Regulating Bank CEO Compensation and Active Boards

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We analyze the role of using CEO compensation and capital requirements in prudential regulation. With a passive uninformed board that delegates the choice of bank strategy to the CEO, requiring a compensation contract where the CEO receives a fixed fraction of total bank payoff eliminates the risk shifting problem and can implement first best; no additional regulatory limit on bank leverage is needed. With an informed, active board that represents shareholder interests, however, there exists no CEO compensation that assures that the socially optimal level of risk is chosen. The optimal policy mix consists of deferred compensation for the CEO, a bonus cap or a compensation that is linear in total payoff, and a constraint on bank leverage. Regulating CEO compensation allows to relax regulatory capital requirements.
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1. Introduction

This paper explores the interaction between banks' capital requirements and the regulation of bank CEO compensation. While capital requirements are a long established tool of bank regulation, bank CEO compensation has only become part of the regulatory toolbox, recently. Most prominently, the EU's new capital requirements directive (DIRECTIVE 2013/36/EU, of 26 June 2013, Art. 94(g) and 94(m)) introduces a cap for the maximum bonus payments a CEO could receive relative to his base salary and mandates deferred compensation. Our paper analyzes the interaction of these two regulatory instruments.

We show that risk shifting incentives can be successfully addressed through deferred CEO compensation in combination with either a cap on the maximum bonus or a wage that is linear in the bank's total payoff. However, with an active board, regulating CEO compensation does not prevent underinvesting in measures that reduce the bank's risk. The combination of regulatory tools results in higher welfare than any of these tools in isolation, but first best will not be achieved. In contrast, with an uninformed, passive board that delegates strategic decisions to the CEO, regulating CEO compensation can implement first best and no regulatory capital requirements are necessary in our model. Our results show that it is important to take the interaction between the board and CEO into account, when considering the optimal structure of bank regulation, in particular, the effectiveness of regulating bank CEO compensation.

To study these issues, we develop a model where a bank CEO searches for new business models (e.g., fee business, trading desk), risk management and lending standards, the use of risk transfer instruments, level of proprietary trading etc., which constitute the bank's strategy. The CEO is employed by the board that represents the interests of shareholders and sets CEO compensation. In the case of an active board, any new strategy has to be approved by the board. If the board does not approve the new strategy the bank's existing strategy remains in place. A new strategy can involve an increase or decrease the bank's risk relative to the bank's existing (default) strategy. Upon finding a new strategy, the CEO can elect whether to present it to the board, or not. The board provides the CEO with incentives to search for new strategies and propose them to the board. It is impossible to reward the CEO on the basis of the effort he makes to find a new strategy. We also assume that it cannot be verified whether a new strategy has been found. However, it is possible to contract upon implementation of a new strategy and the bank's realized payoff.

The bank is financed by a mix of equity and insured deposits, which makes it optimal for shareholders if the bank pursues a risky strategy. Given that the board acts in the interest of shareholders, the incentives for risk taking will be reflected in the CEO's compensation contract absence any regulation of CEO pay. As a consequence of the board's and CEO's incentives, the bank will pursue strategies that involve excessively high risk and forgo risk reducing strategies that are socially optimal.

The empirical evidence on the link between bank CEO compensation and risk taking shows that banks whose CEOs' incentives were more aligned with shareholders took more risk and performed worse during the crises (e.g. Bhagat and Bolton, 2011; Fahlenbach and Stulz, 2011; Hagendorff and Vallascas, 2011). Concerning the role of the board and

corporate governance arrangements the literature provides evidence that more shareholder friendly structures are also associated with higher risk taking and worse performance during the financial crises (e.g. Gropp and Köhler, 2010; Aebi et al., 2012; Beltratti and Stulz, 2012; Berger et al., 2012; Erkens et al., 2012; Peni and Vähämaa, 2012; Ellul and Yerramilli, 2013).

We show that compensation regulation must require that (a sufficient share of) compensation is deferred. The reason is that compensation regulation can only provide incentives against overinvestment into risky strategies if compensation is conditioned on strategy outcomes. This can only be achieved with deferred compensation.

