compensation schemes after the crisis, we have to understand the implications of higher bail-out probabilites for the incentive effects of bank management compensation. In this regard, our work is also related to the paper by Freixas and Rochet (2010), which derives an optimal regulation of SIFIs including—besides systemic risk taxes and resolution procedures—supervisory control of bank compensation. This finding coincides nicely with the results from our model.

The paper proceeds as follows. In Section 2, we introduce the basic setup of our model. In Section 3, we derive the optimal manager compensation scheme and the effect of anticipated bank bail-outs in a setup where the manager can determine the bank's risk. In this setup, ceilings on bonuses are shown to be beneficial, whereas unlimited manager liability is not. In Section 4, we analyze optimal compensation schemes if the manager faces an effort choice. Now ceilings on bonus payments are shown to be harmful, while an increase in manager liability mitigates the underinvestment problem. Section 5 presents a general model including a risk and an effort choice. With limited liability, ceilings on bonuses are desirable if bail-out expectations are high enough. With unlimited liability, ceilings on bonuses are always optimal. Section 6 concludes and derives some policy implications.

2 Model Setup

Consider a bank with a fixed asset volume 1, which is financed by insured deposits d, uninsured liabilities l, and equity k. Hence, the balance sheet identity is $d+l+k=1$. The deposit rate is r, the risk-free rate is r_f. Deposits are covered by deposit insurance at a fee δ. The bank's assets consist of a risky portfolio that returns Y_h with probability $p_h > 0$, Y_m with probability $p_m > 0$, and Y_l with probability $p_l = 1 - p_h - p_m > 0$. We assume that $Y_h > Y_m > Y_l = 0$. The bank is run by a manager whose compensation scheme (z_h, z_m, z_l) may depend on the realized state. The bank manager can influence the return structure of the bank portfolio by choosing an action that has an impact on the three probabilities.[6] The bank is owned by a single shareholder who is the residual claimant and is subject to limited liability. The shareholder determines the compensation scheme of the manager. Due to deposit insurance, the deposit rate does not depend on the bank's risk-taking. The interest rate demanded by lenders depends, however, on anticipated risk.

We distinguish between two settings. In the first setting, discussed in Section 3, the manager chooses a, which is a measure of risk-taking. More specifically, an increase in a leads to a mean-preserving spread, raising risk, but leaving the mean return unchanged. Hence, an increase in a results in a distribution that is second-order stochastically dominated. The manager incurs a private non-monetary cost of risk-taking, $c(a) = \alpha\, a^2/2$. This cost can be interpreted as the cost of hiding risk-taking from supervisors or the potential consequences of bankruptcy for the manager. In the second setting, discussed in Section 4, the portfolio return depends on the manager's effort e, which raises the bank's returns. Hence, an increase in e entails a shift of the mean return and implies first-order stochastic dominance. Again the manager incurs a non-monetary cost, $c(e) = \eta\, e^2/2$. This cost can be interpreted as the cost of monitoring the portfolio. The timing of the model is given in Figure 1.

3 Risk Choice

In the first setting, we assume that the manager's action a affects the risk of the bank's portfolio, but not its mean return. We first describe the bank's return structure. Then we derive the bank's optimal compensation scheme, the manager's effort

[6] This three-point distribution has been used, for example, by Biais and Casamatta (1999). It is the simplest class of distributions that contains mean preserving spreads and where the principal cannot infer the action from observing the payoff.

Figure 1: Time structure

- $t = 0$: The shareholder offers a contract to the manager who can accept or reject.
- The shareholder takes in deposits d, other liabilities l, and inserts equity k.
- The manager chooses a (or e) and invests, incurring non-monetary costs $\alpha\, a^2/2$ (or $\eta\, e^2/2$).
- $t = 1$: The bank portfolio returns are realized; in the non-default states, all creditors are repaid, otherwise the deposit insurance repays the depositors.

choice, and the effects of anticipated bank bail-outs when the manager is subject to either limited or unlimited liability.

3.1 Return Structure of the Bank

In this version of the model, we assume that an increase in a shifts probability mass from the medium state to the two extreme states. We parameterize this in the following way,

$$\begin{aligned} p_h(a) &= \frac{1}{3} + \frac{a}{Y_h\,(Y_h - Y_m)} \geq \frac{1}{3}, \\ p_m(a) &= \frac{1}{3} - \frac{a}{Y_m\,(Y_h - Y_m)} \leq \frac{1}{3}, \\ p_l(a) &= 1 - p_h(a) - p_m(a) = \frac{1}{3} + \frac{a}{Y_h\,Y_m} \geq \frac{1}{3}, \end{aligned} \tag{1}$$

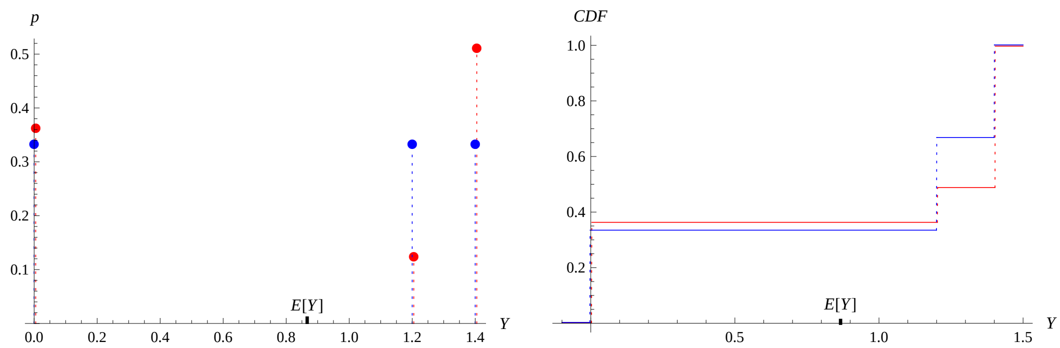
with $a \in [0, Y_m\,(Y_h - Y_m)/3]$.[7] An example of such a distribution function is plotted in Figure 2 for two different values of action a. An increase in a raises the probability of the highest and the lowest return, but lowers the probability of the medium return, resulting in a mean-preserving spread. The expected return does not depend on a,

$$E[Y] = \frac{Y_h + Y_m}{3}, \tag{2}$$

whereas the variance increases in a,

$$V[Y] = a + \frac{2}{9}\,(Y_h^2 - Y_h\,Y_m + Y_m^2). \tag{3}$$

Figure 2: Return distribution depending on effort choice



These pictures show a possible distribution of returns with $Y_h = 1.4$, $Y_m = 1.2$, and $Y_l = 0$ for $a = 0$ (blue) and $a = 0.05$ (red). The probability density function is on the left, the cumulative distribution function on the right.

The first-best choice of a maximizes $E[Y] - c(a)$. Given that the mean $E[Y]$ does not depend on a and that $c(a)$ strictly increases in a, the first-best choice is $a = 0$. Hence, any risk-taking is inefficient. We now analyze the manager's risk choice (depending on the compensation scheme set by the shareholder) in the presence of either limited (Section 3.2) or unlimited liability (Section 3.3) of the manager.

3.2 Limited Liability of the Manager

Project returns can be observed by the shareholder, so he offers the manager a compensation scheme (z_h, z_m, z_l) that depends on the realized state. Given limited liability of the shareholder, compensation cannot exceed the portfolio return of the respective state. Assume that the bank manager is also subject to limited liability. Then all entries of the compensation scheme must be non-negative, $z_h \geq 0$, $z_m \geq 0$, and $z_l \geq 0$.

In the bad state, the payment can be neither positive (due to limited liability of the shareholder), nor negative (due to limited liability of the manager), implying that $z_l = 0$. Given limited liability and deposit insurance, the shareholder wants the manager to take risk. Because more risk moves probability mass away from

[7] At the point $a = Y_m\,(Y_h - Y_m)/3$, the probability $p_m(a)$ would turn negative.

the medium state, the shareholder never rewards the manager in the medium state because this would set incentives for lower risk-taking. Negative payments are ruled out by limited liability of the manager. Therefore, $z_m = 0$. Finally, the shareholder can use a bonus payment in the good state to set incentives for higher risk-taking. This is profitable only if the costs of risk-taking are not too large relative to the gain from risk-shifting. Consequently, the manager receives positive payments only in the good state, $z_h \geq 0$. This leaves us with z_h as the only endogenous variable. Hence, the compensation scheme looks like (the extreme form of) a bonus contract. The manager receives a bonus if the project is very successful; in the two other states of the world, he does not receive any payment.

