# Inside debt, bonus caps, and risk taking in banks

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**Abstract**

In an effort to limit banks' risk taking, regulators propose including unsecured debt held by bank managers, often referred to as inside debt, in their compensation contracts. I show that mandatory inside debt, when implemented in isolation, may not only fail to reduce risk but can also increase it. A key friction is the distortion of risk-taking incentives of shareholders, who optimally increase managers' bonuses in response to mandatory inside debt. Additionally, I show that in regimes with bonus caps, inside debt can sometimes complement them to reduce risk but may also cause adverse effects. The paper provides insights into policy measures for regulating bank manager remuneration.

*Keywords:* bank regulation; risk taking; executive compensation; inside debt; bonus; bonus caps

*JEL Classifications:* G21, G28, G32, J33

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# 1 Introduction

During the financial crisis of 2008, the role of managers in banks' risk taking was widely discussed. In light of evidence that high bonuses were steadily increasing before the crisis (Fortin et al., 2010; Bell and Reenen, 2013), the concern was that the structure of managerial compensation was one of the contributing factors in the buildup of the crisis (Bebchuk and Spamann, 2010; Bebchuk et al., 2010; Bhagat and Bolton, 2014). Consequently, financial authorities felt compelled to regulate compensation systems in banks.[1] In 2009, the Financial Stability Board (FSB) introduced its Principles for Sound Compensation Practices to guide national regulators in designing compensation structures aimed at curbing the risk taking of bank managers. Through continued discussions between regulators and the FSB about how these principles should be implemented, a recommendation emerged that managers' variable pay should include long-term, unsecured debt (such as bonds, which can be written down in case of default) and equity.[2] Furthermore, the FSB suggests that the variable pay should be limited by a multiple of fixed pay (such as base salary), as a form of bonus cap.

However, reports from FSB member countries that implemented such bonus caps and debt-like compensation (APRA, 2018; FSB, 2019; FCA, 2020; Rozen, 2024), as well as empirical studies (Kokkinis, 2018; Cerasi et al. 2020; Deng et al., 2021; Collonello et al., 2023), show no evidence of a decrease in banks' risk taking post reform. These findings suggest that bank compensation regulation may still fall short in addressing underlying risk-taking incentives. Furthermore, recent financial and political shocks reinitiated regulatory discussions on prudent compensation practices and revealed the lack of international

[1] "Compensation at significant financial institutions is one factor among many that contributed to the financial crisis that began in 2007. Official action to address unsound compensation systems must therefore be embedded in the broader financial regulatory reform program [...]" (The Financial Stability Board, 2009, p. 1)

[2] See, e.g., Directive 2013/36/EU (with guidelines specified in EBA, 2014), Dudley (2014), Office of the Comptroller of the Currency et al. (2016), FSB (2019)

consensus on which rules should be implemented.[3]

I analyse the effect of mandatory unsecured managers' debt holding (inside debt) on banks' risk taking in a theoretical framework. A key friction is the distortion in shareholders' risk-taking incentives due to deposit insurance, the price of which is not sensitive to the underlying risk. As Chaigneau (2013) and Hoffmann et al. (2022) point out, it is shareholders who ultimately design the compensation contract of the manager.[4] Therefore, even though the regulation targets manager's incentives, it is crucial to understand its impact on shareholders. I show that inside debt and risk taking interact in a way that creates a dual impact on shareholders' expected payoff. As a result, shareholders optimally increase the manager's bonus in response to the mandatory inside debt, keeping risk levels unchanged and rendering the regulation ineffective. Furthermore, I discuss the role of bonus caps in limiting shareholders' ability to adjust the compensation contract in order to realign the manager's risk-taking incentives with theirs. I show that mandating inside debt under bonus cap regulation could reduce banks' risk taking, but it may also have adverse effects in some cases. The analysis highlights the complexities in aligning regulatory measures with shareholders' interests to achieve optimal risk management in banks.

I consider a model with a bank financed by insured deposits and equity. Deposit insurance is not risk-sensitive, which gives rise to risk-taking incentives of bank shareholders. The bank holds risky assets and is run by a risk-neutral manager, who can increase the underlying risk of the bank's assets at a private cost.[5] I model risk taking

[3]While the US regulators are under pressure to introduce stricter rules for the remuneration of bank executives following the collapse of Silicon Valley Bank in 2023 (Congress of the United States, 2024), the UK regulator relaxed the rules by eliminating the bonus cap in the aftermath of Brexit (BoE, 2023).

[4]In this context, Fahlenbrach and Stulz (2011) analyse incentives of bank managers during the financial crisis of 2008 and argue that bank CEOs did not appear to act solely in their own interests but rather in the interests of shareholders. Also, Gropp and Köhler (2010) show that stronger incentive alignment between management and shareholders leads to higher risk taking.

[5]For example, this cost could stem from the manager's effort to increase the risk such that the regulator does not notice the change and does not intervene.

as a mean-preserving (or -decreasing) spread. The manager's risk-taking incentives are driven by the compensation contract designed by shareholders, maximizing the value of equity. Shareholders cannot observe the manager's risk taking actions. Thus, they design a compensation contract based on the observable output.

Shareholders' contract design is subject to regulatory constraints. Shareholders can be required to include inside debt in the manager's compensation. Inside debt is junior to insured deposits. In the default state, where the project payoff is lower than the amount of insured deposits, the manager gets zero payoff on the inside debt claim. In non-default states, inside debt can be fully paid. The manager's compensation can also be subject to bonus caps. The two regulatory measures are given exogenously. The paper does not seek to define optimal regulation. Rather, it aims to assess the role of mandatory inside debt in managerial compensation contracts given shareholders' risk-taking incentives, thereby analyzing whether it should be considered in regulation of the structure of bankers' compensation.

Without mandatory inside debt shareholders optimally compensate the manager only in the state with the highest project payoff, which can be interpreted as a bonus. Mandating banks to include inside debt in this compensation contract decreases the manager's risk-taking incentives holding the bonus constant. However, I show that in response to mandatory inside debt, shareholders optimally increase the bonus to restore the manager's risk-taking incentives. While a higher bonus creates a cost for shareholders, higher risk taking decreases the expected inside debt payment, completely offsetting the additional cost of a higher bonus. Consequently, mandating banks to include inside debt in the compensation contract does not change the manager's optimal choice of risk.

A fixed cap on bonuses explicitly prohibits shareholders from increasing the bonus. Such a constraint ensures that the risk-reducing effect of inside debt is not counteracted, leading to lower risk taking. Although the fixed bonus cap reduces risk independently,

when combined with inside debt, it can fully eliminate risk even if the cap is set above zero. In contrast, a bonus cap defined as a maximum ratio of base salary to bonuses (relative bonus cap) as recommended by the FSB guidelines and implemented in many national legislations, does not explicitly forbid shareholders from increasing bonuses. Instead, it makes it more costly for shareholders to do so because it necessitates the payment of a higher base salary. However, the interaction between inside debt and risk taking offsets their impact on shareholders' expected payoff in the same way as when no cap is present. Thus, even though this constraint leads to risk reduction, its effect is independent of inside debt. As a result, mandatory inside debt does not complement the relative bonus cap.

Relaxing the assumption that bank deposits are fully insured reveals that mandatory inside debt can have an adverse effect on banks' risk taking. Unlike insured deposits, uninsured debt has the same seniority as inside debt, allowing the manager to recover a share of inside debt in default. Consequently, the cost of risk taking for shareholders decreases, and the optimal risk taking increases with inside debt. In addition, base salary is senior to uninsured deposits. Paying the base salary in default further reduces shareholders' expected wage costs under a relative bonus cap, potentially leading to greater risk taking than without the cap.

In an extension, I show that mandating inside debt is even less effective when the manager's compensation contract features other equity-aligned instruments instead of a bonus. I introduce a constraint that prohibits bonus pay and requires shareholders to compensate the manager with shares in the bank. Absent mandatory inside debt, risk taking decreases because providing risk-taking incentives through equity is more expensive for shareholders than a bonus pay. However, additionally mandating inside debt counteracts this risk reduction. Being senior to equity, mandatory inside debt reduces the manager's equity pay. In less profitable states, higher inside debt causes the manager's equity pay to approach zero, making it more similar to a bonus. Consequently, combining

equity pay with mandatory inside debt results in higher risk taking than equity pay alone.

The model has several policy implications. First, inside debt *per se* does not reduce risk taking in banks. Thus, requiring a part of the manager's compensation to be unsecured debt cannot be understood as a substitute for limiting bonus payments.[6] However, a combination of inside debt and a fixed bonus cap reduces risk taking more effectively than a bonus cap alone. Therefore, inside debt could be a valuable complement to fixed bonus caps, addressing regulators' concerns that too strict bonus caps might hinder banks' ability to attract and retain talented managers.[7] Second, limiting risk taking with a relative bonus cap is challenging and might even backfire. Consistent with the implications of my model, Collonelo et al. (2023) show empirically that after the introduction of relative bonus caps for banks in the EU, base salaries increased and risk taking remained the same for a lot of banks and even increased for some. Kokkinis (2018) argues that the banks in the UK increased fixed compensation and maintained risk taking. The model might also explain evidence from Cerasi et al. (2020), who document on a sample of international banks post-FSB-reform that even though banks reduced variable pay, their non-performing loans increased. Similarly, Rozen (2024) argues that variable pay ratio has decreased in Israeli banks after the reform, but risk taking remained unchanged. Furthermore, Deng et al. (2021) analyse the impact of bank regulation in China, which includes both the relative bonus cap and mandatory inside debt, and argue that higher levels of inside debt are correlated with more risk taking in banks. Third, if bank managers are compensated with shares, mandating inside debt even increases risk taking. Therefore, designing regulation "with a view to encouraging the use of equity or debt instruments"

[6]For example, the regulator in the UK has argued that the recent removal of the bonus cap is expected to result in a larger amount of "at-risk" compensation, such as deferred compensation (which can be categorized under inside debt) and that these instruments should limit excessive risk taking in banks (PRA and FCA, 2023).

[7]See, for example, Hubbard and Palia (1995), The Economist (2009), Thanassoulis (2012), Bannier et al. (2013), Edmans (2016). More recently, this seemed to be one of the main arguments of the UK regulators to cancel the bonus cap (Guardian, 2023).

(Directive 2013/36/EU, Article 65), might result in higher risk taking than requiring that the compensation only consists of equity instruments.

The paper is related to the theoretical literature that discusses the implications of unsecured debt in compensation contracts on the manager's choice of risk, as well as its role in banking regulation. John and John (1993) characterize a welfare-maximizing compensation contract that features equity pay and a fixed payment that loses some value in default (and can be interpreted as inside debt), aligning managers' incentives with those of shareholders and debtholders. The authors show how imposing this contract on the manager limits shareholders' risk-taking incentives. I show that when bank shareholders are allowed to respond to regulations attempting to enforce such a structure on managerial contracts, they adjust the contract to fully realign managers' incentives with their own. Edmans and Liu (2011) characterize the compensation contract that implements the welfare-maximizing project under consideration of inside debt characteristics regarding seniority. I analyse the problem of optimal compensation with inside debt in the banking context, in which seniority of insured deposits has implications on the effect of inside debt and the risk taking of managers.

John et al. (2000) extend the result from John and John (1993) to banking regulation and show that linking deposit insurance pricing to manager's compensation optimizes bank risk choices. In contrast, I analyze whether setting constraints on the structure of the manager's compensation contract, in the form of mandatory inside debt and bonus caps, could limit risk taking when the risk is not fairly priced in deposit insurance. Mandatory inside debt and bonus cap regulation are consistent with the conclusion from John and John (1993), John et al. (2000) and Edmans and Liu (2011) that a higher ratio of incentive pay to debt in managerial compensation leads to higher risk taking and, consequently, limiting the ratio should reduce risk taking. Empirical literature (Sundaram and Yermack, 2007; Cassell et al., 2012; van Bekkum, 2016) indeed provides evidence that a higher ratio

of inside debt over equity compensation leads to lower risk taking. Wei and Yermack (2011) further show that this dynamic is reflected in higher (lower) valuation of debt (equity). It is crucial to recognize that these studies analyse the effect of the ratio of inside debt *relative to equity*, not higher levels of inside debt in isolation. This distinction is particularly important for regulatory design. As I demonstrate, absent other constraints on compensation contracts shareholders with risk taking incentives optimally offset the risk reducing effects of inside debt by increasing the manager's incentive pay, irrespective of the absolute level of inside debt.[8] In addition, I show that setting constraints that effectively attempt to limit the manager's bonus-to-inside debt ratio in banks can work in some cases, but I also highlight problems in implementation of such a regulation and show cases when it can create adverse effects. In this context, Chaigneau (2013) also examines how constraints on compensation influence managerial risk taking (and effort). Unlike the approach discussed here, the author assumes that the regulator can require shareholders to link managerial pay to the total value of the bank instead of equity.