Given deferred compensation. bonus caps limit the maximum compensation that the CEO can receive relative to his base salary. Such bonus caps thus reduce the CEO's incentive to present highly risky investment opportunities to the board. The reason is that a risky strategy is only worthwhile for the CEO if the compensation in the case of success is high enough. The CEO's incentives to present excessively risky strategies to the board can also be curbed by requiring compensation contracts that are linear in the bank's total payoffs. Linear contracts have the benefit that they are more robust than bonus caps, which have to be set optimally to eliminate the CEO's risk shifting incentives.

While compensation regulation can deal with the problem of overinvestment into risky strategies, it cannot eliminate the underinvestment into socially efficient safe strategies. The reason is that safe strategies destroy the option value of bankruptcy for shareholders, which is present in the bank's existing (default) business. Compensation contracts only directly affect how shareholders share their surplus with the CEO, but not the size of the surplus. Hence compensation contracts cannot simultaneously provide incentives for the board to implement and for the CEO to present new safe projects.

Capital regulation directly limits bank leverage and thereby reduces the board's incentive to engage in risk shifting when it decides on a new strategy. Nevertheless, risk-shifting incentives, albeit muted, prevail at any positive level of leverage. To the extent that insured liquid deposits are valuable for households, it is however not optimal for the regulator to fully eliminate deposit financing.

We show that the optimal policy combines compensation regulation and capital regulation. An optimal mix of the two regulatory tools achieves both the implementation of socially optimal risky investment strategies and reduces distortions from high leverage. Hence, it also reduces underinvestment into safe strategies. However, as the social and private incentives for investing into safe strategies differ at any positive level of leverage, even the optimal mix cannot implement the first best, because some socially efficient safe strategies will not get implemented if leverage is positive.

In our model, optimal compensation regulation will lead to an increase in CEO compensation because, with a bonus cap or a linear wage, the CEO also receives a positive wage when the bank does not change its strategy. (Under a bonus cap the base salary must increase to permit bonuses that are high enough to provide the CEO with search incentives.) Thus, the expected compensation for alternative strategies has to increase to provide incentives to search. This increase in CEO compensation is a transfer from shareholders that does not affect efficiency in the model as long as the board still

provides the CEO with incentives to search for new strategies. To increase the board's incentives to induce search even in the presence of compensation regulation, the regulator may give the board a choice of using either a bonus cap or linear incentives. The board will then choose the instrument that allows to implement search at lowest expected wage costs.

For comparison we also analyze the case of a passive, uninformed board. We show that with a passive board compensation regulation can implement the first. Hence there is no rationale for capital regulation in this case. Regulating CEO compensation, however, reduces the board's ability to align the interests of the CEO with those of shareholders. This is consistent with the regulator's objective, but also affects the board's willingness to delegate decisions to the CEO. Indeed, it can provide incentives to the board to become informed and active. We thus predict that current regulatory changes may lead to increased board activism.

Our paper follows the literature that views CEOs' risk taking incentives as an expression of the risk-shifting incentives of highly levered institutions such as banks (John and John, 1993; John et al., 2000; Bebchuk and Spamann, 2010; Bolton et al., 2011). The case for regulatory action follows from the social costs of choosing an inefficient strategy and bank failures that are not internalized by banks' shareholders.

A different strand of the literature focuses on the inefficiencies that arise in the labor market for bank CEOs (Thanassoulis, 2012; Bannier et al., 2013; Archarya et al., 2012). In these models, labor market imperfections lead to risk taking incentives that are excessive from the firm's perspective, which provides a rationale for regulation.

Closest to our paper is a paper by John et al. (2000). In their model, bank shareholders would like to commit themselves not to take excessive risk as this is anticipated and reflected in fairly-priced deposit insurance premium. The shareholders' commitment problem stems from the a time-inconsistency problem in that once the deposit insurance fee is paid, the choice of strategy only depends on the level of capitalization of the bank. For any positive value of risky debt the privately and socially optimal choice of strategy differ, which then leads to a loss in firm value compared to the social optimum. The main idea of their paper is that, by varying the structure of CEO compensation, shareholders can affect the CEO's selection of the strategy. By making the deposit insurance premium a function of the relevant parameters of the CEO compensation a fairly-priced deposit insurance premium forces the shareholders to select the compensation schedule that maximizes firm value.