We now consider the optimization of lenders, the shareholder, and the manager. Depositors are passive and do not have to be considered. Denote the promised repayment to depositors (including principal and interest payments) plus the deposit insurance premium, by $D = (1 + r + \delta)\, d$, and the promised repayment to other lenders (again including principal and interest payments) by L. Assume that $D+L < Y_m$, implying that there is no bankruptcy in state m. The expected profits of the shareholder (E) and the manager (M) are then

$$\begin{aligned} \Pi_E &= p_h(a)\,(Y_h - D - L - z_h) + p_m(a)\,(Y_m - D - L) \quad \text{and} \\ \Pi_M &= p_h(a)\, z_h - \alpha\, a^2/2. \end{aligned} \tag{4}$$

Using backward induction, the manager maximizes expected profits,

$$\Pi_M = \left(\frac{1}{3} + \frac{a}{Y_h\,(Y_h - Y_m)}\right) z_h - \alpha\,\frac{a^2}{2}, \tag{5}$$

which yields

$$a^* = \frac{z_h}{Y_h\,(Y_h - Y_m)\,\alpha}. \tag{6}$$

We see immediately that a higher bonus (high z_h) induces higher risk-taking. Risk-taking depends negatively on the cost parameter α. In order to participate, risk-neutral lenders need to recover their opportunity costs in expectation. They solve

$$\begin{aligned} [p_h(a) + p_m(a)]\, L &= (1 + r_f)\, l \\ \Leftrightarrow L &= (1 + r_f)\, l \cdot \frac{1}{p_h(a) + p_m(a)}. \end{aligned} \tag{7}$$

L increases in the bank's default probability $p_l(a) = 1 - p_h(a) - p_m(a)$. The shareholder maximizes

$$\begin{aligned}\Pi_E &= p_h(a^*)\,(Y_h - D - L - z_h) + p_m(a^*)\,(Y_m - D - L)\\ &= p_h(a^*)\,(Y_h - D - z_h) + p_m(a^*)\,(Y_m - D) - (1 + r_f)\,l,\end{aligned} \tag{8}$$

where a^* is defined by (6). Solving the first-order condition yields[8]

$$z_h^* = D\,\frac{Y_h - Y_m}{2\,Y_m} - \alpha\,\frac{Y_h^2\,(Y_h - Y_m)^2}{6}. \tag{9}$$

We see that the bonus z_h^* increases in D, which determines the gain from risk-shifting. Some algebra shows that $z_h^* < Y_h$, so that the bonus can always be paid; it never exceeds the bank's capacities. Plugging (9) into (6), we obtain the equilibrium value of a^*,

$$a^* = \frac{D}{2\,Y_h\,Y_m\,\alpha} - \frac{Y_h\,(Y_h - Y_m)}{6} > 0. \tag{10}$$

Hence, the shareholder wants the manager to take excessive risk. Since the shareholder himself is subject to limited liability, he can shift losses to the deposit insurance.[9] If there were no insured depositors, there would be no incentives for excessive risk-taking. We see that equilibrium risk-taking increases in D (and hence the gain from risk-taking), implying an increase in the default probability. Higher costs α lower equilibrium risk-taking.

Anticipation of a bail-out. Assume now that lenders anticipate that banks will be bailed out. In the presence of bail-outs, lenders become less sensitive to bank risk-taking. In the extreme case where the bank is bailed out completely with certainty, they do not react to bank risk-taking at all. Hence, they behave like insured depositors. This removes the market discipline exerted by uninsured debt and thereby exacerbates the risk-shifting problem. As a result, the anticipation of a bail-out has the same effect as an increase of D to $(1 + r + \delta)\,d + (1 + r_f)\,l$ and a drop of L to zero.

[8] For exposition, we concentrate on parameters such that we get interior solutions. Looking at (9) reveals, however, that z_h^* is strictly positive only if α is not too large, namely $\alpha \leq 3\,D/\big(Y_h^2\,(Y_h - Y_m)\,Y_m\big)$. Otherwise, the shareholder chooses $z_h^* = 0$.

[9] The deposit insurance does not react to bank managers' risk-taking in our model. Hence, in line with Dewatripont and Tirole (1994), the deposit insurance does not exert market discipline.

Hence, in order to analyze the effects of an anticipated bail-out, we only need to consider the derivatives with respect to D. Here D should be thought of as the amount of risk-insensitive debt.[10] We saw already that $\mathrm{d}z_h^*/\mathrm{d}D > 0$ and $\mathrm{d}a^*/\mathrm{d}D > 0$. Hence, the bonus scheme becomes steeper and the manager takes higher risk. This translates into a higher default probability $p_l(a)$ of the bank. The manager benefits from the bail-out, $\mathrm{d}\Pi_M/\mathrm{d}D > 0$, because he is given a rent to make him take risk. The expected compensation of the manager $p_h(a^*)\, z_h^*$ also increases. These results are summarized in the following proposition, and proven formally in the Appendix.

Proposition 1a (Bail-outs in risk model with limited liability) *Assume that the bank manager is subject to a risk-shifting problem and limited liability. Then if a bank bail-out is anticipated,*

1. *the bonus scheme becomes steeper (z_h^* increases),*
2. *the manager's risk-taking a^* increases, implying that the bank's probability of default $p_l(a^*)$ also increases,*
3. *the expected compensation $p_h(a^*)\, z_h^*$ and the expected profit of the manager increase.*

The intuition is simple: In the presence of bail-outs, market discipline is weakened and bank lenders no longer "punish" their bank for higher (anticipated) risk-taking by demanding higher interest rates. This implies that the risk-shifting problem is exacerbated because the bank can now shift even more losses to other parties (the deposit insurance and the state). The shareholder hence wants to give the bank manager an incentive to take higher risks. This is done through a steeper bonus contract. Given that the manager is protected by limited liability, not only the shareholder, but also the manager benefits from the bail-out guarantee.[11]

From a welfare perspective, risk-shifting ($a > 0$) is always suboptimal in this model. Since the mean of the return distribution is unchanged by risk-shifting, the welfare loss stems only from the costs $c(a)$. Welfare can be improved by regulating the

[10] An increase in D can also be interpreted as an increase in the bail-out probability.

[11] This aspect will be crucial in the discussion of unlimited liability of the manager.

manager's compensation scheme. Specifically, a cap on bonus payments would lead to lower risk-shifting activities and, hence, to an increase in welfare.

Corollary 1 (Caps on bonus payments) *A regulatory cap on bonus payments can reduce risk-shifting and the bank's probability of default, and it may therefore increase welfare. The positive effect of a cap is particularly large if the anticipation of a bail-out generates high risk-shifting incentives for the shareholder.*

3.3 Unlimited Liability of the Manager

Assume now that the manager has unlimited liability. Given limited liability of the shareholder, compensation still cannot be larger than the portfolio return of the respective state, but z_h, z_m, and z_l can now be negative. As before, z_l cannot be positive because the asset portfolio does not return anything, and the shareholder is protected by limited liability. z_l is not negative because the shareholder wants the manager to take risk (to increase a), and $z_l < 0$ would discourage him from risk-taking. Hence, $z_l = 0$. For the same reasons as under limited liability, z_m is not positive. However, a negative z_m (a malus payment) can make the medium state even less attractive, which increases risk-taking. Finally, as before, the shareholder can use a bonus payment in the good state to set incentives for higher risk-taking. We are left with two endogenous variables, z_h and z_m.

The problem is again solved by backward induction. The manager now maximizes

$$\Pi_M = \left(\frac{1}{3} + \frac{a}{Y_h\,(Y_h - Y_m)}\right) z_h + \left(\frac{1}{3} - \frac{a}{Y_m\,(Y_h - Y_m)}\right) z_m - \alpha\,\frac{a^2}{2}, \tag{11}$$

which yields

$$a^* = \frac{Y_m\,z_h - Y_h\,z_m}{Y_h\,Y_m\,(Y_h - Y_m)\,\alpha}. \tag{12}$$

A higher payment in the highest state (z_h) raises risk-taking, whereas a higher payment in the medium state (z_m) lowers risk-taking. For L, we obtain the same expression as in (7). The shareholder maximizes

$$\begin{aligned}\Pi_E &= p_h(a^*)\,(Y_h - D - L - z_h) + p_m(a^*)\,(Y_m - D - L - z_m)\\ &= p_h(a^*)\,(Y_h - D - z_h) + p_m(a^*)\,(Y_m - D - z_m) - (1 + r_f)\,l \end{aligned} \tag{13}$$

subject to the manager's participation constraint, $\Pi_M \geq 0$, and with a^* being given by (12). The participation constraint is binding in equilibrium, yielding a relation between z_h and z_m. This is the major difference to the setup with limited liability, where the manager could not be pushed to the participation constraint.