The paper also contributes to the discussion of the limits of bank regulation through deposit insurance. First, as John et al. (2000) highlight, incomplete information about the banks' risk technology might prevent the regulator from uniquely mapping the compensation contract to the bank's risk level.[9] The regulator who wishes to link deposit price to risk taking through compensation would face a similar problem in my model, having to know not only the risk technology but also the manager's private cost of risk taking. While it might be possible for the regulator to obtain this information, it makes regulating bank risk through deposit insurance pricing challenging in practice. Second, the presence

[8]This result differs from the discussion of relevance of managerial compensation structure in Dybvig and Zender (1991). The authors show that if compensation structure of managers is not limited in a sense that it can include information across periods, it can be constructed in such way that Modigliani–Miller irrelevance results are maintained even in the presence of asymmetric information.

[9]In general, imperfect information about the managerial actions is what makes it difficult to determine the price of deposit insurance that completely eliminates risk taking, as argued by John et al. (1991) and Flannery (1991).

of uninsured deposits limits the ability of the regulator to affect bank risk through the pricing of debt. If uninsured depositors could fairly price debt claims, linking manager compensation to these claims could as well reduce risk taking (see Bolton et al., 2015). However, implicit government guarantees (Ohlrogge, 2023) and incomplete information about managerial compensation can inhibit uninsured depositors' monitoring incentives. Under these conditions, regulators might need to introduce additional measures to limit banks' risk taking. I highlight in the paper that it is then crucial for regulators to understand the individual and combined effects of these measures. For example, the differing seniority of uninsured deposits relative to managers' compensation instruments can render regulations like mandatory inside debt and relative bonus caps counterproductive.

More broadly, my paper is related to the theoretical literature that focuses on various aspects of inside debt. Hoffmann et al. (2022) analyse the effect of the regulation that mandates deferring bonuses. While the authors focus on the optimal timing of the manager's pay, I analyse its optimal structure. Kolm et al. (2017) discuss the limits of regulating managerial compensation to reduce risk taking with an active board.

Several papers point out that bonus caps are important because they can limit excessive risk taking, but that they can also destroy value if they are too strict (Thanassoulis, 2012; Hakenes and Schnabel, 2014). I contribute to this literature by showing that the combination of a fixed bonus cap with inside debt can result in larger decreases in risk taking than a fixed bonus cap alone. This result is particularly relevant for the regulator who wishes to avoid having very strict bonus caps which might destroy social value.

# 2 Model

The model includes two players: shareholders who own the bank, and a manager who runs it. The manager chooses bank's risk taking, while shareholders design the manager's

compensation contract.[10] The compensation contract is subject to exogenously given set of compensation rules. All players are risk neutral and the risk-free rate is normalized to zero.

**Bank project and risk taking.** The bank holds a project, e.g., a loan portfolio or an investment portfolio. The project yields a long-term risky payoff at date 2 with three possible realizations. A high payoff $R_H$ is generated with probability $p_H \geq 0$, a medium payoff $R_M$ with probability $p_M \geq 0$ and a low payoff $R_L$ with probability $p_L = 1 - p_H - p_M \geq 0$, where $R_H > R_M > R_L$.

At date 1, the manager can increase the risk of the project. I follow the literature[11] and model the increase in risk as a second-order stochastically dominated shift in project payoffs, such that an increase in the probability of the high-payoff state by $\Delta p$

i. decreases the probability of the medium-payoff state by $\Delta p(1 + l)$ and

ii. increases the probability of the low-payoff state by $\Delta pl$.

The choice of $\Delta p$ represents the risk taking. The variable $l$ determines whether and by how much the adjustment in risk changes the expected value of the project. Crucially, one unit increase in the probability of the high-payoff state is only possible if the probability of the low-payoff state simultaneously increases by $l$ units. I assume $l \in \left[\frac{R_H - R_M}{R_M - R_L}, \frac{R_H - R_L}{R_M - \delta}\right]$. A classic risk-shifting problem is captured with $l = \frac{R_H - R_M}{R_M - R_L}$, when the manager maximizes the value of equity by changing the risk of the project but not its expected value (mean-preserving spread). For higher values of $l$, the manager can only increase the risk while simultaneously decreasing the expected value of assets, making risk taking less attractive for shareholders. The upper bound on $l$ ensures that risk taking creates a non-negative benefit for shareholders. I illustrate this model of risk in Figure 1.

[10] The actions of shareholders can be understood as an action of a representative shareholder or the board of directors. There are no frictions and no differences among individual shareholders.

[11] For example, Tirole (2010), Hakenes and Schnabel (2014) and Bolton et al. (2015).

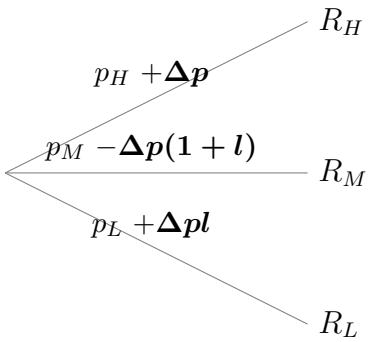



Figure 1: Distribution of payoffs with risk taking

Manager's risk taking is unobservable, and can be interpreted as the choice of risky loans or securities with unobservable risk in the portfolio.[12] Furthermore, the manager incurs a cost for increasing the risk of the project and this cost increases with the level of risk.[13] The manager has limited liability and her outside option is zero, so the manager stays in the bank as long as she receives a non-negative payoff that covers the cost of risk taking. For simplicity, I assume that the manager's cost of risk taking takes the quadratic form $c(\Delta p) = \frac{\Delta p^2 \epsilon}{2}$. I assume that $\epsilon$ is sufficiently low, such that the marginal benefit of risk taking is at least as high as the marginal cost of risk taking for $\Delta p = 0$. This assumption ensures that the shareholders are able to compensate the manager for risk taking and thus have an incentive to choose a positive level of risk taking.

Furthermore, since the probabilities of each state have to remain non-negative after the risk increase, $\Delta p$ is bounded such that $\Delta p \in \left[0, \frac{p_M}{1+l}\right]$, which also implies that $p_H + \Delta p < 1$ and $p_L + \Delta pl < 1$. Therefore, I also assume that $\epsilon$ is sufficiently high such that the bounds

[12] For example, a bank can manipulate soft information and misclassify loans (Berg et al., 2020), reduce high-quality monitoring (Acharya et al., 2006), include fewer and less strict covenants to loan contracts (Gao et al., 2020), postpone loan repayment dates for the non-performing loans (Bruche and Llobet, 2014; Acharya et al., 2022) or trade risky securities for which the regulator cannot observe the risk or has weak incentives or skills to intervene in time (Duchin and Sosyura, 2014; Acharya and Steffen, 2015; Altavilla et al., 2017).

[13] The cost could stem from the manager's effort to increase the risk such that the regulator does not notice the change, or from the penalization that the manager would face for imprudent risk management. Alternatively, it could be interpreted as a risk premium that a risk-averse manager would require to increase risk.

on $\Delta p$ are never binding, to focus on the optimal levels of risk taking driven by the choice of managerial compensation. Otherwise, if risk taking was (nearly) costless, it would be optimal to always choose the highest level of risk taking.

**Bank capital structure and regulation.** The bank project is financed with a mixture of equity and insured deposits.[14] Insured deposits create a payment obligation $\delta$ for shareholders, where $R_M > \delta > R_L$. Hence, if a low payoff is realized, the bank defaults. In case of default, the deposit insurance fund bails out the depositors by providing the amount $\delta - R_L$, and shareholders receive zero profit. I assume deposits are insured at a fee normalized to zero. The outstanding debt gives rise to the risk-taking incentives of bank shareholders, whose goal is to maximize the expected value of equity, i.e., the expected payoff to shareholders at date 2 (see also Laeven and Levine, 2009; Laeven, 2011).

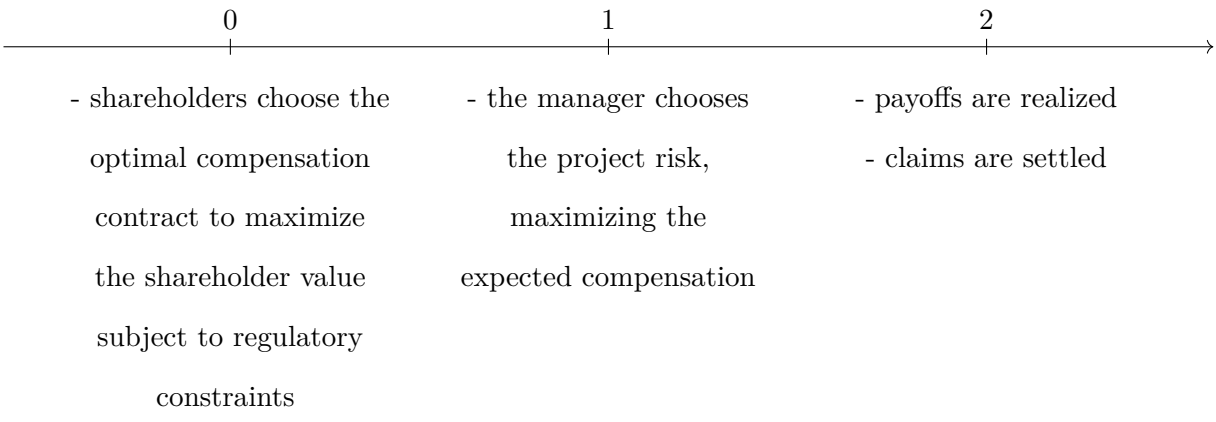
The regulator is concerned about risk taking and implements mandatory inside debt regulation to constraint it.[15] The regulator can also introduce bonus caps.

**The manager's compensation contract.** Shareholders award the manager pay that is based on the observable future payoff realizations at date 2: a wage $w_H$ in the high-payoff state, a wage $w_M$ in the medium-payoff state, and a wage $w_L$ in the low-payoff state. I assume that wages are junior to insured deposits. Consequently, $w_L = 0$ since the entire project payoff is used to pay $\delta$. Furthermore, in states $i \in \{M, H\}$ it has to hold that $w_i \leq R_i - \delta$.

**Timeline.** At date 0, shareholders design the manager's compensation contract based on regulatory constraints in place. At date 1, the manager chooses the level of risk. At date 2 payoffs are realized.

[14] The implications of uninsured debt are discussed in Section 4.

[15] For example, banks' risk taking can lead to costly public funding requirements if deposit insurance must cover unpaid deposits in case of default (see Acharya and Yorulmazer, 2007; 2008). Risk taking can create further costs for the regulator if it decreases welfare.




# 3 Analysis

## 3.1 Manager's utility and shareholders' payoff

Given the constraints on $w_i$ and the assumption $R_M > \delta > R_L$, I define the expected utility of the manager and shareholders' expected value of equity. The manager's expected utility, $\pi_M$, consists of the expected wage and the cost of risk taking that the manager bears, and equals

$$\pi_M = \underbrace{(p_H + \Delta p)w_H + (p_M - \Delta p(1+l))w_M}_{\text{expected wage}} - \underbrace{\frac{\Delta p^2 \epsilon}{2}}_{\text{cost of risk taking}}, \tag{1}$$

whereby the case when $\Delta p = 0$ corresponds to no risk taking.

Shareholders get the cash flow that remains after depositor claims have been settled and the manager's compensation paid, resulting in the expected value of equity $\pi_S$:

$$\pi_S = V + \Delta p B - \underbrace{(p_H + \Delta p)w_H - (p_M - \Delta p(1+l))w_M}_{\text{expected wage}}, \tag{2}$$

where $V \equiv p_H(R_H - \delta) + p_M(R_M - \delta) > 0$, and $B \equiv R_H - R_M - l(R_M - \delta) > 0$.

$V$ is the expected value of equity without risk taking. $B$ is the shareholders' marginal benefit of risk taking, which comprises two effects. Increasing the probability of high state by $\Delta p$ results in a higher payoff compared to the medium state ($R_H - R_M$), increasing the expected benefit. At the same time, the probability of the medium state decreases by more than $\Delta p$, reducing the expected marginal benefit by $l(R_M - \delta)$. For a mean-preserving spread, $B$ equals the expected loss of the deposit insurance fund (see appendix). For larger values of $l$ the benefit decreases, but remains non-negative given the upper bound on $l$. Finally, the remaining two terms in $\pi_S$ arise from the obligation to pay the manager and constitute the expected wage cost.