Our model differs from John et al. (2000) along several dimensions. First, we assume a board that plays an active role in the choice of strategy and show that it is optimal to combine both capital and compensation regulation. Hence, the question we ask is whether recent regulatory developments, in the form of bonus caps, can optimally co-exist with capital regulation. Regarding the question of what regulation can achieve, in John et al. (2000) a fairly-priced deposit insurance fee as a function of CEO compensation can implement the first best. In our model, even the optimal policy mix cannot entirely eliminate under-investment into some socially efficient safe strategies. This is not due to our assumption on the lack of fairly-priced deposit insurance such as the one employed in John et al. (2000). Even if we made deposit insurance a function of leverage and CEO

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compensation, we could not improve on our results.

The reason why the optimal regulation in our paper cannot implement the first best is the interaction between the board and the bank CEO in our framework. In John et al. (2000) shareholders delegate the decision to implement strategies to CEOs and through the compensation contract they can commit to any set of strategies. In our model, the board representing the shareholders are the ultimate decision maker. Hence, this type of commitment cannot work.

The remainder of the paper is laid out as follows. Section 2 describes our model. Section 3 outlines the privately optimal compensation and leverage choice in an unregulated environment. Section 4 derives the optimal compensation regulation and discusses its relation with capital regulation. Section 5 derives the optimal regulation for the case of a passive board that delegates the choice of strategy to the CEO. Section 6 concludes.

2. The Model

2.1. Bank Strategy

We consider a bank with a board of directors and a CEO. The board represents the interests of shareholders; the CEO maximizes the own utility. The board and the CEO are risk-neutral and have an outside option whose value is zero. In a changing economic and competitive environment, the CEO is responsible for searching for new investment opportunities that constitute the bank's strategy. In a broad sense, a bank's strategy comprises its business model (interest or fee business), its risk management and lending standards, the use of risk transfer instruments, level of proprietary trading etc. Laying the foundations and searching for new alternative strategies involves a personal cost c for the CEO. The CEO's decision to search for new alternatives is non-observable; but if the CEO exerts effort, he finds a possible alternative strategy with probability 1. The new strategy may or may not be associated with a higher expected payoff than the current strategy.

We assume that the level of total assets (investment) I is fixed and that there are two states of nature, success and failure (bankruptcy). All possible strategies yield a payoff of zero in case of failure. Thus, strategies are fully characterized by their probability of success p and the payoff in the case of success, H. The bank's current strategy yields payoff $\hat{H}$ with probability $\hat{p}$, which is common knowledge. If the CEO exerts effort, he uncovers a new strategy that is drawn from a set of strategies that is either safe or risky. A safe strategy yields a payoff $H \in [0, \bar{H}]$ with $p = 1$. A risky strategy yields a payoff $\bar{H}$ with probability $p \in [0, 1]$. Thereby we want to capture the idea that strategies can increase or decrease risk relative to the current level. We assume that the CEO uncovers exactly one alternative strategy and focus on the question whether the alternative strategy will be implemented or not. (The qualitative results are not affected if the CEO can choose to propose to use new financial instruments to either increase or reduce risk, which could be modeled as a situation where the CEO uncovers two strategies, one drawn from the set of risky strategies and one from the set of safe

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strategies.) The type of strategy the CEO uncovers is drawn from a uniform distribution over the set of strategies $[0, \bar{H}] \cup [0, 1]$, which implies a density of $f = 1/(1 + \bar{H})$. After exerting effort, the CEO learns the characteristics H and p of the new strategy.

We assume that when a strategy is presented to the board, the board observes its characteristics p and H. The CEO, however can always present an alternative 'fake' strategy with low H or p that is not worthwhile for shareholders. Thereby we capture the idea that the CEO can strategically withhold information if it is unfavorable to the CEO, but to get a new strategy approved, the CEO has to provide the evidence to the board. The board uses the wage structure to provide the CEO with incentives to search for and present strategies that are profitable for shareholders. Ultimately, the decision whether the CEO is allowed to implement a new strategy is taken by the board (active board).