The first-order conditions yield an interior solution

$$z_h^* = \frac{D}{Y_h + Y_m}\Big(Y_h - Y_m - \frac{3\,D}{2\,\alpha\,Y_h\,Y_m^2}\Big), \tag{14}$$

$$z_m^* = -\frac{D}{Y_h + Y_m}\Big(Y_h - Y_m + \frac{3\,D}{2\,\alpha\,Y_h^2\,Y_m}\Big). \tag{15}$$

In an interior solution, z_m is negative and z_h positive. Otherwise, if α is high, we get the corner solution $z_h = z_m = 0$ because risk-shifting is too costly. Plugging (14) and (15) into (12), we obtain the equilibrium value of a^*,

$$a^* = \frac{D}{\alpha\,Y_h\,Y_m} > 0. \tag{16}$$

Again there is excessive risk-taking ($a^* > 0$). In fact, equilibrium risk-taking is larger than with limited liability of the manager. The reason is that, under limited liability, the shareholder has to pay the manager a rent to make him take higher risk. With unlimited liability, the manager can be kept at his participation constraint, making it cheaper for the shareholder to induce the manager to take risk. Consequently, risk-shifting increases.

Anticipation of a bail-out. To analyze the effects of a bail-out, we again take the derivative with respect to D. We find that z_h^* increases and z_m^* decreases in D; the anticipation of a bail-out induces the shareholder to steepen the compensation scheme, as before. However, risk-taking increases even more than with limited liability (which can be seen from the respective derivatives of a^* with respect to D). Hence, the effect of an anticipated bail-out on risk-shifting is strengthened rather than mitigated by unlimited liability of the manager. These results are summarized in the following proposition.

Proposition 1b (Bail-outs in risk model with unlimited liability) *Assume that the bank manager is subject to a risk-shifting problem and unlimited liability. Then if a bank bail-out is anticipated,*

1. *the bonus scheme becomes steeper ($z_h^* > 0$ increases and $z_m^* < 0$ decreases),*

2. *the manager's risk-taking a^* increases, implying that the bank's probability of default $p_l(a^*)$ also increases (even more than with limited liability),*

3. *the expected compensation of the manager, $p_h(a^*)\, z_h^* + p_m(a^*)\, z_m^*$, increases.*

Hence, the negative effects of bail-outs are still reinforced by unlimited liability of the manager. This has important policy implications. Making the bank manager liable does not mitigate the problem of excessive risk-taking but it rather exacerbates it if the shareholder is free to design the compensation scheme of the manager. Unlimited liability leads to a redistribution of rents from the manager to the shareholder, and makes it even more attractive for the shareholder to offer steep compensation schemes.

In the public discussion, the typical argument is that bank managers will avoid risk-taking if their personal liability is increased. The comparison of Propositions 1a and 1b implies exactly the opposite. Since shareholders like risk and determine managers' compensation packages, and since managers' rents from risk-taking drop when they are made liable (which makes it cheaper for the shareholder to set incentives for risk-taking), managers take more risk in equilibrium. The main reason is that shareholders do not make managers liable in the bad states of nature, but rather in the medium state.

Summing up, Propositions 1a and 1b imply that caps on bonus payments may increase welfare, especially if the anticipation of bail-outs generates high risk-shifting incentives for shareholders. Increasing the liability of the bank managers is harmful because it allows the shareholder to extract all rents from the manager and therefore makes risk-shifting cheaper. This exacerbates the risk-shifting problem.

4 Effort Choice

We now consider an alternative setting, in which the manager can exert effort in order to increase the mean return of the bank's portfolio. In Section 5, we then combine the two models and consider the general case in which the manager can choose risk and effort. We start by describing the bank's return structure before analyzing compensation schemes, effort choices, and the effects of anticipated bank bail-outs with limited and unlimited liability of the manager.

4.1 Return Structure of the Bank

Assume that managers can exert effort in order to increase the mean return of the bank by moving probability mass from bad states to better states. For concreteness, we assume the following return structure,

$$
\begin{aligned}
p_h(e) &= \frac{1}{3} + e, \\
p_m(e) &= \frac{1}{3}, \\
p_l(e) &= 1 - p_h(e) - p_m(e) = \frac{1}{3} - e,
\end{aligned} \tag{17}
$$

with $e \in [0;\, 1/3]$. With this parametrization, an increase in effort e shifts probability mass from the worst to the best state, hence it leads to a new distribution that first-degree stochastically dominates the original distribution. Given the cost function $c(e) = \eta\, e^2/2$, the first-best level of effort is $e = \frac{Y_h}{\eta}$.[12]

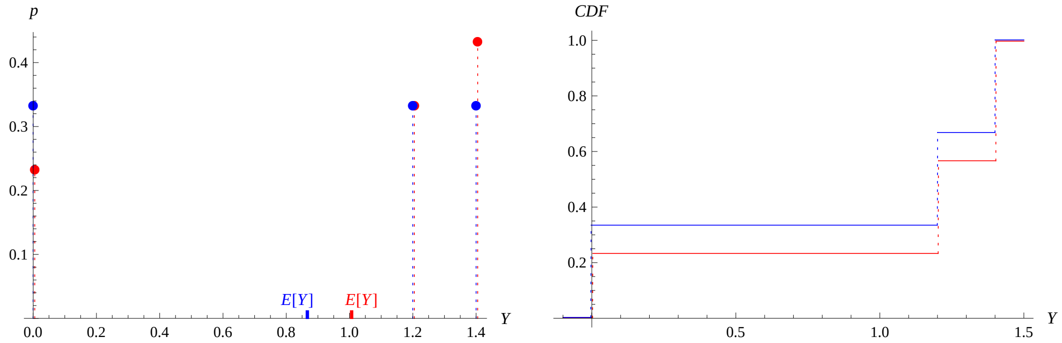
4.2 Limited Liability of the Manager

In this section, we assume that managers are subject to limited liability. As before, compensation cannot be negative and cannot exceed portfolio returns. In order to induce effort, the shareholder offers a bonus in the good state. Using similar arguments as above, $z_l = z_m = 0$ in equilibrium, so z_h is the only endogenous variable. The first-order condition of the manager's optimization problem yields

$$e^* = \frac{z_h}{\eta}. \tag{18}$$

[12]One advantage of this parametrization is that it can easily be combined with the probability distribution in the risk-shifting problem (see Section 5). Note that one could also assume that effort shifts probability in all three states, for example from l to m and from m to h. The aggregate results would again be a shift from l to h.

Figure 3: Return distribution depending on effort choice



This picture shows a possible distribution of returns with $Y_h = 1.4$, $Y_m = 1.2$, and $Y_l = 0$ for $e = 0$ (blue) and $e = 0.1$ (red). The probability density function is on the left, the cumulative distribution function on the right.

Hence, a higher bonus induces a higher effort level; higher costs reduce effort. Profit-maximizing behavior by shareholders implies[13]

$$z_h^* = \frac{Y_h - D}{2} - \frac{\eta}{6}, \tag{19}$$

$$e^* = \frac{Y_h - D}{2\,\eta} - \frac{1}{6} < \frac{Y_h}{\eta}. \tag{20}$$

We see that equilibrium effort is below the first-best level. The reason is that higher effort partly benefits the manager (who obtains a rent) and the deposit insurance, which benefits from a lower default probability. Therefore, the shareholder has insufficient incentives to implement a contract that entails the efficient effort level. There is an underinvestment problem. We also see that the bonus z_h^* and the effort level e^* decrease in D, which captures the positive externality on the deposit insurance. The higher the externality, the higher is the inefficiency from the underinvestment problem.

Anticipation of a bail-out. As before, the effects of an anticipated bail-out correspond to the comparative statics with regard to D. Taking the derivative with respect to D, we find that the anticipation of bail-outs leads to a *flatter* compensation scheme, and hence to a lower effort choice, implying an increase in the bank's

[13] We must have $\eta \leq 3\,(Y_h - D)$, otherwise it does not pay for the shareholder to incentivize the manager, see footnote 8.

default probability $p_l(e^*)$. The reason is an increase in the positive externality of effort on the deposit insurance or the state, which is not taken into account by the shareholder when designing the compensation package. Hence, bail-outs are harmful (just as in the risk-shifting setup) because they increase the underinvestment problem.