## 3.2 Inside debt

When inside debt $f$ is mandatory, shareholders are obliged to pay the manager at least the amount $f \geq 0$. Inside debt is classified as uninsured debt, which is junior to insured deposits. In the default state, insured deposits get settled first, and inside debt claims can be paid only with residual payoff. Otherwise, inside debt claims pay out the promised amount $f$ in full. I assume that $R_M - \delta \geq f$, so that inside debt does not create default in state $i = M$.[16] I model mandatory inside debt as a constraint on the minimum wage, such that $w_i \geq f$ for $i \in \{M, H\}$.

Shareholders maximize the value of equity with a choice of risk taking, $\Delta p$, and choose manager's wages which implement that level of risk. For $i \in \{H, M\}$, shareholders'

[16] I show in an extension that the model implications are the same if $R_M - \delta < f < R_H - \delta$.

optimization problem is:

$$\max_{w_i, \Delta p} \pi_S \tag{3}$$

subject to

$$\pi_M \geq 0 \tag{PC}$$

$$w_i \geq f \tag{R}$$

$$w_i \leq R_i - \delta \tag{J}$$

$$\Delta p \in \arg\max \pi_M \tag{IC}$$

Condition *PC* is the participation constraint of the manager. Condition *R* ensures that all wages satisfy the regulatory constraint. Condition *J* is the upper limit on the manager's junior wage, so that it cannot be higher than the cash flow that remains after settling the debt claims. Condition *IC* is the incentive constraint of the manager. Solving the optimization problem leads to the following proposition.

**Proposition 1.** *Assume that the regulator requires that the manager is awarded an amount $f$ of inside debt. The optimal level of risk taking equals $\Delta p^* = \frac{B}{2\epsilon} - \frac{p_H}{2}$ and is independent of inside debt. The manager gets a state-contingent wage package $\{w_H^*, w_M^*\} = \{\frac{B}{2} - \frac{p_H \epsilon}{2} + (1+l)f, f\}$ and the expected value of equity is $\pi_S^* = V + \Delta p^{*2}\epsilon - (p_H(1+l) + p_M)f$.*

Proposition 1 states that risk taking $\Delta p^*$ does not depend on $f$. The reason lies in the twofold effect of inside debt on the value of equity. Consider first the manager's incentive constraint,

$$w_H - (1+l)w_M = \Delta p \epsilon. \tag{4}$$

The manager chooses the level of risk taking for which the marginal benefit of risk taking (left-hand side) equals the marginal cost of risk taking (right-hand side). The manager's benefit from risk taking increases in the wage $w_H$. In contrast, risk-taking incentives

of the manager decrease in the wage $w_M$. Furthermore, the wage $w_M$ also has a direct negative effect on the expected value of equity. Therefore, shareholders optimally choose the lowest possible wage $w_M$. Given regulatory constraints, $w_M = f$. Substituting the incentive constraint in the shareholders' objective function yields

$$\pi_S = V + \Delta pB - (p_H + \Delta p)(\Delta p\epsilon + (1+l)f) - (p_M - (1+l)\Delta p)f. \tag{5}$$

In order to maintain the same level of risk taking as without regulation, shareholders have to pay a higher wage $w_H$. An increase of $w_H$ increases shareholders' expected wage cost (captured in the third term of Condition (5)). At the same time, a higher risk taking $\Delta p$ reduces the expected wage cost, because it reduces the expected inside debt payment. As the risk increases, the probability of the state $i = M$ decreases by more than $\Delta p$ (as reflected in the last term of Condition (5)), making it less likely that shareholders will need to pay inside debt. Thus, $f$ makes risk taking more expensive through a higher $w_H$, but also more beneficial as risk taking reduces the expected inside debt payment. The two effects completely offset each other, and consequently, $f$ does not affect optimal risk taking. Therefore, a regulatory constraint that only asks for mandatory inside debt in compensation contracts of bank managers does not decrease the risk taking.

The optimal risk taking $\Delta p^* = \frac{B}{2\epsilon} - \frac{p_H}{2}$ is determined by two components. First, $\Delta p^*$ depends on the benefit of risk taking, $B$, relative to the cost parameter of risk taking, $\epsilon$. As the benefit of risk taking increases, shareholders optimally choose higher risk levels. The manager's private cost of risk taking, $\epsilon$, is ultimately borne by shareholders and reduces optimal risk taking. Second, the probability of the high payoff absent risk taking, $p_H$, reduces optimal risk taking. High $p_H$ increases the expected wage cost, making risk taking less attractive for shareholders. Intuitively, shareholders are unwilling to pay the manager to influence outcomes in situations where success is almost guaranteed (e.g., very

good economic conditions, a high-quality project). This result is related to Chaigneau et al. (2024), who argue and show empirically that the skewness of the measure used to evaluate managerial performance is negatively correlated with convexity of the manager's compensation. The authors argue that lower skewness makes the performance measure less informative about managerial effort. While their results are derived in a standard moral hazard model with a choice of effort, I show that skewness plays an important role in the model with risk-taking incentives. Finally, the assumption that the marginal benefit of risk taking is higher than the marginal cost of risk taking for $\Delta p = 0$ is fulfilled for $B > p_H \epsilon$, making risk taking attractive for shareholders.

Without mandatory inside debt ($f = 0$), $w_M = 0$ and $w_H = \Delta p \epsilon$. Thus, shareholders optimally compensate the manager only in the state with the highest project payoff, which can be interpreted as a bonus.[17] With regulation ($f \in (0, R_M - \delta]$), shareholders optimally choose $w_M^* = f$. The wage $w_H = \Delta p \epsilon + (1+l)f$ can be viewed as a combination of inside debt $f$ and a bonus payment $\Delta p \epsilon + lf$. Thus, shareholders facing the mandatory inside debt regulation increase the optimal bonus. Therefore, an important determinant of risk taking is the ability of shareholders to optimally increase the bonus in response to mandatory inside debt. In the subsequent section, I analyse the joint effect of inside debt and bonus caps, which could hinder shareholders' ability to optimally adjust the manager's compensation contract.

## 3.3 Bonus caps

In order to study bonus caps, it is necessary to define instruments that can be included in the manager's wage. While this distinction is not necessary for specifying the optimal contract, it is important for the definition of bonus caps. I assume that the wages $w_i$ for $i \in \{H, M, L\}$ can consist of base salary, inside debt, and bonuses. Furthermore, I assume

[17] These compensation contracts can alternatively be interpreted as stock option rewards.

that the base salary $w$ is junior to insured deposits, so it still holds that $w_L = 0$. Finally, I define a bonus to be equal to $w_i - f - w$.[18]

The bonus cap can be fixed, in which case the bonus cannot exceed an absolute amount $\bar{w}$. Alternatively, the bonus cap can be defined in terms of the base salary $w$ (relative bonus cap), and equal $\beta w$, where $\beta \geq 1$ determines how much larger the bonus can be compared to the base salary.[19]

The base salary $w$ is similar to inside debt and increases the minimum wage constraint to $w_i \geq f + w$. However, unlike inside debt, it is chosen by shareholders. Increasing the base salary $w$ is equivalent to voluntarily increasing inside debt $f$. From Condition (5) it follows that shareholders would never voluntarily pay out $f$ because it does not affect risk taking, but it increases the expected wage cost. For the same reason, shareholders do not optimally pay a base salary unless they are indirectly required to do so by the relative bonus cap.

**Fixed bonus cap.** A fixed bonus cap introduces one more constraint to the optimization problem in (3). Since $w^* = 0$ in case of the fixed bonus cap, the regulation is captured by the following condition:

$$w_H - f \leq \bar{w}. \tag{6}$$

Absent inside debt ($f = 0$), it follows from the incentive constraint (4) that the optimal risk taking can at most be equal to $\Delta p = \frac{\bar{w}}{\epsilon}$, assuming that the cap is binding ($w_H^* > \bar{w}$). The only bonus cap that eliminates risk taking is $\bar{w} = 0$. That is, the regulator would have to completely forbid paying out bonuses to stop banks from increasing the risk.

[18] Another interpretation of the regulation could be that inside debt is also a type of variable compensation and thus a subject to the bonus cap. Then, the bonus equals $w_i - w$. The intuition of the results does not change under such specification of the bonus cap.

[19] For example, the EU regulation defines the bonus cap relative to the base salary, with $\beta = 2$.

For $f \in (0, R_M - \delta)$, the bonus $w_H - f$ must not exceed $\bar{w}$, and the optimal risk taking given the fixed bonus cap can at most equal $\Delta p = \frac{\bar{w} - lf}{\epsilon}$. Then, any combination of $\bar{w}$ and $f$ that satisfies the condition $\bar{w} = lf$ results in zero risk taking. Thus, risk taking can be zero even if the regulator does not eliminate bonus payments.

**Proposition 2.** *Inside debt can decrease risk taking if it is combined with a fixed bonus cap, $\bar{w}$. The regulator can choose any combination of $\bar{w}$ and $f$ that satisfies the condition $\bar{w} = lf$ to eliminate bank risk taking.*

**Relative bonus cap.** With a relative bonus cap, in addition to the optimization problem in (3) it has to hold

$$w_H - f - w \leq \beta w \tag{7}$$

Therefore, if shareholders wish to pay a bonus, they have to pay a base salary $w$ as well. Paying $w_M$ beyond the minimum wage constraint is not optimal, thus $w_M = w + f$. Then, substituting the incentive constraint (4) in the relative bonus cap (7) yields

$$w \geq \frac{\Delta p \epsilon + lf}{\beta - l}. \tag{8}$$

Since paying a base salary above regulatory required minimum increases $w_M$ and is thus costly for shareholders, Condition (8) is binding. Substituting these conditions in (2) leads to the following proposition.

**Proposition 3.** *Assume that a bonus can at most be a $\beta$ multiple of base salary $w$. Then*

*i. For $\beta > \hat{\beta} = l + \frac{p_H(1+l)+p_M}{2\Delta p^*}$: shareholders incentivize the manager to choose risk taking $\Delta p^*_\beta = \Delta p^* - \frac{p_H(1+l)+p_M}{2(\beta - l)} > 0$ by setting the optimal compensation contract to $\left\{w^*_{H,\beta}, w^*_{M,\beta}\right\} = \{(\beta+1)w^* + f, w^* + f\}$, where $w^* = \frac{\Delta p^*_\beta \epsilon + lf}{\beta - l}$. The resulting value*

*of equity is* $\pi_{S,\beta} = V + \Delta p_\beta^{*2} - (p_H(1+l) + p_M)\left(f + \frac{lf}{\beta - l}\right)$. *Optimal base salary* $w^*$ *is increasing in* $f$ *and decreasing in bonus cap multiple* $\beta$.

*ii. Otherwise, optimal risk taking is* $\Delta p_\beta^* = 0$, $w_{H,\beta}^* = w_{M,\beta}^* = f$ *and* $w^* = 0$.

*The threshold* $\hat{\beta}$ *is increasing in* $p_H$ *and* $l$.

The proposition implies that the relative bonus cap always results in a decrease in risk taking. However, while a very tight bonus cap (low $\beta$) is equivalent to setting an absolute bonus cap $\bar{w}$ to zero and fully disincentivizes banks from taking risks, a laxer bonus cap (high $\beta$) does not completely eliminate risk taking. Such a partial reduction of risk taking is more likely to happen in banks that have an incentive to choose particularly high risk taking absent regulation (i.e., when banks choose a high $\Delta p^*$). More explicitly, a relative bonus cap fails to fully eliminate risk taking if, *ceteris paribus*, the manager's cost of risk taking ($\epsilon$) is low, the marginal benefit of risk taking for shareholders ($B$) is high, or when risk taking decreases the mean (low $l$). This result suggests that a relative bonus cap would be particularly unsuccessful in limiting risk taking exactly in cases that are the most concerning for the regulator.

Furthermore, the reduction in risk is unrelated to the level of inside debt $f$. While relative bonus cap makes it more expensive for shareholders to increase a bonus, it does not explicitly prevent them from doing so. The positive effect of inside debt (lower expected inside debt payment) and the negative effect (higher bonus) still cancel out in shareholders' expected payoff function. Therefore, if risk taking is "cost effective" for shareholders, they will maintain the same risk level despite inside debt. Thus, inside debt cannot be made effective under the relative bonus cap, nor can it complement the cap.

Perhaps counter-intuitively, while risk is decreasing with a laxer relative bonus cap, the optimal bonus could increase. The wage $w_H$ can be interpreted as a payment that includes inside debt $f$, base salary $w = \frac{\Delta p_\beta^* \epsilon + lf}{\beta - l}$ and a bonus $\beta \frac{\Delta p_\beta^* \epsilon + lf}{\beta - l} = \beta w$. Absent relative bonus

cap, the bonus equals $\Delta p^* \epsilon + lf$ (Proposition 1). While $\Delta p^* > \Delta p^*_\beta$, $\beta > \beta - l$, making the relation between the optimal bonuses in these two cases not straightforward even when $f = 0$.