As a reference case, we also consider a setting where the characteristics of the strategy are private information to the CEO and cannot be revealed to the board (uninformed board). In this case, the board has to delegate the implementation decision to the CEO. The board thus has to provide incentives for the CEO to implement those strategies that are optimal for shareholders.

2.2. CEO Compensation

The CEO's incentives will be shaped by a compensation contract set by the board, subject to possible regulatory constraints.

We assume that the search effort and the success probability of the new strategy are not contractible. However, the realized payoff in the case of success is contractible. Thus, a wage contract can consist of a fixed wage w_F and a deferred bonus $w(H)$ if the bank does not default and which can depend on the bank's realized return H in the case of success. We assume that, in contrast to the deferred bonus, the fixed wage can be paid independent of whether the bank fails or not. (As we will discuss below, the bank has to raise capital to pay the fixed wage.) Thereby, we want to capture differences in fixed and deferred compensation that are at the heart of the current debate about the role of regulating compensation for senior bank employees for bank risk taking incentives.

We assume that it can be observed whether a new strategy is implemented, so that the wage structure can depend on whether a new strategy is implemented or not. The CEO receives a fixed wage $\hat{w}_F$ and variable pay $\hat{w}$ if the bank's strategy is not changed. If a new strategy is implemented, the CEO receives a fixed wage w_F and variable pay $w(H)$. We note that the fixed wage is independent of the bank's future payoff. However, it can still change (and thus be variable) if a different fixed wage is chosen for the current strategy than for a new strategy. We further assume that the CEO is protected by limited liability so that the total wage payment cannot be negative.[1]

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[1]Note that a claw back arrangement in our setting would imply that the CEO could lose the fixed wage w_F if the bank fails: as limited liability implies that $w_F + w(0) \geq 0 \Leftrightarrow w(0) \geq -w_F$. However, any wage structure with $w_F > 0, w(H)$, and $w(0) = k < 0$ is equivalent to a wage structure where $w(0)$ is set equal to zero and w_F and $w(H)$ are reduced by k. Thus, without loss of generality, we restrict our analysis to $w(0) = 0$ (no claw back).

We assume that the board cannot fire the CEO after the presentation of a new strategy in order to save any wages that were promised to provide incentives to search for a new strategy. (For example, a very high severance pay would prevent this.) However, we allow for renegotiation of the wage contract if both the CEO and the board agree to a change in the contract. Renegotiation takes the following form.

1. The CEO decides whether to propose a new strategy or not.

2. The board decides whether to offer the CEO a new wage. It can, for example, offer a fixed wage $w'_F = \hat{w}_F + \hat{p}\hat{w}$ which makes the CEO indifferent between the old and the new strategy.

3. The CEO decides whether to accept the new offer or whether to reject it. If the CEO rejects the new contract, the old contract stays in place.

4. The board decides whether to implement the new strategy or not.

Renegotiation is valuable whenever the board can observe the characteristics of the new strategy. The reason is that ex ante, it is not possible to write a compensation contract that explicitly depends on the strategy's risk (success probability), but only the future realized payoff. Renegotiation avoids that strategies with low expected payoff are forgone because of high CEO compensation.

We assume that H is an upper bound for the bank's payoff in the case of success. The CEO can always take measures to reduce this level. Thus, the variable pay $w(H)$ is non decreasing in H.

2.3. Bank Leverage

The bank is financed with equity E and deposits D. Depositors are assumed to be fully insured by deposit insurance and demand the risk-free rate of return, which we normalize to 0. We assume that the premium for deposit insurance is not sensitive to the risk of the bank's strategy and that, because of deposit insurance, the bank's shareholders prefer debt financing over equity financing. There are a number of additional reasons why debt finance might be cheaper than equity finance. These include among others implicit guarantees, tax benefits of debt financing, the additional value of money like claims provided by deposits, and frictional cost of equity.