Proposition 2a (Bail-outs in effort model with limited liability) *Assume that the bank manager is subject to and effort problem and limited liability. Then if a bank bail-out is anticipated,*

1. *the bonus scheme becomes flatter (z_h^* decreases),*
2. *the manager's effort* e^* *decreases, implying that the bank's probability of default* $p_l(e^*)$ *increases,*
3. *the expected compensation* $p_h(e^*)z_h^*$ *and the expected profit of the manager decrease.*

Now the judgment of caps on bonus payments is very different from Section 3. From a welfare perspective, the manager's effort choice is always suboptimally low. A binding cap on bonus payments would worsen the manager's choice. When a bail-out is anticipated, the bonus scheme becomes even flatter. This implies that caps on bonuses would potentially become ineffective because they would no longer be binding. Hence, a cap on bonuses would be harmful or, at best, ineffective in this setting.

Corollary 2 (Cap on bonus payments) *If the manager faces an effort choice, a regulatory cap on bonus payments can be detrimental because it exacerbates the underinvestment problem. The anticipation of bail-outs makes bonus caps less effective.*

4.3 Unlimited Liability of the Manager

Consider now a manager with unlimited liability. Again, the optimal compensation contract looks similar to that in the risk-shifting setup. A bonus payment in the high state can be used to increase the manager's effort. A malus payment in the medium state pushes the manager to the participation constraint without having any incentive effects. A negative z_l is unattractive to shareholders because it benefits the deposit insurance. Consequently, $z_l = 0$, and we are left with two endogenous variables, z_h and z_m. A higher bonus induces higher effort,

$$e^* = \frac{z_h}{\eta}, \tag{21}$$

whereas z_m does not have any effect on the effort level. We then obtain

$$z_h^* = Y_h - D > 0, \tag{22}$$

$$z_m^* = -\left(Y_h - D\right) - \frac{3\left(Y_h - D\right)^2}{2\,\eta} < 0, \tag{23}$$

$$e^* = \frac{Y_h - D}{\eta}. \tag{24}$$

We find that the bonus scheme is steeper than with limited liability; z_h^* increases, and z_m^* becomes negative. The reason is that it is now cheaper for the shareholder to induce the manager to exert effort. The equilibrium level of effort (e^*) is also higher, and the bank's probability of default $p_l(e^*)$ drops. Hence, unlimited liability mitigates the underinvestment problem. Nevertheless, effort is still below the first-best level, but less than under limited liability of the manager.

Anticipation of a bail-out. An increase in D lowers the bonus payment and the manager's effort, implying an increase in the bank's default probability $p_l(e^*)$. Moreover, the spread between high- and medium-state compensation decreases. Hence, the anticipation of a bail-out again leads to a flatter compensation scheme. The effect of an anticipated bail-out is again stronger (in fact, twice as strong) than with limited liability. With unlimited liability, the equilibrium effort is reduced more in reaction to anticipated bank bail-outs.

Proposition 2b (Bail-outs in effort model with unlimited liability) *Assume that the bank manager is subject to an effort problem and unlimited liability. Then if a bank bail-out is anticipated,*

1. *the bonus scheme becomes flatter (z_h^* decreases and z_m^* increases),*

2. *the manager's effort e^* decreases such that the bank's probability of default $p_l(e^*)$ increases (even more than with limited liability),*

3. *the expected compensation, $p_h(e^*)\, z_h^* + p_m(e^*)\, z_m^*$, of the manager decreases.*

Hence, unlimited liability of the manager mitigates the underinvestment problem and stabilizes banks because it allows the shareholder to extract all rents from the manager and therefore makes it cheaper to induce effort. However, the anticipation of bail-outs is harmful even with unlimited liability. Since the manager's effort is in any case too low, a cap on bonus payments is never useful in this setup.

Taken together with the results from the previous section, these propositions have several policy implications. The anticipation of bail-outs is always harmful: it exacerbates both the risk-shifting and the effort problem. Caps on bonus payments are useful if banks are subject to a risk-shifting problem and if bail-out expectations are high. They are not useful when there is an underinvestment problem. For unlimited liability, the opposite is true. It is useful only if managers put too little effort in administering their portfolio (if they are thought to be "lazy"). However, if the problem is that managers take too much risk (and shareholders like them to do just that), an increase in the managers' liability backfires, managers take even more risk, and financial stability deteriorates.

5 General Model with Risk and Effort Choices

We now consider a generalization of Sections 3 and 4 where the manager can influence the return distribution by choosing risk *and* effort.

5.1 Return Structure of the Bank

We assume that the manager can take risk by choosing a at a private cost $\alpha\, a^2/2$, and increase the mean return by exerting an effort e at a private cost $\eta\, e^2/2$. The return distribution is given by

$$\begin{aligned}
p_h(e,a) &= \frac{1}{3} + e + \frac{a}{Y_h\,(Y_h - Y_m)}, \\
p_m(e,a) &= \frac{1}{3} - \frac{a}{Y_m\,(Y_h - Y_m)}, \\
p_l(e,a) &= 1 - p_h(e,a) - p_m(e,a) = \frac{1}{3} - e + \frac{a}{Y_h\,Y_m}.
\end{aligned} \tag{25}$$

The two earlier models are limiting cases of the general model for $\eta \to \infty$ and $\alpha \to \infty$, respectively. If effort costs are extremely high, the effort choice is irrelevant and we are back in the risk choice framework from Section 3. If instead risk-taking costs become prohibitive, we are left with the model of effort choice from Section 4. Note that effort and risk do not interact in the return distribution. But even with this simple specification, the two choices interact in an interesting way. Due to the separability of the distribution functions regarding a and e, the first-best choices are the same as before: $a = 0$ and $e = Y_h/\eta$.

5.2 Limited Liability of the Manager

We first consider the case of limited liability of the manager. Unsurprisingly, the compensation scheme has the same structure as before. Only z_h is positive in equilibrium, and $z_m = z_l = 0$. This implies that the shareholder has only one instrument to influence the two choice parameters of the manager. Following an analogous procedure as above, we obtain – due to separability – the same expressions as above,

$$\begin{aligned}
a^* &= \frac{z_h}{Y_h\,(Y_h - Y_m)\,\alpha}, \\
e^* &= \frac{z_h}{\eta}.
\end{aligned} \tag{26}$$

Risk and effort are proportional to the bonus z_h. When z_h goes up, the manager takes more risk a and increases the effort e. The maximization of the shareholder yields

$$z_h^* = \frac{1}{2}\,\frac{\frac{D}{Y_m\,(Y_h - Y_m)}\,\frac{\eta}{\alpha} + Y_h^2\left(Y_h - D - \frac{\eta}{3}\right)}{\frac{1}{(Y_h - Y_m)^2}\,\frac{\eta}{\alpha} + Y_h^2}. \tag{27}$$

In equilibrium, there is excessive risk-taking and underinvestment. Now the effect of anticipated bail-outs is no longer unambiguous. Taking the derivative with respect to D yields

$$\frac{dz_h^*}{dD} = \frac{1}{2}\Big(\frac{Y_h}{Y_m\left(1 + Y_h^2\,(Y_h - Y_m)^2\,\alpha/\eta\right)} - 1\Big)^{-1}. \tag{28}$$

This derivative is positive if and only if

$$\frac{\eta}{\alpha} > Y_h^2\,Y_m\,(Y_h - Y_m). \tag{29}$$

Hence, the effect of an anticipated bail-out now depends on the relative importance of the risk-shifting and the effort problem. This result is intuitive. If D increases, the shareholder adjusts the contract for the manager. There are two countervailing effects. First, as in Section 3, an increase in risk becomes more attractive for the shareholder, so he wants to increase z_h. This channel is particularly strong if risk-taking is relatively cheap, hence if η/α is large. Then the manager strongly adjusts risk-taking in reaction to a higher bonus payment, while effort is hardly adjusted. Second, as in Section 4, a high effort e becomes less attractive for the shareholder, so he wants to reduce z_h. This channel is particularly strong if η/α is small. Which of the two effect dominates hence depends on the relative size of η and α.