This result stems from the interaction between the bonus cap multiple, $\beta$, and the base salary, $w$. As the bonus cap tightens (lower $\beta$), the base salary ($w$) increases. This outcome is intuitive: the tighter the cap, the more banks must increase the base salary to meet the bonus cap requirements. With an increase in the wage $w_M$ by $w$, shareholders also increase the bonus that the manager receives in the state $H$ to restore the manager's risk-taking incentives. At the same time, a lower $\beta$ reduces the optimal risk taking thus reducing the optimal bonus. If the increase in bonus stemming from mandatory base salary is larger than the reduction in the wage as a consequence of a lower choice of risk, then the optimal bonus increases. This scenario arises when, despite risk taking becoming very costly, shareholders still opt for a positive level of risk if the marginal benefits of risk outweigh the costs. Such a situation is likely to occur under a regulatory framework that is neither too strict nor too lax. If regulation is sufficiently strict, increasing bonuses becomes expensive, which may lead to a higher bonus under a relative bonus cap. However, overly strict regulation could deter shareholders from pursuing increased risk altogether.

This effect becomes even more pronounced when $f > 0$. With the relative bonus cap, the optimal bonus increases by $\frac{\beta}{\beta - l} lf > lf$, whereas it increases only by $lf$ without the cap. Mandatory inside debt makes risk taking more costly, which in turn results in a higher optimal base salary, $w$. The bonus-increasing impact of $w$ is thus more likely to overweigh the bonus-decreasing effect of $\beta$. Therefore, while inside debt does not affect risk taking with a relative bonus cap, it can lead to escalating bonus payments for banks that find it profitable to sustain high risk levels.

**Regulatory and empirical implications.** To evaluate the overall effectiveness of the regulation, it is important to recognize that the regulation may influence outcomes in multiple directions, all of which should be considered in empirical research and regulatory decisions.

A relative bonus cap which links bonuses to base salary can either result in a significant or a moderate reduction in risk. A moderate reduction in risk is more likely to occur in banks in which the marginal benefit of risk taking for shareholders ($B$) is high. Since $B$ increases in $\delta$, this scenario is more likely to occur in banks with higher leverage. Furthermore, the threshold $\hat{\beta}$ increases with $p_H$. A lower $p_H$ can reflect a weaker economy or a low-quality project, making risk taking more attractive for shareholders, as success under these conditions is more informative about managerial skill than a generally favorable environment. Due to stronger risk-taking incentives, a lower $p_H$ makes it more likely that the bank will maintain the same level of risk despite the relative bonus cap. Furthermore, banks would only moderately reduce risk if the manager has a low cost of increasing it. This scenario could be consistent with the manager being under a weak regulatory supervision, or the manager being very skilled in increasing the risk without being detected by the regulator. These factors generally align with a profile of a risky bank operating in a weak economy and/or under weak regulatory oversight.

For these banks, the risk would not reduce significantly, the base salary would increase, whereas the bonus could either increase or decrease. The bonus is more likely to increase for a bonus cap that is moderately tight. This result could be an explanation for empirical literature that finds no effect on risk taking post reforms regarding compensation policies but reports different effects on variable compensation, such as Kokkinis (2018), Cerasi et al. (2020), Deng et al. (2021), Colonnello et al. (2023), and Rozen (2024). Furthermore, Kokkinis (2018), Colonnello et al. (2023), and Rozen (2024) show that banks affected by the regulation saw a sharp increase in fixed compensation, typically base salary. This

is in line with the main mechanism of the model, which shows that banks that wish to maintain risk taking increase base salary to comply with the regulation.

In contrast, a bank with opposite characteristics, which could be interpreted as a less risky bank in a better economy and under stronger regulation, would fully eliminate the risk. Furthermore, low risk taking might occur as a consequence of a less skilled manager with a high cost of increasing the risk. Absent risk-taking incentives, shareholders would not find it beneficial to pay the manager any variable compensation, or to pay base salary. This result has two implications. As the compensation of the manager of a less risky bank decreases, the manager might be more likely to leave the bank for a higher outside option, resulting in higher voluntary executive turnover. Kleymenova and Tuna (2021) document that UK banks decreased their risk following compensation reforms, but executive turnover increased. Alternatively, managers in banks that reduce risk taking but face pay reduction might start to exploit company resources. Bae et al. (2024) suggest that this occurred in Chinese companies affected by the regulations similar to the bankers' bonus cap.[20] In contrast, Colonnello et al. (2023) and Rozen (2024) found no significant executive turnover in their bank samples in which banks maintained or even increased the risk.

Examples of countries that have introduced a fixed bonus cap are rare. In countries that have introduced both fixed and relative bonus caps, banks seem to have chosen to comply with the latter. This finding is in line with the model, which implies that the relative bonus cap allows banks to maintain relatively high risk levels, unlike the fixed bonus cap. While it is straightforward that a fixed bonus cap would reduce risk taking, one concern with implementing such regulation is that it could severely restrict bank compensation, potentially making it harder for banks to attract talented managers. The model predicts that some of these concerns could be alleviated by combining the fixed

[20] Authors note that centrally administered state-owned enterprises in China are allowed to pay a bonus up to 30 times larger than the firm's average salary.

bonus cap with inside debt. Some legislations tax manager's bonuses that exceed a certain fixed amount. Even though the law does not explicitly prohibit paying high bonuses, one might assume that tax disadvantages would discourage banks from doing so. However, empirically this does not appear to be the case.[21]

Another possibility for structuring the regulation would be to link the relative bonus cap to inside debt instead of the base salary. Mandating a fixed amount of inside debt would directly determine the level of risk taking. However, this would give the regulator complete control over managerial compensation in banks, which is unlikely to be a viable solution. In contrast, if the regulator could link the bonus to inside debt and allow banks to determine the level of inside debt themselves, such a bonus cap would be equivalent to setting $f = 0$ and interpreting $w$ as inside debt. While banks would have no incentive to pay $f$ if they forfeit the opportunity to increase the risk, they would be willing to pay $f > 0$ to maintain moderately high risk taking.

In this setup, there is no difference between linking the cap to base salary or inside debt. However, as I show in the subsequent chapter, allowing for uninsured deposits changes the seniority order of claims in default. This change introduces a difference between base salary and inside debt, and shows that in this case, a relative bonus cap might even lead to a higher risk taking.

# 4 Uninsured debt and seniority

In the baseline model, I assumed that debt $\delta$ consists entirely of insured deposits. In this section, I relax that assumption to account for the fact that bank deposits typically also include uninsured deposits.

[21] For example, in the US in the 1990s bonuses of top three executives exceeding 1 million dollars were taxed differently than the lower amounts. However, there was no significant change in compensation practices, which led to an extension of the rule to top five bank executives.

The two deposit categories can differ in two aspects - sensitivity of the cost of debt to changes in the risk and seniority compared to different instruments in the manager's compensation contract. To focus on the impact of inside debt and bonus caps under different seniority regimes, I assume that uninsured deposits are risk-insensitive. For example, the regulator might be willing to bail out these depositors to maintain stability in the financial sector, despite a lack of legal obligation to do so.[22] Furthermore, outside debtholders might rely on regulatory monitoring instead of conducting their own analysis of the bank risk.[23] Alternatively, the uninsured debt could consist of long-term debt claims. Consequently, shareholders have an incentive to maximize the risk and the regulator would like to minimize it to avoid bailing out any depositors.

Including uninsured deposits in the model leads to two implications. First, uninsured deposits and inside debt can be of the same seniority, as they are both unsecured debt claims.[24] Second, the base salary is senior to uninsured deposits.[25] In both cases, the manager's pay in default takes precedence over uninsured deposits, increasing the manager's compensation.

I adjust the setup of the baseline model as follows. A share $\upsilon$ of $\delta$ are uninsured deposits and the rest are insured. I focus on the case where $R_L$ suffices to pay the insured but not all uninsured debt claims in default. Absent base salary, insured depositors get paid first and the remaining profits, $R_L^u = R_L - (1-\upsilon)\delta$, get distributed across uninsured debtholders, including inside debt holders.

The manager gets a proportional share $\gamma = \frac{f}{f+\upsilon\delta}$ of the available cash flow $R_L^u$, which increases with $f$.[26] The manager's pay in default then equals $w_L = R_L^u\gamma < f$, which

[22] Most recently, the US regulator bailed out uninsured depositors of the Silicon Valley Bank in 2023. For further evidence see, for example, Ohlrogge, 2023.

[23] John et al. (2010) show that while managerial compensation is less performance-sensitive with higher share of subordinated uninsured deposits, the performance-sensitivity increases in regulatory monitoring.

[24] See, for example, Anantharaman et al. (2014). The authors argue that the type of inside debt also impacts seniority. For example, some deferred compensation plans may even be senior to outside debt.

[25] This assumption aligns with most bankruptcy laws worldwide, aiming to protect employees' rights.

[26] Inside debt could also have a higher seniority over some uninsured debt claims, leading to an even

increases the manager's expected utility from Condition (1) to

$$\pi_{M,sen} = \pi_M + (p_L + \Delta pl)w_L. \tag{9}$$

The shareholders' expected payoff remains the same as in (2), as well as the optimization problem in (3).

In absence of bonus caps, solving the problem leads to the following proposition.

**Proposition 4.** *Assume that the difference to Proposition 1 is that the share of bank deposits is not insured, and capital available to uninsured debtholders in default is $R_L^u$. The manager gets a $\gamma$ share of $R_L^u$, proportional to the size of inside debt. Compared to the case without uninsured deposits (Proposition 1):*

*i. The optimal compensation contract includes payment in default and features a lower bonus: $\{w^*_{H,sen}, w^*_{M,sen}, w^*_{L,sen}\} = \left\{\frac{B-l\gamma R_L^u}{2} - \frac{p_H\epsilon}{2} + (1+l)f, f, \gamma R_L^u\right\}$.*

*ii. The optimal risk taking increases to $\Delta p^*_{sen} = \frac{B+l\gamma R_L^u}{2\epsilon} - \frac{p_H}{2}$.*

*The value of equity is $\pi^*_{S,sen} = V + \Delta p^{*2}_{sen}\epsilon - (p_H(1+l) + p_M)f + p_H l\gamma R_L^u$.*

The same seniority of inside debt and uninsured deposits results in a positive default pay, $w_L$, and impacts risk-taking incentives of the manager. The incentive constraint equals

$$w_H - (1+l)w_M + lw_L = \Delta p\epsilon \tag{10}$$

*Ceteris paribus*, a positive wage in state $L$, $w_L = \gamma R_L^u$, enhances the manager's incentive to take on more risk. The wage in default is paid at the cost of other debtholders, as it dilutes uninsured external debt claims. As a result, shareholders can attain the same level of risk taking as in the case without uninsured debt while paying the manager a lower

higher $\gamma$.

compensation. The optimal wage in state $H$ decreases by $w_H^* - w_{H,sen}^* = \frac{l\gamma R_L^u}{2}$, which is equivalent to $\frac{lw_L}{2}$.

Intuitively, due to its seniority, inside debt becomes less effective at reducing the convexity of the manager's compensation. In fact, it lowers the cost of risk taking for shareholders, since the manager's partially retrieved inside debt is paid out at the expense of uninsured depositors. Optimal risk taking increases by $\Delta p_{sen}^* - \Delta p^* = \frac{l\gamma R_L^u}{2\epsilon}$, or equivalently by $\frac{lw_L}{2\epsilon}$. Furthermore, as $f$ increases, the share of the capital available in default that the manager receives also increases ($\gamma$ increases with $f$). Consequently, risk taking becomes cheaper for shareholders as $f$ increases, leading to higher optimal risk taking.

The higher seniority of inside debt also affects the fixed bonus cap, defined in (6). Similar to the case with insured deposits, shareholders do not pay out a base salary unless required by regulation, since it does not impact risk taking (it is paid out in all states) while increasing the expected wage cost. Therefore, $w^* = 0$, and the bonus in state $H$ equals $w_H - f = \Delta p\epsilon + l(f - \gamma R_L^u)$. Under a fixed bonus cap, the bonus cannot exceed $\bar{w}$.

Analogous to the case with only insured debt, risk taking can be eliminated for any combination of fixed bonus and inside debt that satisfies $\bar{w} = l(f - \gamma R_L^u)$. Since the right-hand side is increasing in $f$,[27] there exists an $f$ for which risk taking can be eliminated with a non-zero bonus cap. Nevertheless, $f$ has to be much larger to eliminate risk taking under the same bonus cap as in the case with only insured debt.