However, the bank cannot increase the debt level above the initial investment I. Thus, even absent regulation, the bank cannot raise the debt level above 100% of the value of the assets on the balance sheet (i.e., $D/I \leq 1$). This assumption implies that, even absent regulatory capital constraints, the bank cannot increase leverage to finance up-front dividends to shareholders. It also implies that the bank cannot finance additional expenses including wages with debt, and changes in the fixed wage are de facto fully borne by shareholders: the bank has to raise capital to make a fixed (upfront) wage payment, but given a binding leverage constraint, any increase in the fixed wage requires an increase in equity.

2.4. Regulatory Tools

We assume that depositors (households) associate a positive value with liquid deposits and deposit insurance, which provide money like claims. Thus, it is not socially optimal to prohibit funding with deposits or give up deposit insurance. A large literature justifies the presence of deposit insurance, but we do not attempt to derive it here from primitives. Moreover, evidence presented by Laeven (2002) and Demirgüç-Kunt and Kane (2002) indicates that deposit insurance pricing is at best only weakly related to loan portfolio riskiness. As a result of deposit insurance, depositors fail to charge the bank for the risk that it incurs.

We also assume that the regulator does not observe the bank's strategy or riskiness so that the regulator cannot implement risk based regulation. This excludes both a deposit insurance with a risk dependent premium and risk based capital requirements. Given that deposit insurance does not depend on the risk of the bank, we normalize the bank's cost of deposit insurance to zero.

We focus on two regulatory tools to influence the choice of strategy and thereby the risk-choice of the bank. The regulator can impose a capital requirement, which limits the amount of deposits raised to a maximum level of D. The regulator can also impose constraints on the structure of CEO compensation. The aim of regulation is to provide incentives that result in the implementation of projects that increase expected social surplus.

Of course, to allow for effective compensation regulation, it is necessary that the compensation contract is the only possibility of the board to commit to future payments. Thus, the board must not be able to commit to make payments to the CEO through mechanisms other than the compensation contract.

The regulator knows the characteristics of all possible strategies and the distribution that governs the manager's discovery of new strategies and maximize welfare.

2.5. Time-Line

The interaction between the board and the CEO is depicted in Figure 1. Taking the regulatory constraints as given, the board raises deposits and designs the CEO's compensation contract at $t = 1$. At $t = 2$, the CEO decides whether to search for a new strategy. If he discovers a new strategy, he learns about the strategy's characteristics and decides whether to present the new strategy to the board. At $t = 3$, the board learns the characteristics of the presented strategy and can make a take-it-or-leave-it offer to the CEO to change his compensation contract. At $t = 4$, the board decides whether to implement a potential new strategy or stay with the default strategy. At $t = 5$, uncertainty is resolved and the bank's payoffs are realized.

The possibility to renegotiate the CEO's compensation after a new strategy has been presented allows the board to implement all strategies that increase shareholder surplus. Otherwise, some strategies that increase the available shareholder surplus (gross of compensation) would not be implemented because the associated increase in CEO compensation would render the strategy unprofitable. It seems natural to assume that a
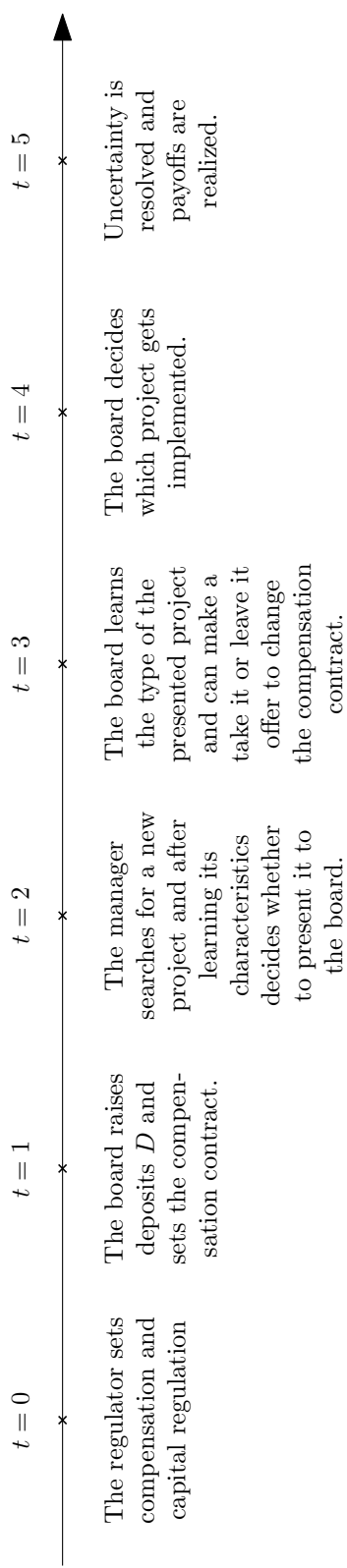
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$t=0$	$t=1$	$t=2$	$t=3$	$t=4$	$t=5$
The regulator sets compensation and capital regulation	The board raises deposits D and sets the compensation contract.	The manager searches for a new project and after learning its characteristics decides whether to present it to the board.	The board learns the type of the presented project and can make a take it or leave it offer to change the compensation contract.	The board decides which project gets implemented.	Uncertainty is resolved and payoffs are realized.