Proposition 3a (Bail-outs in general model with limited liability) *Assume that the bank manager is subject to a risk-shifting and an effort problem and to limited liability. Then if a bank bail-out is anticipated,*

1. *the bonus scheme becomes steeper (z_h^* increases) if and only if*

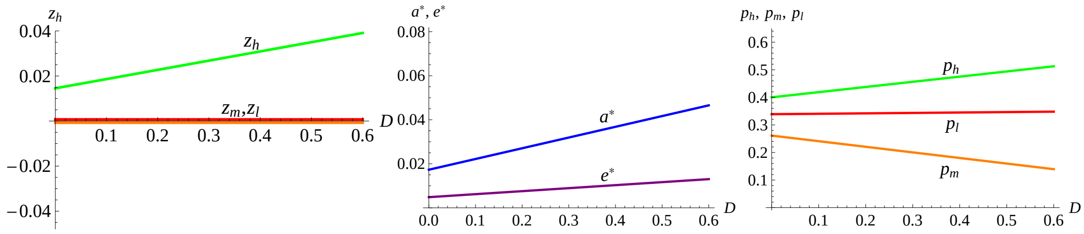
   $$\frac{\eta}{\alpha} > Y_h^2\,Y_m\,(Y_h - Y_m),$$

2. *the manager's effort e^* and risk choice a^* increase under the same condition, but the bank's probability of default $p_l(e^*, a^*)$ always increases,*

3. *the expected compensation $p_h(e^*, a^*)\,z_h^*$ and the expected profit of the manager increase under the same condition.*

Figure 4 illustrates the equilibrium for one particular parameter set, for which condition (29) is satisfied. The first panel shows the equilibrium value of the bonus payment z_h, which increases in D, corresponding to the first part of the proposition. In the second panel, we see that a^* and e^* also increase in D, as stated by the second part of the proposition. The right panel depicts the probabilities p_h, p_m and p_l: p_h and p_l increase in D, whereas p_m decreases.

Figure 4: Equilibrium values under limited liability



Parameters are $Y_h = 1.4$, $Y_m = 1.2$, and $\alpha = \eta = 3$. For these parameters, condition (29) is satisfied. An increase in D corresponds to rising bail-out expectations. The first panel shows that z_h increases in D; z_m and z_l are equal to zero. The second panel depicts a^* and e^*, which both increase in D. In the third panel, p_h and p_l increase in D, whereas p_m decreases.

Welfare effects of caps on bonus payments. The welfare effects of caps on bonus payments are no longer unambiguous. In Section 3, we saw that a cap on bank manager bonuses prohibits inefficient risk choices and therefore increases welfare. In Section 4, a cap curbs the manager's effort and is therefore undesirable. In the combined model, both effects are present, so the welfare effect of a cap is ambiguous.

To see under which conditions a cap on bonus payments is optimal from a welfare perspective, we maximize welfare with respect to the bonus payment. Welfare is defined as the aggregate net present value, net of the manager's non-monetary costs,

$$W = p_h\, Y_h + p_m\, Y_m - (1+r)\, d - (1+r_f)\, l - \eta\, e^2/2 - \alpha\, a^2/2. \tag{30}$$

p_h, p_m, e, and a depend on z_h. The welfare-maximizing bonus is given by

$$z_h^W = \frac{Y_h}{\frac{1}{Y_h^2\,(Y_h - Y_m)^2}\,\frac{\eta}{\alpha} + 1}. \tag{31}$$

This bonus z_h^W decreases in η/α. If the risk-shifting problem is relatively important compared to the effort problem (η/α is relatively high), the welfare-optimal bonus is lower.[14] If the equilibrium bonus z_h^* from equation (27) exceeds the welfare-optimal bonus z_h^W, a cap on bonus payments raises welfare. If z_h^* is smaller than z_h^W, the bonus payment implemented by the shareholder is too small from a welfare

[14] These results are similar in spirit to John and John (1993) and John, Mehran, and Qian (2011). Note, however, that in their models, the welfare-optimal solution is equivalent to the optimal choice by the shareholder.

perspective because it induces too little effort. Hence, putting a cap on bonus payments is undesirable. A comparison of (27) and (31) shows that $z_h^* > z_h^W$ if and only if

$$D > \frac{Y_h + \eta/3}{\frac{1}{Y_h^2\, Y_m\, (Y_h - Y_m)}\, \frac{\eta}{\alpha} - 1}. \tag{32}$$

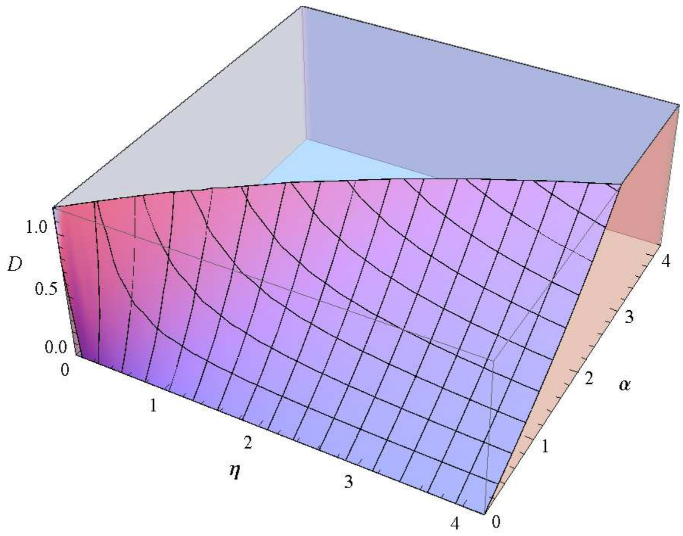
This condition is illustrated in Figure 5 for different combinations of η and α. If α is small, risks-shifting is cheap. As a consequence, for a positive compensation z_h^*, the manager has strong risk-shifting incentives, leading to a reduction in welfare. Hence, for small α, it is always optimal to reduce risk-shifting incentives by capping the bonus. This is also visible in the figure: for $\alpha \to 0$, capping bonuses is optimal for any positive D, independently of η. The argument for η is the other way around. If η is small, exerting effort is cheap, and for positive z_h^*, the manager exerts a lot of effort. Then a cap on bonuses is never optimal because bank bonuses are already chosen too low by the shareholder. Finally, a cap is efficient if the amount of risk-insensitive debt D is high. The larger D, the larger the risk-shifting motive of shareholders. The optimal bonus induces the manager to take excessive risk. As a result, the regulator should cap bonuses especially for high D.

Anticipation of a bail-out. As before, the effect of an anticipated bail-out is identical to the effect of an increase in D. Condition (32) and Figure 5 show that, even if one starts at a point where caps on bonuses are welfare-decreasing (below the plane), an increase in D can lead into the region where caps on bonus payments increase welfare. This leads to the following proposition.

Proposition 3b (Optimal caps on bonus payments with limited liability) *Assume that the bank manager is subject to a risk-shifting and an effort problem and to limited liability. Then if a bail-out is anticipated, the parameter space increases for which regulatory caps on bonus payments are optimal from a welfare perspective.*

If bail-out expectations are strong enough, a cap on bonuses is desirable from a welfare perspective. Hence, the recent calls for caps on bank bonuses in reaction to the current crisis may well be justified. Given the huge bail-out packages to many banks, expected bail-out probabilities increased sharply. Most of all, this concerns

Figure 5: Condition for a welfare increase of bonus caps



This simulation is again based on the parameters $Y_h = 1.4$ and $Y_m = 1.2$. For parameter combinations of D, η and α *above* the plane, a cap on bonus payments raises welfare. If η is close to zero, exerting effort is cheap, and it is never optimal to have restrictions on bonuses. If α is close to zero, risk-shifting is cheap, and it is always optimal to limit bonuses. If D is high enough, risk-shifting incentives are so strong that bonuses should be curbed.

systemically important financial institutions (SIFIs). After the recent promises of government officials from many countries not to let any such institution fail, bail-out probabilities of SIFIs are now close to one. It remains to be seen whether regulation will be able to curb such expectations.

5.3 Unlimited Liability of the Manager

We now show that the results are even stronger with unlimited liability. In this case, caps on bonuses are *always* optimal. Moreover, increasing the manager's liability always reduces welfare relative to the situation with limited liability.

Note first that the optimal contract has $z_h \geq 0$, $z_m \leq 0$ and $z_l = 0$. The payment in the bad state cannot be positive because the bank has no earnings to pay out to the manager. It is not negative because a payment from the manager to the bank would benefit lenders or the deposit insurance, but not the shareholder. Hence, it must be zero, $z_l = 0$. A payment in the medium state would reduce risk and not affect effort, whereas the payment in the good state is a means to induce the manager to take risk and exert effort. Hence z_h is positive and $z_m \leq 0$. z_h and z_m are tied together through the manager's binding participation constraint, hence the shareholder has again just one instrument to influence risk and effort.