**Proposition 5.** *If the manager receives a share of inside debt in default, combining it with a fixed bonus cap can eliminate risk taking. However, a higher level of inside debt is necessary to result in $\Delta p^* = 0$, given the same fixed bonus cap as in Proposition 2, since it has to hold that $\bar{w} = l(f - \gamma R_L^u)$.*

[27] It holds that $\frac{\partial(f-\gamma R_L^u)}{\partial f} = \gamma + \frac{\upsilon\delta(f+\upsilon\delta-R_L^u)}{(f+\upsilon\delta)^2} > 0$.

Finally, the effect of inside debt under a relative bonus cap changes compared to the baseline scenario as well. A relative bonus cap requires banks to pay a base salary $w$ to be able to pay a bonus. Since base salary is senior to insured deposits, it has to be paid out after insured deposits but before inside debt and uninsured depositors, increasing the write-off in default. Then, $w_L = w + (R_L^u - w)\gamma$. As in the case with only insured deposits, relative bonus cap condition (7) is binding and has to be fulfilled. Given the incentive constraint in (10), it has to hold

$$w = \frac{\Delta p \epsilon + l(f - \gamma R_L^u)}{\beta - l\gamma}. \tag{11}$$

Solving the problem under the relative bonus cap constraint leads to the following proposition.

**Proposition 6.** *Assume that the difference to the Proposition 3 is that deposits are only partially insured. The manager receives a base salary in default, as well as a $\gamma$ share of capital available to uninsured depositors. Then:*

*i. For $\beta > l\gamma + \frac{p_H(1+\gamma l)+p_M}{2\Delta p^*_{sen}} - \frac{l^2(1-\gamma)(f-\gamma R_L^u)}{2\epsilon\Delta p^*_{sen}}$:*

*i.a. the manager chooses the optimal risk taking $\Delta p^*_{sen,\beta} = \Delta p^*_{sen}\frac{\beta - l\gamma}{\beta - l} - \frac{p_H(1+l\gamma)+p_M}{2(\beta-l)} + \frac{l^2(1-\gamma)(f-\gamma R_L^u)}{\beta - l\gamma} > 0$ and shareholders set the optimal base salary to $w^*_{sen} = \frac{\Delta p^*_{sen,\beta}\epsilon + l(f-\gamma R_L^u)}{\beta - l\gamma}$, which is increasing in $f$ and can either increase or decrease in $\beta$.*

*i.b. The optimal compensation contract is*

$$\left\{w^*_{H,sen,\beta}, w^*_{M,sen,\beta}, w^*_{L,sen,\beta}\right\} = \{(\beta+1)w^*_{sen} + f, w^*_{sen} + f, w^*_{sen} + \gamma R_L^u\},$$

*resulting in the value of equity*

$$\pi_{S,sen,\beta} = V + \Delta p^{*2}_{sen,\beta}\epsilon - (p_H(1+l)+p_M)f + \frac{l(f-\gamma R_L^u)}{\beta - l\gamma}(p_H(1-\gamma l)+p_M) + p_H l\gamma R_L^u.$$

*i.c. Risk taking with the relative bonus cap increases in comparison to Proposition*

*(4) if* $2(1-\gamma)l\Delta p^* + \frac{(1-\gamma)l^2 f}{\epsilon} > 1 - p_L + p_H l\gamma$.

*ii. Otherwise, risk taking is eliminated and* $\Delta p^*_\beta = 0$ *and* $w^*_{H,sen,\beta} = w^*_{M,sen,\beta} = f$*, and* $w^*_{L,sen,\beta} = \gamma R^u_L$.

First, when deposits are partially insured, the relative bonus cap does not guarantee a risk decrease. Shareholders face a trade-off between bearing the higher cost of the base salary and the benefit of incentivizing risk taking through a higher bonus. However, with uninsured deposits the base salary can be paid out fully even in default. As a result, the cost of the base salary that shareholders must bear to be able to pay the bonus decreases. For $f = 0$, Condition *i.c.* from Proposition (6), indicates that risk taking increases under a relative bonus cap when $\Delta p^* > \frac{1-p_L}{2l}$. This result occurs when the unconstrained optimal risk taking is high enough, driven by a large benefit of risk taking ($B$) and a low cost of risk taking ($\epsilon$). Such a case would be within the possible range of $\Delta p$, since the upper limit on risk taking $\frac{p_M}{1+l}$ implies $\Delta p < \frac{1-p_L}{l}$. Thus, the relative bonus cap with uninsured deposits incentivizes higher risk taking when optimal risk taking absent bonus cap ($\Delta p^*$) is already relatively high. In contrast to the case with only insured deposits, the base salary is not always decreasing in $\beta$. Consequently, in some regions of $\beta$ the base salary decreases with a laxer bonus, ultimately leading to higher risk taking than without the cap.

The dynamics are even more complex for $f \in (0, R_M - \delta - w)$. As $f$ increases, Condition *i.c.* in Proposition (6) is more likely to hold and therefore it becomes more likely that risk is higher with than without the bonus cap. Nonetheless, it also becomes increasingly more likely that the relative bonus cap eliminates risk taking, as captured by Condition *i.* in Proposition (6).

Unlike the relative bonus cap in scenarios with only insured deposits, inside debt does have an impact on the relative bonus cap in this case. Yet, even though the relative bonus cap becomes more effective with higher levels of inside debt $f$, it is generally less likely

to eliminate risk taking than the relative bonus cap when the bank holds only insured deposits. Furthermore, in cases when it does not eliminate risk taking, it can lead to a risk increase.

Consequently, when bank deposits are partially insured, mandating inside debt might be effective when combined with a fixed bonus cap. In the absence of the cap inside debt could have an adverse effect on risk taking. Furthermore, a relative bonus cap with a base salary that is senior to uninsured deposits could result in higher risk taking than without the bonus cap, even if $f = 0$.

# 5 Extensions

## 5.1 Default in the medium-payoff state

Assume now that the regulator sets $f$ such that $R_H > \delta + f > R_M > \delta$. Since insured deposits are paid first, the regulator has no additional costs in this state. But the bank defaults on the inside debt payment, since only a maximum of $R_M - \delta < f$ can be paid to the manager. Solving the optimization problem leads to the following proposition.

**Proposition 7.** *Assume that shareholders are required by regulation to include an inside debt $f$ in the manager's compensation contract such that $R_H > \delta + f > R_M$. Optimal risk taking $\Delta p^*_{R_M-\delta}$ remains the same as in Proposition 1. Shareholders get a positive payoff $\pi^*_{S,R_M-\delta} = p_H B + \Delta p^{*2}_{R_M-\delta}\epsilon$*

Inside debt $f \in (R_M - \delta, R_H - \delta]$ that causes default in the medium-payoff state leads to the same risk taking as $f \in [0, R_M - \delta]$. Furthermore, any increase of inside debt beyond the level that triggers default in state $i = M$ does not change the optimal level of risk.

The manager's risk-taking incentives increase in $f > R_M - \delta$ since it holds that

$$w_H - (1 + l)(R_M - \delta) = \Delta p \epsilon. \tag{12}$$

The manager's expected loss in default ($l(R_M - \delta)$) does not increase with $f$, because the inside debt payment in state $i = M$ is limited to $R_M - \delta$. In contrast, a higher $f$ increases only the wage $w_H$.

Shareholders only have a positive payoff in the high-payoff state. Consider that the equality $R_H - \delta - w_H = B - \Delta p \epsilon$ holds, given the incentive constraint in (12). Increasing the probability of a high state increases shareholders' payoff compared to the medium state ($R_H - \delta - 0$). However, the manager's bonus depends on the expected loss in the value of inside debt $\Delta p(1 + l)(R_M - \delta)$. This cost is ultimately carried by shareholders who pay the bonus. It also exactly equals the amount that shareholders would forego in case $f < R_M - \delta$ to get a higher payoff $R_H$ and constitutes their benefit of risk taking $B$.

In conclusion, regardless of what $f$ the shareholders are required to pay the manager according to the regulation, they have the incentive to design a contract such that the risk does not decrease unless additionally constrained with a bonus cap. Consequently, the regulator cannot reduce risk taking to socially optimal $\Delta p = 0$ merely by introducing mandatory inside debt, regardless of how high this requirement is.

## 5.2 Compensation contract with equity pay

FSB guidelines on prudent compensation advocate for the use of equity in compensation contracts of managers. The specificity of this instrument is that it rewards the manager in all states when equity is positive. Thus, unlike bonuses, it prevents shareholders from maximizing the manager's risk-taking incentives by paying only in the extreme outcomes. In its form, it is similar to the relative bonus cap when debt is fully insured in that it

enables paying out a bonus in state $i = H$ only if there is a certain payment in the state $i = M$ as well. Consequently, risk taking is lower than with a bonus payment. However, unlike base salary, equity is junior to inside debt. The value of equity and thus manager's remuneration in states $i \in \{M, H\}$ are a function of inside debt. In this section, I investigate whether inside debt affects risk taking if managers are compensated with shares.

Given the distinct form of remuneration with shares, I do not model the mandatory inside debt as a minimum wage requirement. Instead, I assume that the manager gets inside debt $f$ and is awarded wages that equal $\alpha$ share of the residual payoff, such that $w_H = \alpha(R_H - \delta - f) + f$, $w_M = \alpha(R_M - \delta - f) + f$, with $\alpha \in [0, 1]$.

Similar to the Problem (3), shareholders maximize the value of equity, but now by choosing the optimal $\alpha$ share of equity to remunerate the manager.

**Proposition 8.** *Assume that the manager receives a share of bank equity $\alpha$ and inside debt $f$, payable in the non-default states. The optimal equity share of the manager is $\alpha^* = \frac{1}{2} - \frac{V-(p_H+p_M)f}{2(B+lf)^2}\epsilon$ and it induces risk taking $\Delta p^*_{\alpha,f} = \frac{B}{2\epsilon} - \frac{V-(p_H+p_M)f}{2(B+lf)}$. Shareholders get a positive payoff $\pi^*_{S,\alpha,f} = (V - (p_H + p_M)f)\frac{B}{B+lf} + \Delta p^{*2}_{\alpha,f}\epsilon$.*

*Risk taking, $\Delta p^*_{\alpha,f}$, is increasing in $f$.*

The result is driven by the effect that inside debt has on the manager's risk taking incentive,

$$\alpha B - (1 - \alpha)lf = \Delta p\epsilon. \tag{13}$$

As in the case where the manager receives only a bonus, the risk-taking incentives of the manager decrease in $f$. However, while the cost of risk taking increases by $lf$ with a bonus payment, it increases by a lower amount, $(1-\alpha)lf$, if the manager is remunerated with shares. At the same time, $\frac{\partial \alpha}{\partial f} > 0$. Therefore, while $f > 0$ still increases the marginal cost of risk taking, as $f$ increases it gets less expensive for shareholders to increase the

risk with higher inside debt.

A higher $f$ creates a loss for the manager in default, but it also reduces the value of equity in solvent states. As $f$ increases, the equity in state $i = M$, and with that the wage $w_M = \alpha(R_M - \delta - f)$, reaches zero. The remuneration contract becomes more convex, similar to a bonus, strengthening risk-taking incentives of the manager. Still, the overall effect of inside debt on shareholder's equity is negative, so shareholders would not voluntarily remunerate the manager with inside debt. Nevertheless, if they are forced to include inside debt in the manager's compensation contract, this would lead them to choose a higher level of risk. Thus, adding inside debt to the contract that remunerates the manager with shares in bank equity mitigates the risk-reducing effect of mandatory equity.

The assumption that the marginal benefit of risk taking is higher than the marginal cost of risk taking for $\Delta p = 0$ is fulfilled for $B > \frac{\pi}{B}\epsilon > p_H\epsilon$. Since risk taking is more costly if the manager is compensated with shares rather than a bonus, the benefit also has to be higher to make risk taking attractive for shareholders.

As in the case of bonuses, if deposits are not fully insured, the manager is remunerated in default. Consequently, manager's risk-taking incentives are stronger, making risk taking less expensive for shareholders. Thus, optimal risk taking is higher when deposits are not fully insured.

**Proposition 9.** *If the only difference to Proposition 8 is that deposits are not fully insured, a marginal increase in inside debt leads to an even larger increase in optimal risk taking than in Proposition 8.*

# 6 Conclusion

In the aftermath of the financial crisis of 2008, the role of managerial compensation in the risk taking of banks became one of the central concerns of bank regulators. The Financial Stability Board issued a set of principles that national regulators are advised to follow to ensure prudent and internationally consistent compensation practices. These principles highlight the importance of making managers' variable compensation susceptible to losses in default to prevent excessive risk taking. One of the suggestions is that this can be achieved by mandating that managers' compensation contracts feature unsecured debt instruments.