Figure 1: Time-Line of Events

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board and a CEO are able to successfully renegotiate under such circumstances.

3. Unregulated Bank

In the following section we solve the game between the CEO and the board by backwards induction, starting with the implementation decision. We first derive the optimal CEO compensation in the absence of regulation.

3.1. Choice of Strategy

The board will only approve a new strategy if it increases shareholder value. Implementation thus depends on the shareholder value that a given strategy generates and its distribution between shareholders and the CEO. The set of strategies that increases the shareholder value for risky strategies gross of CEO compensation is

$$p(\bar{H} - D) \geq \hat{p}(\hat{H} - D) \Leftrightarrow p \geq \hat{p}\frac{\hat{H} - D}{\bar{H} - D}, \tag{1}$$

and for safe strategies

$$H - D \geq \hat{p}(\hat{H} - D). \tag{2}$$

If a strategy increases shareholder value gross of CEO compensation, but reduces it net of CEO compensation, i.e.,

$$p(H - D - w(H)) - w_F < \hat{p}(\hat{H} - D - \hat{w}) - \hat{w}_F, \tag{3}$$

the board renegotiates the original (t=1) CEO compensation. The CEO accepts any wage that leaves him with the same expected wage under the new strategy as under the old strategy. The reason is that the CEO knows that a new strategy that reduces shareholder value net of compensation will not be implemented without renegotiation anyway. Renegotiation at $t = 3$ implies that the board is willing to implement all strategies that increase shareholder value gross of CEO compensation.

Lemma 1. *Any strategy that the CEO presents to the board and that increases gross shareholder value (the sum of shareholder value and expected CEO compensation) will eventually be approved by the board.*

Proof. When (3) holds and the compensation contract is not altered, the board will stay with the default strategy in which case the CEO receives an expected wage of $\hat{w}_F + \hat{p}\hat{w}$. Thus, the CEO is willing to accept a new contract that satisfies

$$w'_F + pw'(H) \geq \hat{w}_F + \hat{p}\hat{w}.$$

Since the board can make a take-it-or-leave-it offer, this condition will hold with equality, which implies

$$p(H - D - w'(H)) - w'_F \leq \hat{p}(\hat{H} - D - \hat{w}) - \hat{w}_F \Leftrightarrow p(H - D) \leq \hat{p}(\hat{H} - D)$$

and strategies that increase gross shareholder value also increase net shareholder value and will be approved by the board. $\square$

The straightforward intuition is that when there is an option to increase the available surplus and renegotiation is possible, then, given symmetric information, both parties will find a contract that allows them to realize the additional surplus.

3.2. Incentives to Search and Present a New Strategy

The CEO is willing to present a new strategy to the board if his expected compensation from implementing it exceeds the expected compensation from the default strategy. Thus, the CEO will present a risky strategy if

$$w_F + pw(\bar{H}) \geq \hat{w}_F + \hat{p}\hat{w}. \tag{4}$$

and a safe strategy if

$$w_F + w(H) \geq \hat{w}_F + \hat{p}\hat{w}. \tag{5}$$

The CEO anticipates that the board successfully renegotiates the compensation contract whenever the wage increase is larger than the increase in gross shareholder value. However, the CEO also presents all strategies that lead to a renegotiation of the original compensation contract because he is never worse off after renegotiation then when the default strategy gets implemented.