The manager's expected profit is

$$\Pi_M = p_h\, z_h + p_m\, z_m - \eta\, \frac{e^2}{2} - \alpha\, \frac{a^2}{2}, \tag{33}$$

which, for given z_h and z_m, is maximized for

$$a^* = \frac{1}{\alpha\, Y_h\, Y_m}\, \frac{Y_m\, z_h - Y_h\, z_m}{Y_h - Y_m} \qquad \text{and} \qquad e^* = \frac{z_h}{\eta}. \tag{34}$$

Assume for a moment that the manager's liability is limited and that z_m is set to the maximum liability. Then the shareholder sets z_h, taking into account z_m. The shareholder's expected profit

$$\Pi_E = p_h\, (Y_h - D - z_h) + p_m\, (Y_m - D - z_m) \tag{35}$$

is maximized for

$$z_h^* = \frac{\alpha\, (Y_h - D)\, Y_h^2 (Y_h - Y_m)^2 Y_m + \eta\, \big(D\, (Y_h - Y_m) + Y_h\, (2z_m - Y_h Y_m\, (Y_h - Y_m)\, \alpha/3)\big)}{2Y_m\, \big(\alpha\, Y_h^2\, (Y_h - Y_m)^2 + \eta\big)}. \tag{36}$$

The derivative with respect to z_m is positive,

$$\frac{\partial z_h^*}{\partial z_m} = \frac{\eta\, Y_h}{2\, Y_m\, \big(\alpha\, Y_h^2\, (Y_h - Y_m)^2 + \eta\big)} > 0. \tag{37}$$

If the shareholder takes money from the manager in the medium state, this already gives the manager incentives to avoid the medium state, hence to shift risk. Consequently, the shareholder has a lower benefit from giving the manager additional incentives to take more risk; z_h^* decreases. Overall, the manager takes more risk and exerts less effort. Hence, lowering the payment in the medium state unambiguously lowers welfare,

$$\frac{\partial W}{\partial z_m} = \frac{Y_h^2\, (Y_m - z_m)}{Y_m^2\, \big(\alpha\, Y_h^2\, (Y_h - Y_m)^2 + \eta\big)} > 0. \tag{38}$$

As a direct consequence, extending the manager's liability unambiguously reduces aggregate welfare. Given our earlier results, this is surprising. In the risk-shifting setup, extending the manager's liability exacerbated the problem. In the effort setup, extended liability mitigated the problem. The above calculations show that in the generalized model with unlimited liability, the negative welfare effect of risk always overcompensates the positive effect of effort choice.

Anticipation of a Bail-out. If a bail-out is anticipated (i. e., if D is raised), the shareholder prefers the manager to take more risk, but also to take less effort. The following proposition states that the second effect *always* dominates the first.

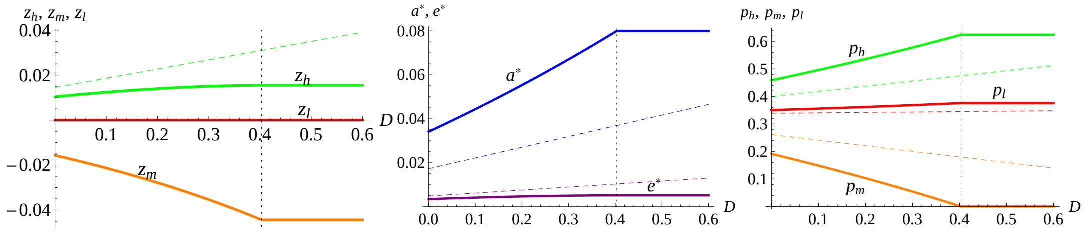
Proposition 3c (Impact of bail-outs in general model with unlimited liability) *Assume that the bank manager is subject to a risk-shifting and an effort problem and to unlimited liability. Then if a bank bail-out is anticipated,*

1. *the bonus scheme becomes steeper (z_h^* increases and z_m^* decreases),*
2. *the manager's effort e^* and risk-taking a^* both increase, and the bank's probability of default $p_l(e^*, a^*)$ always increases,*
3. *the expected compensation $p_h(e^*, a^*)\, z_h^* + p_m(e^*, a^*)\, z_m^*$ of the manager increases.*

This result stands in some contrast to Proposition 3a. With limited liability, it depends on the ratio η/α whether the bonus contract becomes steeper in reaction to the anticipation of a bail-out. With unlimited liability, shareholders always increase risk-taking incentives when they anticipate a bail-out. The intuition for this result is as follows. Assume for the moment that the shareholder chooses the same value z_h^* as under limited liability, but chooses a negative payment in the medium state to make the participation constraint binding. Then effort would be the same as under limited liability, but risk-shifting would shoot up because the negative payment in the medium state would set additional risk-shifting incentives. Therefore, the optimal z_h^* under unlimited liability will be smaller than under limited liability, and so will be effort. Risk-shifting, however, will be higher. Anticipated bail-outs raise risk-shifting incentives even further, with the side-effect of also raising effort.

Figure 6 illustrates the equilibrium with unlimited liability (thick curves) and, for comparison, with limited liability (dashed curves). As can be seen from the figure, the probability of the medium state hits zero at $D \approx 0.4$. From then on, all relevant variables are constant. The first panel shows the equilibrium values of $z_h > 0$ and $z_m < 0$ (z_l is always zero). Under limited liability, z_m is also zero and is not shown. When the manager is made liable, he is punished in the medium state. Consequently, the shareholder has to implement fewer risk incentives in the good

Figure 6: Equilibrium values under unlimited liability



Parameters are $Y_h = 1.4$, $Y_m = 1.2$, and $\alpha = \eta = 3$. An increase in D corresponds to rising bail-out expectations. Thick curves refer to the case with unlimited liability, dashed curves to limited liability. At the dotted vertical line, p_m becomes zero, and a^* reaches its maximum. From this point on, all curves are flat. The first panel shows that z_h increases in D, whereas z_m decreases. z_l is equal to zero. The second panel depicts a^* and e^*, which both increase in D. In the third panel, p_h and p_l increase in D, whereas p_m decreases.

state, and z_h drops compared to limited liability. With rising bail-out expectations, z_h increases and z_m decreases. The second panel shows the equilibrium values of a^* and e^* as functions of D. Risk-shifting is higher than under limited liability, but effort is smaller. As before, a^* and e^* increase when bail-out expectations increase (until $D \approx 0.4$), but the increase in risk is stronger than before, whereas the increase in effort is milder. The third panel depicts the three probabilities. The probabilities of the high and low state are larger than under limited liability, that of the medium state is smaller. As before, p_h and p_l increase in D, whereas p_m decreases.

Welfare effects of caps on bonus payments. A cap on bonus payments reduces z_h^*. Since the manager's participation constraint is binding, it at the same time increases z_m^*. Hence, the manager takes less risk, but also reduces effort. The following proposition states that the negative welfare effect of risk-shifting effect exceeds the positive effect from increased effort. Consequently, putting a cap on bonuses increases welfare. The reason is that, in comparison to the limited liability case, there is much more risk shifting, with negative welfare implications. In other words, bail-out anticipations raise the effort choice mildly, but they strongly raise risk-shifting. This effect can be contained by capping bonuses. Hence, a cap increases welfare whenever the resulting constraint is binding.

Proposition 3d (Optimal caps on bonus payments with unlimited liability) *Assume that the bank manager is subject to a risk-shifting and an effort problem and to unlimited liability. Then if a bail-out is anticipated, regulatory caps on bonus payments are always beneficial from a welfare perspective.*

Again, Figure 6 gives some intuition. One can see that, in comparison to the limited liability case, effort decreases mildly and risk-shifting increases sharply. The manager is compensated in the good state and punished in the medium state, setting additional risk-shifting incentives. As was explained before, this leads to a lower bonus payment z_h^* and lower effort. In contrast, risk-shifting rises strongly. Hence, unlimited liability of the manager amplifies the negative welfare effects of bonuses. As a result, capping the compensation has an unambiguous positive welfare effect. We see that unlimited liability is no substitute for a regulation of bank manager compensation. Quite the opposite, the case for ceilings on bank bonuses is even stronger under unlimited liability.

6 Conclusion

In this paper, we have shown that bonus contracts may arise endogenously as a response to agency problems within banks. If there is a risk-shifting problem, the shareholder designs a bonus scheme that induces the bank manager to take excessive risk. Alternatively, bank bonuses can be used to incentivize the manager to take effort. This leads to an underinvestment problem because the shareholder does not fully internalize the benefits of higher effort.

The anticipation of a bail-out weakens market discipline and induces the shareholder to steepen the bonus scheme in the risk-shifting setup, exacerbating the risk-shifting problem. In the effort choice setup, anticipated bail-outs flatten the bonus scheme, reducing effort even further. In both setups, bail-outs are harmful and raise a bank's probability of default. When both types of agency problems are present and managers are subject to limited liability, the effect of anticipated bail-outs on bonus schemes is ambiguous, depending on the relative importance of the risk-shifting and the effort problem. In contrast, when managers are subject to unlimited liability, bonus schemes always become steeper in reaction to higher bail-out expectations. In any case, anticipated bail-outs are destabilizing.