I show that mandating inside debt is not a straightforward tool for reducing banks' risk taking. First, I show that inside debt *per se* does not affect risk taking, because shareholders correct managers' incentives by increasing their bonuses. With higher risk taking the expected inside debt payment decreases, completely offsetting the cost of a higher bonus for shareholders. A combination of inside debt and a fixed bonus cap can fully eliminate risk taking if the fixed bonus cap is larger than zero. However, if the bonus cap is defined as a multiple of base salary, mandating inside debt in addition does not affect risk taking.

If bank deposits are not fully insured, the seniority of compensation instruments relative to deposits changes. Inside debt is of the same seniority as uninsured debt, and the manager is remunerated in default. In this case, higher inside debt increases optimal risk taking. While the risk taking can be inhibited with a bonus cap, the relative bonus cap is less effective. The ability to pay the base salary before insured deposits are settled increases the implicit subsidy from the mispriced deposit insurance. Consequently, risk taking becomes less expensive and could even lead to higher risk taking than in the absence of the bonus cap.

Furthermore, if the regulator mandates that bank managers are compensated with

shares instead of bonuses, bank risk taking is lower than with a bonus compensation. However, if the regulators require that the manager holds both equity and inside debt, bank risk taking increases in the level of inside debt that the manager is required to hold.

In the paper, I show the importance of understanding not only the effect of single regulatory tools but their interaction as well. In addition, I highlight the importance of correctly designing the bonus cap to achieve target results.

# References


[1] Acharya, V.V., Crosignani, M., Eisert, T. and S. Steffen. 2022. Zombie lending: Theoretical, international, and historical perspectives. *Annual Review of Financial Economics* 14, 21-38.

[2] Acharya, V.V., Hasan, I. and A. Saunders. 2006. Should banks be diversified? Evidence from individual bank loan portfolios. *The Journal of Business* 79(3), 1355-1412.

[3] Acharya, V.V. and S. Steffen. 2015. The "greatest" carry trade ever? Understanding eurozone bank risks. *Journal of Financial Economics* 115(2), 215-236.

[4] Acharya, V.V. and T. Yorulmazer. 2007. Too many to fail-An analysis of time-inconsistency in bank closure policies. *Journal of Financial Intermediation* 16(1), 1-31.

[5] Acharya, V.V. and T. Yorulmazer. 2008. Cash-in-the-market pricing and optimal resolution of bank failures. *The Review of Financial Studies* 21(6), 2705-2742.

[6] Anantharaman, D., Fang, V.W. and G. Gong. 2014. Inside debt and the design of corporate debt contracts. *Management Science* 60(5),1260-1280.

[7] Altavilla, C., Pagano, M. and S. Simonelli. 2017. Bank exposures and sovereign stress transmission. *Review of Finance* 21(6), 2103-2139.

[8] Australian Prudential Regulation Authority (APRA). 2018. APRA seeks improvement in executive remuneration practices, 04 April. Available at: www.apra.gov.au, accessed 08 November 2024.

[9] Bae, K.H., Gong, Z. and W.H., Tong. 2024. Restricting CEO pay backfires: Evidence from China. *Journal of Business Finance & Accounting* 51(5-6), 1015-1045.

[10] Bank of England (BoE). 2023. PS9/23 - Remuneration: Ratio between fixed and variable components of total remuneration ('bonus cap'), 24 October. Available at: www.bankofengland.co.uk, accessed 08 November 2024.

[11] Bannier, C.E., Feess, E. and N. Packham. 2013. Competition, bonuses, and risk-taking in the banking industry. *Review of Finance* 17(2), 653-690.

[12] Bebchuk, L.A., Cohen, A. and H. Spamann. 2010. The wages of failure: executive compensation at Bear Stearns and Lehman 2000–2008. *Yale Journal on Regulation* 27, 257–282.

[13] Bebchuk, L.A. and H. Spamann. 2010. Regulating bankers' pay. *Georgetown Law Journal* 98, 247-287

[14] Bell, B.D. and J.V. Reenen. 2013. Extreme wage inequality: pay at the very top. *American Economic Review* 103(3), 153-157.

[15] Berg, T., Puri, M. and Rocholl, J. 2020. Loan officer incentives, internal rating models, and default rates. *Review of Finance* 24(3), 529-578.

[16] Bolton, P., Mehran, H. and J. Shapiro. 2015. Executive compensation and risk taking. *Review of Finance* 19(6), 2139-2181.

[17] Bruche, M. and G. Llobet. 2014. Preventing zombie lending. *The Review of Financial Studies* 27(3), 923-956.

[18] Cassell, C.A., Huang, S.X., Sanchez, J.M. and M.D. Stuart. 2012. Seeking safety: The relation between CEO inside debt holdings and the riskiness of firm investment and financial policies. *Journal of Financial Economics* 103(3), 588-610.

[19] Cerasi, V., Deininger, S.M., Gambacorta, L. and T., Oliviero. 2020. How post-crisis regulation has affected bank CEO compensation. *Journal of International Money and*

*Finance* 104, Article 102153.

[20] Chaigneau, P. 2013. Risk-shifting and the regulation of bank CEOs' compensation. *Journal of Financial Stability* 9(4), 778-789.

[21] Chaigneau, P., Chang, W.J. and S.A., Hillegeist. 2024. Performance measure skewness and the structure of CEO compensation: Theory and evidence. *Contemporary Accounting Research* 41, 1754–1784.

[22] Colonnello, S., Koetter, M. and K. Wagner. 2023. Compensation regulation in banking: Executive director behavior and bank performance after the EU Bonus Cap. *Journal of Accounting and Economics, forthcoming.*

[23] Congress of the United States. 2024. Comment on Proposed Rule: Incentive-based Compensation Arrangements, 15 May. Available at: www.sec.gov, accessed 08 November 2024.

[24] Deng, K., Ge, W. and J. He. 2021. Inside debt and shadow banking. *Journal of Corporate Finance* 69, Article 102038.

liquidity, *The Journal of Political Economy* 91, 401–419.

[25] Directive 2013/36/EU, of the European Parliament and of the Council. 2013. On access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, *Journal of the European Union* L 176, 338–436.

[26] Duchin, R. and D. Sosyura. 2014. Safer ratios, riskier portfolios: Banks' response to government aid. *Journal of Financial Economics* 113(1), 1-28.

[27] Dudley, W.C. 2014. Enhancing Financial Stability by Improving Culture in the Financial Services Industry, October 20, Available at: www.newyorkfed.org accessed 12 November 2024.

[28] Dybvig, P.H. and J.F. Zender. 1991. Capital structure and dividend irrelevance with asymmetric information. *The Review of Financial Studies* 4(1), 201-219.

[29] European Banking Authority (EBA). 2014. *EBA FINAL draft Regulatory Technical Standards on classes of instruments that are appropriate to be used for the purposes of variable remuneration under Article 94(2) of Directive 2013/36/EU* , 19 February. Available at: www.eba.europa.eu

[30] The Economist. 2009. Attacking the corporate gravy train, 28 May. Available at: www.economist.com, accessed 17 November 2023.

[31] Edmans, A. and Q. Liu. 2011. Inside debt. *Review of Finance* 15(1), 75-102.

[32] Edmans, A. 2016. Why has CEO pay risen so much faster than worker pay?. Access to Finance, 19 September. Available at: alexedmans.com, accessed 17 November 2023

[33] Fahlenbrach, R. and R. Stulz. 2011. Bank CEO incentives and the credit crisis. *Journal of Financial Economics* 99(1), 11-26.

[34] Financial Conduct Authority (FCA). 2020. Letter to the Chair of the Remuneration Committee, 22 July. Available at: www.fca.org.uk, accessed 08 November 2024.

[35] Financial Stability Board (FSB). 2009. *FSB Principles for Sound Compensation Practices*, 25 September. Available at: www.fsb.org, accessed 17 November 2023.

[36] Financial Stability Board (FSB). 2019. *Implementing the FSB Principles for Sound Compensation Practices and their Implementation Standards (Sixth progress report)* , 17 June. Available at: www.fsb.org, accessed 05 November 2024.

[37] Flannery, M. 1991. Pricing deposit insurance when the insurer measures bank risk with error. *Journal of Banking and Finance* 15, 975-998.

[38] Fortin, R., Goldberg, G.M. and G. Roth. 2010. Bank risk taking at the onset of the current banking crisis. *Financial Review* 45(4), 891-913.

[39] Gao, J., Kleiner, K. and J. Pacelli. 2020. Credit and punishment: are corporate bankers disciplined for risk-taking?. *The Review of Financial Studies* 33(12), 5706-5749.

[40] Gropp, R. and M. Köhler. 2010. Bank owners or bank managers: who is keen on risk? Evidence from the Financial Crisis. ZEW Discussion Paper no. 10-013. Centre for European Economic Research. Available at: madoc.bib.uni-mannheim.de, accessed 10 December 2023.

[41] The Guardian. 2023. UK financial regulators scrap cap on bankers' bonuses, 24 October. Available at: www.theguardian.com, accessed 17 November 2023.

[42] Hakenes, H. and I. Schnabel. 2014. Bank bonuses and bailouts. *Journal of Money, Credit and Banking* 46(s1), 259-288.

[43] Hoffmann, F., Inderst, R. and M. Opp. 2022. The economics of deferral and clawback requirements. *The Journal of Finance* 77(4), 2423-2470.

[44] Hubbard, R.G. and D. Palia. 1995. Executive pay and performance evidence from the US banking industry. *Journal of Financial Economics*, 39(1), pp.105-130.

[45] John, T.A. and K. John. 1993. Top-management compensation and capital structure. *The Journal of Finance* 48(3), 949-974.

[46] John, K., John, T.A. and L.W. Senbet. 1991. Risk-shifting incentives of depository institutions: A new perspective on federal deposit insurance reform. *Journal of Banking & Finance* 15(4-5), 895-915.

[47] John, K., Mehran, H. and Y. Qian. 2010. Outside monitoring and CEO compensation in the banking industry. *Journal of Corporate Finance* 16(4), 383-399.

[48] John, K., Saunders, A. and L. W. Senbet. 2000. A theory of banking regulation and management compensation. *Review of Financial Studies* 13, 95-125.

[49] Kleymenova, A. and I. Tuna. 2021. Regulation of compensation and systemic risk: Evidence from the UK. *Journal of Accounting Research* 59(3), 1123-1175.

[50] Kolm, J., Laux, C. and G. Lóránth. 2017. Bank regulation, CEO compensation, and boards. *Review of Finance* 21(5), 1901-1932.

[51] Laeven, L. 2011. Banking crises: A review. *Annual Review of Financial Economics* 3(1), 17-40.

[52] Laeven, L. and R. Levine. 2009. Bank governance, regulation and risk taking. *Journal of Financial Economics* 93(2), 259-275.

[53] Kokkinis, A. 2018. Exploring the effects of the 'bonus cap' rule: the impact of remuneration structure on risk-taking by bank managers. *Journal of Corporate Law Studies* 19(1), 167–195.

[54] Ohlrogge, M. 2023. *Why Have Uninsured Depositors Become De Facto Insured?*. (SSRN working paper No. 4624095). Available at: www.papers.ssrn.com.

[55] PRA and FCA. 2023. Remuneration: Ratio between fixed and variable components of total remuneration ('bonus cap') (CP15/22). Available at: www.bankofengland.co.uk, accessed 27 December 2023.

[56] Office of the Comptroller of the Currency, Federal Deposit Insurance Corporation, Federal Housing Finance Agency, and National Credit Union Administration. 2016.

Incentive-based Compensation Arrangements. Available at: www.fdic.gov, accessed 11 November 2024.

[57] Rozen, M.G. 2024. Effectiveness of executive compensation cap law: Evidence from Israel. Discussion Paper 2024 7. Research Department Bank of Isreal. Available at: al.boi.gov.il, accessed 12 November 2024.

[58] Sundaram, R.K. and D.L. Yermack. 2007. Pay me later: Inside debt and its role in managerial compensation. *The Journal of Finance* 62(4), 1551-1588.

[59] Thanassoulis, J. 2012. The case for intervening in bankers' pay. *The Journal of Finance* 67(3), 849–895.

[60] Tirole, J. 2010. The theory of corporate finance. Princeton university press.

[61] Times of India. 2019. 50% of the CEO pay to be variable: RBI, 05 November. Available at: timesofindia.indiatimes.com, accessed 11 November 2024.

[62] Van Bekkum, S. 2016. Inside debt and bank risk. *Journal of Financial and Quantitative Analysis* 51(2), 359-385.

[63] Wei, C. and D. Yermack. 2011. Investor reactions to CEOs' inside debt incentives. *The Review of Financial Studies* 24(11), 3813-3840.