Thus, the CEO gets compensated for search only when the new strategy does not involve renegotiation of the original contract. This is the case for a risky strategy when

$$p(\bar{H} - D - w(\bar{H})) - w_F \geq \hat{p}(\hat{H} - D - \hat{w}) - \hat{w}_F \Leftrightarrow p \geq \frac{\hat{p}(\hat{H} - D - \hat{w}) + w_F - \hat{w}_F}{\bar{H} - D - w(\bar{H})} \tag{6}$$

and for a safe strategy when

$$H - D - w_F - w(H) \geq \hat{p}(\hat{H} - D - \hat{w}) - \hat{w}_F \Leftrightarrow H \geq \hat{p}(\hat{H} - D - \hat{w}) + D + w_F + w(H) - \hat{w}_F. \tag{7}$$

The CEO's expected compensation when engaging in search is

$$\pi_M(\text{search}) = \hat{w}_F + \hat{p}\hat{w} + f \int_{\mathbf{H}_S} \max\{w_F + w(H) - \hat{w}_F - \hat{p}\hat{w}, 0\} \, dH$$

$$+ f \int_{\underline{p}_S}^1 \max\{w_F + pw(\bar{H}) - \hat{w}_F - \hat{p}\hat{w}, 0\} \, dp$$

where $\mathbf{H}_S$ and $\underline{p}_S$ describe the sets of safe and risky strategies respectively that the board is willing to approve without renegotiating CEO compensation. The maxima inside the integrals follow from the fact that the CEO will only present strategies that do not decrease the expected compensation.

At t=2, the CEO searches for a new strategy if the expected increase in his compensation exceeds his search cost. The CEO's incentive compatibility constraint is given by

$$\pi_M(\text{search}) - \hat{w}_F - \hat{p}\hat{w} \geq c \tag{8}$$

The CEO's participation constraint is implied by the incentive constraint. The CEO earns a rent if his compensation exceeds the search cost, which is the case if $\hat{w}_F + \hat{p}\hat{w} > 0$.

3.3. Privately Optimal Compensation Contract

This section analyzes the case where the board chooses the privately optimal compensation contract. If the board chooses not to provide search incentives to the CEO, then the CEO's participation constraint is binding and the optimal wage is zero; shareholder value in this case is $\hat{p}(\hat{H} - D)$.

With search, the shareholder value net of CEO compensation is

$$\pi_S(\omega) = \hat{p}(\hat{H} - D) + f \int_{\mathbf{H}_M} \max\{H - D - \hat{p}(\hat{H} - D), 0\} \, dH$$

$$+ f \int_{\underline{p}_M}^1 \max\{p(\bar{H} - D) - \hat{p}(\hat{H} - D), 0\} \, dp - \pi_M(\text{search})$$

where $\mathbf{H}_M$ and $\underline{p}_M$ describe the sets of safe and risky strategies that the CEO is willing to present. The maxima inside the integrals follow from the fact that the board will only approve strategies that increase shareholder value.

When the board provides search incentives to the CEO, it will choose a contract that solves

$$\max_{\omega} \pi_S(\omega)$$

s.t. the CEO's incentive constraint (8) and his participation constraint. When setting CEO compensation, the board tries to minimize the expected wage cost and takes into account that the manger may not present all strategies to the board.

Given limited liability, the wage cannot be negative and the CEO is willing to present all new strategies to the board if $\hat{w}_F = \hat{w} = 0$. Thus, the CEO may only have incentives to withhold information about a new strategy if $\hat{w}_F + \hat{p}\hat{w}$ is positive.

Whenever the board can implement search with $\hat{w}_F = \hat{w} = 0$, the CEO earns zero rent and the expected compensation equals the search cost. This implies that the board will provide search incentives whenever the increase in shareholder surplus that is generated by searching for new strategies exceeds the search cost. In the following we assume that the search cost is sufficiently low so that $\hat{w}_F = \hat{w} = 0$ in the privately optimal compensation contract and that it is optimal for the board to provide the CEO with incentives to search for a new strategy even in the presence of regulation.