Regulatory caps on bonuses are a way to mitigate the risk-shifting problem. However, this comes at the cost of reducing managers' incentives to exert effort. But especially if bail-out expectations are strong, the risk-shifting problem always dominates even with limited liability. This leads to excessively high bonus payments and yields a rationale for regulatory bonus restrictions.

Interestingly, unlimited liability of the manager may be counterproductive, both from a welfare and stability perspective. While it helps to mitigate the effort problem, it exacerbates the risk-shifting problem. Since the latter dominates when bail-out expectations are high, raising managers' liability may not be desirable in the current situation. A stronger alignment of interests between shareholders and managers may destabilize banks if shareholders have strong risk-taking incentives.

In the crisis, several countries introduced strict bonus caps only on banks that were bailed out. While this may be justified on grounds of fairness, efficiency considerations suggest that caps should be imposed on all banks with sufficiently high bail-out probabilities. These may well be banks that were not bailed out in the recent crisis. Moreover, the optimality of bonus caps was shown to depend on bank-specific parameters in our model, implying that one size may not fit all. In fact, our paper supports caps on bonus payments especially for systemically important financial institutions (SIFIs), for which (implicit) bail-out guarantees are strongest. Taxes on bonuses can achieve the same result as bonus caps, but not if they are imposed ex post on a one-time basis, as in the United Kingdom. With permanently higher bail-out perceptions, caps should not be lifted after the crisis, unless a new regulatory framework is able to curb bail-out expectations. At the moment, this seems unlikely.

A Proofs

Proof of Proposition 1a: The first two points are proven in the main text. The increase in the manager's expected (monetary) compensation, $p_h\, z_h$, follows directly from the rise in p_h (due to the rise in a^*) and the rise in z_h^*. The manager's expected profit (net of the non-monetary cost) is

$$\Pi_M = \frac{1}{24\,\alpha}\left(\frac{D}{Y_h\,Y_m} + \alpha\,Y_h\,(Y_h - Y_m)\right)\left(\frac{3\,D}{Y_h\,Y_m} - \alpha\,Y_h\,(Y_h - Y_m)\right). \tag{39}$$

The derivative of profits with respect D is positive, $d\Pi_M/dD > 0$. ■

Proof of Proposition 1b: Some parts of the proof are already given in the main text. The optimal contract is defined by (14) and (15), the equilibrium choice of a^* is given by (16). This defines the probabilities of the three states in equilibrium. The function $z_h^*(D)$ is a concave parable with maximum at $\alpha/3\,Y_h\,Y_m^2\,(Y_h - Y_m)$. However, the interior solution applies only as long as all probabilities remain in the interval $[0,1]$. In equilibrium, we have

$$p_h = \frac{1}{3} + \frac{D}{\alpha\,Y_h^2\,Y_m\,(Y_h - Y_m)}, \tag{40}$$

$$p_m = \frac{1}{3} - \frac{D}{\alpha\,Y_h\,Y_m^2\,(Y_h - Y_m)}, \tag{41}$$

$$p_l = \frac{1}{3} + \frac{D}{\alpha\,Y_h^2\,Y_m^2}. \tag{42}$$

p_m is positive as long as $D < \alpha/3\,Y_h\,Y_m^2\,(Y_h - Y_m)$, which is just the maximum of the parable above. Hence, we have shown that z_h^* is increasing in D as long as there is an interior solution. Once the solution reaches the border, probabilities are constant. z_m^* decreases for all $D > 0$. This proves the first statement. The second statement follows from (16). The derivative of a^* with respect to D is double that under limited liability, see (10). To prove the third statement, consider the expected compensation,

$$p_h\,z_h^* + p_m\,z_m^* = \frac{D^2}{2\,\alpha\,Y_h^2\,Y_m^2}. \tag{43}$$

This increases in D, which completes the proof. ■

Proof of Proposition 2a: An expected bailout has the same effect as an increase in D. From (19) and (20), it is apparent that $dz_h^*/dD < 0$ and $de^*/dD < 0$, which proves the first two statements. The manager's expected compensation $p_h\, z_h$ decreases in D because p_h decreases (due to the drop in e^*) and z_h^* decreases. The manager's expected profit

$$\Pi_M = \frac{(Y_h - D + \eta)\,(3\,Y_h - 3\,D - \eta)}{24\,\eta} \tag{44}$$

also decreases in D. This completes the proof. ■

Proof of Proposition 2b: Looking at (22), z_h^* decreases in D. As shown by (23), z_m^* is negative and increasing in D for $D < Y_h + \eta/3$, i. e., in the complete domain of definition because $D \le Y_m < Y_h$. Effort decreases twice as fast in D as under limited liability, see (20). The expected compensation is

$$p_h\, z_h^* + p_m\, z_m^* = \frac{(Y_h - D)^2}{2\,\eta}, \tag{45}$$

which decreases in D until Y_h is reached, which lies outside of the domain of definition. This proves the final point. ■

Proof of Proposition 3a: The first statement has been shown in (28) and (29). We give conditions for an interior solution. The manager's equilibrium choices are

$$a^* = \frac{Y_h\,(Y_h - Y_m)}{6\,(Y_h^2\,(Y_h - Y_m)^2\,\alpha + \eta)}\Big(3\,Y_h - \eta - 3\,D\,\big(1 - \frac{\eta}{Y_h^2\,Y_m\,(Y_h - Y_m)\,\alpha}\big)\Big), \tag{46}$$

$$e^* = \frac{Y_h - Y_m}{6\,\eta\,Y_m}\,\frac{\alpha\,Y_h^2\,Y_m\,(Y_h - Y_m)\,(3\,Y_h - \eta) - 3\,D\big(\alpha\,Y_h^2\,Y_m\,(Y_h - Y_m) - \eta\big)}{\alpha\,Y_h^2\,(Y_h - Y_m)^2 - \eta}. \tag{47}$$

Inserting these into the probabilities, we find that p_m is non-negative for

$$D \le \frac{Y_h\,(Y_h - Y_m)\,Y_m\,\alpha\,\big(Y_h^2\,(3 - 2\,\alpha\,Y_m\,(Y_h - Y_m)^2 - \eta\,(Y_h + 2\,Y_m)\big)}{3\,\alpha\,Y_h^2\,Y_m\,(Y_h - Y_m) - 3\,\eta}. \tag{48}$$

It is important to bear in mind that these constraints have to be fulfilled in equilibrium. The second statement follows directly because a^* and e^* are increasing in z_h^*, see (26). Inserting equilibrium values into p_l and taking the derivative with respect to D yields

$$\frac{\mathrm{d}p_l}{\mathrm{d}D} = \frac{(\alpha\,Y_h^2\,Y_m\,(Y_h - Y_m) - \eta)^2}{2\,\alpha\,\eta\,Y_h^2\,Y_m^2\,(\alpha\,Y_h^2\,(Y_h - Y_m)^2 + \eta)} > 0. \tag{49}$$

For the third point, look at the expected compensation and take the derivative with respect to D,

$$\frac{\mathrm{d}(p_h\, z_h^* + p_m\, z_m^*)}{\mathrm{d}D} = -\frac{\alpha\, Y_h^2\, Y_m\, (Y_h - Y_m) - \eta}{\alpha\, Y_h^2\, (Y_h - Y_m) + \eta} \cdot \frac{\alpha\, Y_h^2\, Y_m\, (Y_h - D)(Y_h - Y_m) + D\, \eta}{2\, \alpha\, \eta\, Y_h^2\, Y_m^2}. \tag{50}$$

The denominators of both fractions are always positive. The numerator of the first fraction is negative if and only if (29) holds, the condition in the proposition. The numerator of the second fraction is positive for all $D < Y_h$. ■

Proof of Proposition 3b: This is a direct consequence of condition (32) and the fact that an increase in bail-out anticipations is equivalent to an increase in D. ■