# A Appendix

## A.1 The benefit of risk taking.

For $l = \frac{R_H - R_M}{R_M - R_L}$, the benefit of risk taking equals

$$\begin{aligned} B &= R_H - R_M - l(R_M - \delta) \\ &= \frac{R_H - R_M}{R_M - R_L}(R_M - R_L) - \frac{R_H - R_M}{R_M - R_L}(R_M - \delta) \\ &= \frac{R_H - R_M}{R_M - R_L}(\delta - R_L). \end{aligned}$$

Since $\delta > R_L$ per assumption, the benefit of risk taking is larger than zero in a mean-preserving spread.

## A.2 Proof of Proposition 1.

The incentive constraint determines the wage level necessary to implement a level of risk $\Delta p$ to ensure that the shareholders' optimal choice of $\Delta p$ also maximizes the manager's payoff. From the first-order condition $\frac{\partial \pi_M}{\partial \Delta p} = 0$, it follows:

$$w_H - (1 + l)w_M = \Delta p \epsilon. \tag{14}$$

Substituting this condition in the manager's expected utility yields:

$$\begin{aligned} \pi_M &= p_H w_H + p_M w_M + \Delta p(w_H - (1 + l)w_M) - \frac{\Delta p^2 \epsilon}{2} \\ &= p_H w_H + p_M w_M + \frac{(w_H - (1 + l)w_M)^2}{\epsilon} - \frac{\epsilon(w_H - (1 + l)w_M)^2}{2\epsilon^2} \\ &= p_H w_H + p_M w_M + \frac{(w_H - (1 + l)w_M)^2}{2\epsilon} \end{aligned}$$

which is larger than zero, given the regulatory constraint ($R$). Therefore, Condition $PC$ always holds and the optimal choice of wages is determined by the incentive constraint.

It follows from the incentive constraint that $w_H = \Delta p\epsilon + (1+l)w_M$, so it holds that $w_H > w_M$ and ($R$) reduces to the requirement that $w_M \geq f$. Substituting the incentive constraint in (4) in the expected value of equity defined in (2)

$$\begin{aligned}\pi_S &= V + \Delta pB - (p_H + \Delta p)(\Delta p\epsilon + (1+l)w_M) - (p_M - \Delta p(1+l))w_M \\ &= V + \Delta p(B - p_H\epsilon - (\Delta p\epsilon + (1+l)w_M) + (1+l)w_M) - (p_H + p_M)w_M \\ &= V + \Delta p(B - p_H\epsilon - \Delta p\epsilon) - (p_H + p_M)w_M.\end{aligned}$$

The optimal level of risk taking follows from the first-order condition $\frac{\partial \pi_S}{\partial \Delta p} = 0$, which is equivalent to

$$\begin{aligned}B - 2\Delta p^*\epsilon - p_H\epsilon &= 0 \\ \Delta p^* &= \frac{B}{2\epsilon} - \frac{p_H}{2}.\end{aligned}$$

The expected value of equity given the optimal risk taking equals

$$\begin{aligned}\pi_S^* &= V + \Delta p(B - p_H\epsilon - \Delta p\epsilon) - (p_H + p_M)w_M \\ &= V + \Delta p(2\Delta p\epsilon - \Delta p\epsilon) - (p_H + p_M)w_M \\ &= V + \Delta p^2\epsilon - (p_H + p_M)w_M.\end{aligned}$$

Since $\frac{\partial \Delta p^*}{\partial w_M} = 0$, $\frac{\partial \pi_S^*}{\partial w_M} = -(p_H + p_M) < 0$.

Finally, to see that $R_H$ is always sufficiently high to pay $\delta$ and $w_H$ under the assumption $R_M \geq \delta + f$, consider first that

$$\begin{aligned}\frac{R_H}{2} + \frac{R_M - lf}{2} &> R_M \\ R_H + R_M - lf &> 2R_M \\ R_H - R_M &> lf \\ B + l(R_M - \delta) &> lf \\ B + l(R_M - \delta - f) &> 0\end{aligned}$$

which holds since $R_M \geq f + \delta$. Then,

$$
\begin{aligned}
&R_H \geq \delta + w_H \\
&R_H \geq \delta + f + \left( \frac{R_H - R_M - l(R_M - \delta)}{2} - \frac{p_H \epsilon}{2} + lf \right) \\
&R_H - \frac{R_H - R_M - l(R_M - \delta)}{2} + \frac{p_H \epsilon}{2} - lf \geq \delta + f \\
&\frac{R_H}{2} + \frac{R_M - lf}{2} + \frac{l(R_M - \delta - f)}{2} + \frac{p_H \epsilon}{2} \geq \delta + f \\
&\underbrace{\frac{R_H}{2} + \frac{R_M - lf}{2}}_{> R_M, \text{ see above}} + \underbrace{\frac{l(R_M - \delta - f)}{2}}_{>0} + \frac{p_H \epsilon}{2} > R_M \geq \delta + f.
\end{aligned}
$$

The condition $R_H - \delta > w_H^*$ holds. □

Therefore, shareholders optimally choose the lowest possible wage in state $M$, $w_M^* = f$, and consequently $w_H^* = \frac{R_H - R_M - l(R_M - \delta)}{2} - \frac{p_H \epsilon}{2} + (1 + l)f$ can always be paid if $R_M \geq \delta + f$.

## A.3 Proof of Proposition 3.

The optimal compensation in the state $i = M$ is $w_M = w + f$ and from (7) it follows that $w_M = \frac{\Delta p \epsilon + lf}{\beta - l} + f$. The value of equity defined in (5) then equals

$$
\pi_{S,\beta} = V + \Delta p B - (p_H + \Delta p)\Delta p \epsilon - (p_H(1 + l) + p_M) \left( f + \frac{\Delta p \epsilon + lf}{\beta - l} \right)
$$

From the first-order condition it follows that

$$
\begin{aligned}
&B - p_H \epsilon - 2\Delta p \epsilon - \frac{(p_H(1 + l) + p_M)\epsilon}{\beta - l} = 0 \\
&\Delta p_\beta^* = \frac{B}{2\epsilon} - \frac{p_H}{2} - \frac{p_H(1 + l) + p_M}{2(\beta - l)}.
\end{aligned}
$$

Risk taking $\Delta p_{\beta w} \geq 0$ if

$$\begin{aligned}
\frac{B}{2\epsilon} - \frac{p_H}{2} &\geq \frac{p_H(1+l)+p_M}{2(\beta-l)} \\
\beta &> l + \frac{\epsilon(p_H(1+l)+p_M)}{B-p_H\epsilon} \\
\beta &> \hat{\beta} = l + \frac{p_H(1+l)+p_M}{2\Delta p^*}.
\end{aligned}$$

The threshold $\hat{\beta}$ is increasing in $p_H$, since it holds

$$\frac{\partial \hat{\beta}}{\partial p_H} = \epsilon \frac{(1+l)(B-p_H\epsilon)+(p_H(1+l)+p_M)\epsilon}{(B-p_H\epsilon)^2} = \epsilon \frac{(1+l)B+p_M\epsilon}{(B-p_H\epsilon)^2} > 0.$$

The value of equity equals

$$\begin{aligned}
\pi_{S,\beta} &= V + \Delta p_\beta \left( B - p_H\epsilon - \frac{(p_H(1+l)+p_M)\epsilon}{2(\beta-l)} - \Delta p_\beta \epsilon \right) - (p_H(1+l)+p_M)\left(f + \frac{lf}{\beta-l}\right) \\
&= V + \Delta p_\beta \left(2\Delta p_\beta \epsilon - \Delta p_\beta\right) - (p_H(1+l)+p_M)\left(f + \frac{lf}{\beta-l}\right) \\
&= V + \Delta p_\beta^2 \epsilon - (p_H(1+l)+p_M)\left(f + \frac{lf}{\beta-l}\right).
\end{aligned}$$

To derive comparative statics regarding $w$, notice first that $w = \frac{\Delta p_\beta^* \epsilon + lf}{\beta - l} = \frac{B+2lf}{2(\beta-l)} - \frac{(1+\beta)p_H+p_M}{2(\beta-l)^2}\epsilon$. It is straightforward to see that $\frac{\partial w}{\partial f} > 0$.Furthermore,

$$\begin{aligned}
\frac{\partial w}{\partial \beta} &= -\frac{B+2lf}{2(\beta-l)^2} - \frac{\epsilon}{2}\frac{p_H(\beta-l)^2 - ((1+\beta)p_H+p_M)2(\beta-l)}{(\beta-l)^4} \\
&= -\frac{B+2lf+p_H\epsilon}{2(\beta-l)^2} + \epsilon\frac{(1+\beta)p_H+p_M}{(\beta-l)^3} > 0
\end{aligned}$$

if

$$\frac{B}{2\epsilon} + \frac{lf}{\epsilon} > \frac{(1+l)p_H + p_M}{2(\beta - l)}$$

which holds, since $\Delta p^*_\beta > 0$ implies $\frac{B}{2\epsilon} > \frac{(1+l)p_H + p_M}{2(\beta-l)}$.

□

## A.4 Proof of Proposition 4.

From the first-order condition $\frac{\partial \pi_M}{\partial \Delta p} = 0$, it follows:

$$w_H - (1+l)w_M + lw_L = \Delta p \epsilon. \tag{15}$$

Substituting the incentive constraint in the manager's expected utility yields

$$\begin{aligned}
\pi_M &= p_H w_H + p_M w_M + p_L w_L + \Delta p(w_H - (1+l)w_M + lw_L) - \frac{\Delta p^2 \epsilon}{2} \\
&= p_H w_H + p_M w_M + p_L w_L + \frac{(w_H - (1+l)w_M + lw_L)^2}{\epsilon} - \frac{\epsilon(w_H - (1+l)w_M + lw_L)^2}{2\epsilon^2} \\
&= p_H w_H + p_M w_M + p_L w_L + \frac{(w_H - (1+l)w_M + lw_L)^2}{2\epsilon},
\end{aligned}$$

which is larger than zero, given the regulatory constraint ($R$), and thus the participation constraint ($PC$) always holds.

Inserting the incentive constraint in the expected value of equity yields

$$\begin{aligned}
\pi_S &= V + \Delta p B - (p_H + \Delta p)(\Delta p \epsilon + (1+l)f + l\gamma R^u_L) - (p_M - \Delta p(1+l))f \\
&= V + \Delta p(B - p_H \epsilon - \Delta p \epsilon + l\gamma R^u_L) - (p_H(1+l) + p_M)f + p_H l\gamma R^u_L.
\end{aligned}$$

From the first-order condition $\frac{\partial \pi_S}{\partial \Delta p} = 0$, it follows

$$B - 2\Delta p\epsilon + l\gamma R_L^u - p_H\epsilon = 0$$
$$\Delta p = \frac{B + l\gamma R_L^u}{2\epsilon} - \frac{p_H}{2}$$

and the expected value of equity can be expressed as

$$\begin{aligned}\pi_S &= V + \Delta p(B + l\gamma R_L^u - p_H\epsilon - \Delta p\epsilon) - (p_H(1+l) + p_M)f + p_H l\gamma R_L^u \\ &= V\Delta p(2\Delta p\epsilon - \Delta p\epsilon) - (p_H(1+l) + p_M)f + p_H l\gamma R_L^u \\ &= V + \Delta p^2\epsilon - (p_H(1+l) + p_M)f + p_H l\gamma R_L^u.\end{aligned}$$

□

## A.5 Proof of Proposition 6

For $w_M = w + f$, $w_L = w(1-\gamma) + \gamma R_L^u$, and $w = \frac{\Delta p\epsilon + l(f - \gamma R_L^u)}{\beta - l\gamma}$, the value of equity equals

$$\begin{aligned}\pi_{S,sen,\beta} =& V + \delta pB - (p_H - \Delta p)\Delta p\epsilon - f(p_H(1+l) + p_M) - (p_H(1+l\gamma) + \\ & p_M - \Delta p l(1-\gamma))\frac{\Delta p\epsilon + l(f - \gamma R_L^u)}{\beta - l\gamma} + (p_H + \Delta p)l\gamma R_L^u\end{aligned}$$

From the first-order condition $\left(\frac{\partial \pi_{S,sen,\beta}}{\partial \Delta p} = 0\right)$ it follows

$$B - p_H\epsilon - 2\Delta p\epsilon + l\gamma R_L^u - \frac{\epsilon}{\beta - l\gamma}(p_H(1-l\gamma) + p_M - 2\Delta p(1-\gamma)l) + \frac{l^2(1-\gamma)(f - \gamma R_L^u)}{\beta - l\gamma} = 0$$
$$\Delta p^*_{sen,\beta} = \left(\frac{B + l\gamma R_L^u}{2\epsilon} - \frac{p_H}{2}\right)\frac{\beta - l\gamma}{\beta - l} - \frac{p_H(1+l\gamma) + p_M}{2(\beta - l)} + \frac{l^2(1-\gamma)(f - \gamma R_L^u)}{\beta - l\gamma}$$
$$\Delta p^*_{sen,\beta} = \Delta p^*_{sen}\frac{\beta - l\gamma}{\beta - l} - \frac{p_H(1+l\gamma) + p_M}{2(\beta - l)} + \frac{l^2(1-\gamma)(f - \gamma R_L^u)}{\beta - l\gamma} \tag{16}$$

The value of equity equals

$$\begin{aligned}\pi^*_{S,sen,\beta} &= V - (p_H(1+l)+p_M)f + \frac{l(f-\gamma R^u_L)}{\beta - l\gamma}(p_H(1-\gamma l)+p_M) + p_H l\gamma R^u_L + \\ &\Delta p^*_{sen,\beta}(B - p_H\epsilon - \Delta p^*_{sen,\beta}\epsilon - \frac{\epsilon}{\beta - l\gamma}(p_H(1+l\gamma)+p_M) - \frac{\Delta p^*_{sen,\beta}\epsilon l(1-\gamma)}{\beta - l\gamma} - \\ &\frac{l^2(1-\gamma)(f-\gamma R^u_L)}{\beta - l\gamma} + \gamma l R^u_L) \\ &= V - (p_H(1+l)+p_M)f + \frac{l(f-\gamma R^u_L)}{\beta - l\gamma}(p_H(1-\gamma l)+p_M) + p_H l\gamma R^u_L + \Delta p^{*2}_{sen,\beta}\epsilon\end{aligned} \tag{17}$$

The optimal base salary equals

$$w^*_{sen} = \frac{l(f-\gamma R^U_L)}{\beta - l\gamma} + \frac{B + l\gamma R^U_L}{\beta - l} - \frac{p_H(\beta+1)+p_M}{2(\beta-l)(\beta-l\gamma)}\epsilon,$$

and its derivative with respect to the strictness of the bonus cap is

$$-\frac{B + l\gamma R^U_L}{2}\frac{\beta - \gamma l}{\beta - l} + \frac{p_H(\beta+1)}{2(\beta-l)} + \frac{p_M\epsilon}{2(\beta-l)} > 0$$

if

$$\beta > l\gamma + 2l.$$

While $\beta > l\gamma$, the condition above might not hold. The derivative increases in large enough values of $\beta$, whereas it decreases for smaller values of $\beta$.

The base salary is increasing in $f$, since

$$\frac{\partial}{\partial f}\left(\frac{l(f-\gamma R^u_L}{\beta - l\gamma}\right) = \ + \frac{l((\beta-l)f^2 + \beta\upsilon(2f+\upsilon - R^u_L))}{((\beta-l)f+\upsilon\beta)^2} > 0, \tag{18}$$

and $\frac{\partial \Delta p^*_{sen,\beta}}{\partial f} > 0$ as well.

□

## A.6 Proof of Proposition 8

With inside debt, the expected payoff of shareholders ($\pi_{S,\alpha,f}$) and the expected utility of the manager ($\pi_{M,\alpha,f}$) are respecively

$$\begin{aligned}\pi_{S,\alpha,f} &= (p_H + \Delta p)(1-\alpha)(R_H - \delta - f) + (p_M - \Delta p(1+l))(1-\alpha)(R_M - \delta - f) \\ &= (1-\alpha)(V + \Delta pB - (p_H + p_M)f + \Delta plf)\end{aligned}$$

$$\begin{aligned}\pi_{M,\alpha,f} &= (p_H + \Delta p)[\alpha(R_H - \delta - f) + f] + (p_M - (1+l)\Delta p)[\alpha(R_M - \delta - f) + f] - \frac{\Delta p^2 \epsilon}{2} \\ &= \alpha(V + \Delta pB - (p_H + p_M)f + \Delta plf) + (p_H + p_M - l\Delta p)f - \frac{\Delta p^2 \epsilon}{2}\end{aligned}$$

The first-order condition $\frac{\partial \pi_M}{\partial \Delta p} = 0$ yields a condition for the compensation necessary to create incentives for the manager to increase the risk by $\Delta p$:

$$\alpha = \frac{\Delta p\epsilon + lf}{B + lf}.$$

In order for manager to participate, it has to hold

$$(p_H + \Delta p)(\alpha(R_H - \delta - f) + f) + (p_M - \Delta p(1+l))(\alpha(R_M - \delta - f) + f) - \frac{\Delta p^2 \epsilon}{2} \geq 0.$$

The compensation that ensures that the manager participates is

$$\alpha \geq \left(\frac{\Delta p^2 \epsilon}{2} - f(p_H + p_M - \Delta pl)\right) \frac{1}{p_H(R_H - \delta - f) + p_M(R_M - \delta - f) + \Delta pB}.$$

The incentive constraint is binding if

$$\frac{\Delta p\epsilon + lf}{B + lf} \geq \left(\frac{\Delta p^2 \epsilon}{2} - f(p_H + p_M - \Delta pl)\right) \frac{1}{p_H(R_H - \delta - f) + p_M(R_M - \delta - f) + \Delta p(B + lf)}$$

$$(\Delta p\epsilon + lf)(p_H(R_H - \delta - f) + p_M(R_M - \delta - f)) + \Delta p^2\epsilon(B + lf) + lf\Delta p(B + lf) \geq \frac{\Delta p^2 \epsilon B}{2} -$$

$$f(p_H + p_M - \Delta pl)(B + lf)$$

$$\frac{\Delta p^2 \epsilon(B + lf)}{2} \geq -(\Delta p\epsilon + lf)(p_H(R_H - \delta - f) + p_M(R_M - \delta - f)) - f(p_H + p_M - \Delta pl)(B + lf) -$$

$$lf\Delta p(B + lf)$$

which always holds since the left-hand side of the inequality is positive and the right-hand side is negative. Therefore, the compensation contract $\alpha$ that creates incentives for the manager to increase the risk always provides incentive for the manager to participate as well.

Substituting the incentive constraint in the shareholders' optimization problem yields

$$\begin{aligned}
\max_{\Delta p} \pi_S &= (1 - \alpha)(V + \Delta pB - (p_H + p_M)f + \Delta plf) \\
&= \left(1 - \frac{\Delta p\epsilon + lf}{B + lf}\right)(V + \Delta pB - (p_H + p_M)f + \Delta plf) \\
&= V + \Delta pB - (p_H + p_M)f + \Delta plf - \frac{\Delta p\epsilon + lf}{B + lf}(V - (p_H + p_M)f) - \Delta p^2\epsilon - \Delta plf \\
&= V + \Delta pB - (p_H + p_M)f - \frac{\Delta p\epsilon + lf}{B + lf}(V - (p_H + p_M)f) - \Delta p^2\epsilon.
\end{aligned}$$

The optimal level of risk taking follows from the first-order condition $\frac{\partial \pi_S}{\partial \Delta p} = 0$, which is equivalent to

$$\begin{aligned}
B - \frac{\epsilon}{B + lf}(V - (p_H + p_M)f) - 2\Delta p\epsilon &= 0 \\
\Delta p^*_{\alpha,f} &= \frac{B}{2\epsilon} - \frac{V - (p_H + p_M)f}{2(B + lf)}.
\end{aligned}$$

The optimal risk taking increases in $f$, since:

$$\frac{\partial \Delta p^*_{\alpha,f}}{\partial f} = -\frac{1}{2}\frac{-(p_H+p_M)(B+lf)-(V-(p_H+p_M)f)l}{(B+lf)^2} = \frac{(p_H+p_M)B+Vl}{2(B+lf)^2} > 0.$$

The optimal compensation $\alpha^*$ also increases in $f$ since

$$\frac{\partial \alpha^*}{\partial f} = \frac{(V-(p_H+p_M)f)lf}{(B+lf)^3} + \frac{(p_H+p_M)\epsilon}{2(B+lf)^2} > 0$$

and $V-(p_H+p_M)f = p_H(R_H-\delta-f)+p_M(R_M-\delta-f) > 0$.

The expected value of equity given the optimal risk taking is

$$\begin{aligned}
\pi^*_{S,\alpha,f} &= V + \Delta p^*_{\alpha,f}B - (p_H+p_M)f - \frac{\Delta p^*_{\alpha,f}\epsilon + lf}{B+lf}(V-(p_H+p_M)f) - \Delta p^{*2}_{\alpha,f}\epsilon \\
&= V-(p_H+p_M)f + \Delta p^*_{\alpha,f}\left(B - \frac{(V-(p_H+p_M)f)\epsilon}{B+lf}\right) - \frac{lf}{B+lf}(V-(p_H+p_M)f) - \Delta p^{*2}_{\alpha,f}\epsilon \\
&= (V-(p_H+p_M)f)\left(1-\frac{lf}{B+lf}\right) + \Delta p^{*2}_{\alpha,f}2\epsilon - \Delta p^{*2}_{\alpha,f}\epsilon \\
&= (V-(p_H+p_M)f)\frac{B}{B+lf} + \Delta p^{*2}_{\alpha,f}\epsilon
\end{aligned}$$

The expected value of equity decreases in $f$, since:

$$\frac{\partial \pi^*_{S,\alpha,f}}{\partial f} = -(p_H+p_M)\frac{4B(B+lf)-\epsilon}{4(B+lf)^2} - (V-(p_H+p_M)f)\frac{2B(B+lf)-\epsilon}{2(B+lf)^3} < 0,$$

since $\Delta p^*_{\alpha,f} \geq 0$ and $V-(p_H+p_M)f > 0$ imply $B(B+lf) \geq \epsilon(V-(p_H+p_M)f) \geq \epsilon$. □

## A.7 Proof of Proposition 9

With uninsured debt, only the expected utility of the manager changes and equals

$$\pi_{M,\alpha} = \alpha(V+\Delta pB-(p_H+p_M)f+\Delta plf)+(1-p_Ll\gamma)f-\frac{\Delta p^2\epsilon}{2}.$$

The incentive constraint follows from the first-order condition, $\frac{\partial \pi_{M,\alpha}}{\partial \Delta p} = 0$, and equals

$$\alpha = \frac{\Delta p \epsilon + l f \gamma}{B + l f}.$$

In order for the manager to participate it has to hold that $\pi_{M,\alpha} \geq 0$, which is always fulfilled since

$$\begin{aligned}\pi_{M,\alpha} &= \frac{\Delta p \epsilon + l \gamma f}{B + l f}(B + l f)\Delta p + \frac{\Delta p \epsilon + l \gamma f}{B + l f}(V - (p_H + p_M)f) - \frac{\Delta p^2 \epsilon}{2} + (1 - \Delta p l \gamma)f \\ &= l f \gamma + \frac{\Delta p^2 \epsilon}{2} + + \frac{\Delta p \epsilon + l \gamma f}{B + l f}(V - (p_H + p_M)f) > 0.\end{aligned}$$

Shareholders' expected payoff is

$$\begin{aligned}\pi_{S,\alpha} &= \left(1 - \frac{\Delta p \epsilon + l \gamma f}{B + l f}\right)(V - (p_H + p_M)f) \\ &= V + \Delta p(B + l f) - (p_H + p_M)f - \frac{\Delta p \epsilon + l \gamma f}{B + l f}(V - (p_H + p_M)f) - \Delta p^2 \epsilon - \Delta p l f \gamma.\end{aligned}$$

The optimal level of risk taking follows from the first-order condition $\frac{\partial \pi_{S,\alpha}}{\partial \Delta p} = 0$ and equals

$$\begin{aligned}&B + l f - \frac{\epsilon}{B + l f}(V - (p_H + p_M)f) - 2\epsilon \Delta p - l f \gamma \\ &\Delta p^*_\alpha = \frac{B + l f(1 - \gamma)}{2\epsilon} - \frac{V - (p_H + p_M)f}{2(B + l f)}\end{aligned}$$

The second term of $\Delta p^*_\alpha$ is the same as in the case with insured deposits and is decreasing in $f$, increasing the optimal risk taking. Unlike the case of insured deposits where the first term is independent of $f$, in this case it is increasing. Therefore, $\Delta p^*_\alpha$ is increasing in $f$.

The expected payoff of shareholders given the optimal risk taking is

$$\begin{aligned}\pi^*_{S,\alpha} =&\Delta p^*_\alpha \left( B + lf(1-\gamma) - \frac{\epsilon}{B+lf}(V-(p_H+p_M)f) - \Delta p^*_\alpha \epsilon \right) + \\ &(V-(p_H+p_M)f)\left(1-\frac{lf\gamma}{B+lf}\right) \\ =&(V-(p_H+p_M)f)\left(1-\frac{lf\gamma}{B+lf}\right) + \Delta p^{*2}_\alpha \epsilon.\end{aligned}$$

□