Proof of Proposition 3c: The explicit solution of the general problem with unlimited liability is intractable. Therefore, we prove the proposition without referring to the explicit solution. In equilibrium, the shareholder sets z_m such that the manager's expected profits are zero, taking into account his costs of effort and risk-taking. Inserting (34) into (33) yields

$$\Pi_M = \frac{z_h^2}{2\,\eta} + \frac{z_h + z_m}{3} + \frac{(Y_m\, z_h - Y_h\, z_m)^2}{2\, \alpha\, Y_h^2\, (Y_h - Y_m)^2\, Y_m^2}, \tag{51}$$

depending only on the endogenous variables z_m and z_h. The shareholder's profit is

$$\begin{aligned}\Pi_E = {} & (Y_h - D - z_h) \left(\frac{1}{3} + \frac{Y_m\, z_h - Y_h\, z_m}{\alpha\, Y_h^2\, (Y_h - Y_m)^2\, Y_m} + \frac{z_h}{\eta}\right) \\ & + (Y_m - D - z_m) \left(\frac{1}{3} - \frac{Y_m\, z_h - Y_h\, z_m}{\alpha\, Y_h\, (Y_h - Y_m)^2\, Y_m^2} + \frac{z_h}{\eta}\right).\end{aligned} \tag{52}$$

The shareholder solves a constrained optimization problem with the Lagrangian $L = \Pi_E - \lambda\, \Pi_M$. Taking derivatives with respect to z_h and z_m allows us to eliminate λ and then solve for z_m. The result is then substituted into Π_E, yielding an equation that can be solved for z_h^*. We are interested in the derivative with respect to D,

$$\begin{aligned}\frac{\mathrm{d}z_h^*}{\mathrm{d}D} = {} & -\alpha^2\, \eta^3\, Y_h^2\, Y_m^4 \cdot \big(3\, Y_h\, (Y_h - D) + \eta\, (Y_h + Y_m)\big)^3 \cdot \\ & \cdot \big(\alpha\, Y_h^2\, Y_m^2\, (Y_h - Y_m)^2 + \eta\, (Y_h + Y_m)^2\big)^2 \cdot \\ & \cdot \big(\eta\, (Y_h + Y_m) + Y_h^2 (3 - \alpha\, Y_m^2 (Y_h - Y_m))\big) \cdot \big(3D - \alpha Y_h Y_m^2 (Y_h - Y_m)\big).\end{aligned} \tag{53}$$

The signs of all but the last two factors are unambiguously positive. Only the last factor depends on D. The derivative changes the sign at the point

$$D = \bar{D} := \frac{\alpha}{3}\, Y_h\, Y_m^2\, (Y_h - Y_m). \tag{54}$$

Hence, the function $z_h^*(D)$ reaches an extremum at this point. It remains to show whether this is a minimum or a maximum. For $D = 0$, the last factor is negative. Thus for small D, the sign of the slope of $z_h^*(D)$ is identical to the sign of the last but one factor, which is positive for

$$\alpha < \bar{\alpha} := \frac{3\, Y_h^2 + \eta\, (Y_h + Y_m)}{Y_h^2\, Y_m^2\, (Y_h - Y_m)}. \tag{55}$$

However, substituting $\bar{\alpha}$ into the equations, one finds that it is optimal to put incentives to zero, $z_h^* = z_m^* = 0$. Consequently, in the relevant parameter range, condition (55) always holds. Hence, the sign of (53) is determined by whether $D > \bar{D}$ or not. One can show that, for $D > \bar{D}$, the algebraic solution does not apply because p_m becomes negative. Consequently, the sign of (53) is positive, and $z_h^*(D)$ is a increasing function in the relevant range of parameters. Now consider p_l as a function of D. Inserting equilibrium values and taking the derivative with respect to D yields a fraction with a positive denominator and the numerator

$$Y_m \left(Y_h^2\, (3 - \alpha\, Y_m^2\, (Y_m - Y_h)) + \eta\, (Y_h + Y_m)\right)^2 \sqrt{\alpha\, \eta\, \left(\alpha\, Y_h^2\, (Y_h - Y_m)^2\, Y_m^2 + \eta\, (Y_h + Y_m)^2\right)}. \tag{56}$$

All factors are positive, hence the derivative $\mathrm{d}p_l/\mathrm{d}D$ is positive. The remaining statements are direct consequences. Given the binding participation constraint, z_m^* drops if z_h^* rises. Incentives to exert effort and to shift risk are raised. In equilibrium, the manager is compensated exactly for his expected costs, $\alpha\, a^2/2$ and $\eta\, e^2/2$. Hence, if both a and e increase, the expected compensation also increases. ■

Proof of Proposition 3d: We set up the welfare function, taking into account that z_h^* is a function of z_m^* because of the manager's participation constraint,

$$W = p_h(z_h^*)\, Y_h + p_m(z_m^*)\, Y_m - \alpha\, a^2/2 - \eta\, e^2/2.$$

Taking the derivative with respect to z_m^* yields

$$\frac{\mathrm{d}W}{\mathrm{d}z_m^*} = \frac{Y_h^2}{Y_m^2} \cdot \frac{Y_m - z_m^*}{\alpha\, Y_h^2\, (Y_h - Y_m)^2 + \eta} > 0 \tag{57}$$

because $z_m^* < 0$. A cap on bonuses reduces z_h^* and raises z_m^*. According to (57), welfare increases. ■

References

Acharya, V. V., M. Pagano, and P. F. Volpin (2010): "Seeking Alpha: Excess Risk Taking and Competition for Managerial Talent," Unpublished working paper.

Bannier, C. E., E. Feess, and N. Packham (2012): "Competition, Bonuses, and Risk-Taking in the Banking Industry," *Review of Finance*, forthcoming.

Bebchuk, L. A., A. Cohen, and H. Spamann (2010): "The Wages of Failure: Executive Compensation at Bear Stearns and Lehman 2000- 2008," Harvard law school working paper no. 657.

Becht, M., P. Bolton, and A. Röell (2003): "Corporate Governance and Control," in *Handbook of the Economics of Finance*, 1–109. Elsevier.

Biais, B., and C. Casamatta (1999): "Optimal Leverage and Aggregate Investment," *Journal of Finance*, 54(4), 1291–1323.

Caprio, G., and R. Levine (2002): "Corporate Governance in Finance: Concepts and International Observations," in *Financial Sector Governance: The Roles of the Public and Private Sectors*, 17–50. Brookings Institution Press, Washington, DC.

Cheng, I.-H., H. G. Hong, and J. A. Scheinkman (2010): "Yesterday's Heroes: Compensation and Creative Risk-Taking," Ecgi - finance working paper no. 285/2010.

Chesney, M., J. Stromberg, and A. F. Wagner (2010): "Risk-Taking Incentives, Governance, and Losses in the Financial Crisis," Swiss finance institute research paper series no. 10-18.

Demirgüç-Kunt, A., and H. Huizinga (2004): "Deposit Insurance and Market Discipline," *Journal of Monetary Economics*, 51(2), 375–399.

Dewatripont, M., and J. Tirole (1994): *The Prudential Regulation of Banks*. MIT Press.

Fahlenbrach, R., and R. Stulz (2011): "Bank CEO Incentives and the Credit Crisis," *Journal of Financial Economics*, forthcoming.

Financial Stability Board (2009): "FSB Principles for Sound Compensation Practices – Implementation Standards," Discussion paper.

Freixas, X., and J.-C. Rochet (2010): "Taming SIFIs," Unpublished working paper.

Gropp, R., H. Hakenes, and I. Schnabel (2010): "Competition, Risk-Shifting, and Public Bail-out Guarantees," *Review of Financial Studies*, 24(6), 2084–2120.

Gropp, R., and M. Köhler (2010): "Bank Owners or Bank Managers: Who is Keen on Risk? Evidence from the Financial Crisis," European business school research paper series no. 10-02.

Houston, J. F., and C. James (1995): "CEO Compensation and Bank Risk: Is Compensation in Banking Structured to Promote Risk Taking?," *Journal of Monetary Economics*, 36(2), 405–431.

John, K., and T. A. John (1993): "Top-Management Compensation and Capital Structure," *Journal of Finance, Papers and Proceedings*, 48(3), 949–974.

John, K., H. Mehran, and Y. Qian (2011): "Outside Monitoring and CEO Compensation in the Banking Industry," *Journal of Corporate Finance*, forthcoming.

John, K., A. Saunders, and L. W. Senbet (2000): "A Theory of Banking Regulation and Management Compensation," *Review of Financial Studies*, 13(1), 95–125.

Laeven, L., and R. Levine (2009): "Corporate Governance, Regulation, and Bank Risk Taking," *Journal of Financial Economics*, in press.

Macey, J. R., and M. O'Hara (2001): "The Corporate Governance of Banks," *FRBNY Economic Policy Review*, April, 91 – 107.

Prendergast, C. J. (1999): "The Provision of Incentives in Firms," *Journal of Economic Literature*, 37(1), 7–63.

Shleifer, A., and R. W. Vishny (1997): "A Survey of Corporate Governance," *Journal of Finance*, 52(2), 737–783.