The following Proposition 1 defines a class of compensation contracts that maximize the CEO's search incentives for $\hat{w}_F = \hat{w} = 0$. Thereby it implicitly defines parameter conditions for which search incentives can be provided without giving the CEO a rent.

Proposition 1. *There exists a privately optimal contract ω^p where the CEO does not earn any rent if and only if there exists a $w^p(\bar{H})$ such that*

$$w^p(H) = \max\{\min\{H - D - \hat{p}(\hat{H} - D), w^p(\bar{H})\}, 0\} \tag{9}$$

satisfies the CEO's incentive constraint for $w_F^p = \hat{w}_F^p = \hat{w}^p = 0$.

Proof. Given $\hat{w}_F = \hat{w} = 0$, the fixed and variable pay for implementing a new strategy, w_F and $w(H)$, that maximizes the expected payment to the CEO also maximizes incentives

to search for a new strategy. The board's incentive to approve a new strategy without renegotiation and the requirement that the compensation must be non-decreasing in H limit the maximum expected CEO compensation.

The expected increase in the compensation that the CEO receives from finding a risky strategy is given by

$$f \int_{\underline{p}_S}^1 \max\{w_F^p + pw(\bar{H}), 0\}\, dp,$$

which is concave in $w_F^p + w(\bar{H})$ since the board will renegotiate the compensation for a larger set of risky strategies as $w_F^p + w(\bar{H})$ increases. To reduce the distortions from the wage payment, it is optimal to set $w_F^p = 0$ and $w(\bar{H}) > 0$.

The maximum pay that the board can credibly promise to the CEO for finding a safe strategy with payoff H is given by the increase in shareholder value $H - D - \hat{p}(\hat{H} - D)$. To avoid renegotiation and maximize the wage to the CEO, it is optimal to set $w_F^p = 0$; $w(H)$ could then be set equal to $H - D - \hat{p}(\hat{H} - D)$ without renegotiating the wage prior to implementing a "safe" strategy. However, since $w(H)$ must be non decreasing in H, the board can never promise the CEO a compensation that is higher than the variable pay for a risky strategy $w(\bar{H})$. Thus, for a given $w(\bar{H})$, the maximum compensation that the manager can receive from finding a safe project with H is $w^p(H)$.

Since $\pi_M(\text{search})$ is continuous, any intermediate level of expected CEO compensation can be implemented by reducing $w(H)$. It follows that for $\hat{w}_F = \hat{w} = 0$ there only exists a compensation contract that satisfies the CEO's incentive constraint if there exists a contract $w^p(H)$ that does so.

Assume that there exists a contract $\hat{w}_F^p = \hat{w}^p = 0$ and $w^p(H) > 0$ that satisfies the CEO's incentive constraint with equality. This implies that the CEO's expected compensation equals the search cost and the CEO does not earn any rent. The CEO is willing to present all strategies with $w(H) > 0$, which, for $w(\bar{H}) > 0$, includes all strategies that increase shareholder value. There always exist some risky strategies that increase shareholder value for which the board will renegotiate. This implies that the expected gross shareholder value that is generated by the implementation of new strategies is strictly larger than the expected CEO compensation. Together, these properties imply that the contract is privately optimal. □

Consider a compensation contract ω^p that satisfies the CEO's incentive constraint with strict inequality. There are arbitrarily many contracts with $\hat{w}_F = \hat{w} = 0$ and ω' with $w'(H) \leq w^p(H) \forall H$ that satisfy the incentive compatibility constraint with equality. Any of these contracts is optimal as along as it ensures that the manger is willing to present all profitable strategies. For example, if c is sufficiently low a fixed fee for implementing a new project provides efficient search incentives: $\hat{w}_F = \hat{w} = 0$; $w(H) = 0$; $w_F > 0$; where w_F equals c divided by the probability of receiving the wage. If c increases, it may be necessary to have a wage contingent on H, $w(H) > 0$ and $w_F = 0$ to be able to increase the expected CEO compensation after a change in strategy. Increasing the fixed wage w_F is not sufficient as it also increases the probability of renegotiation in which case the compensation is zero; a deferred variable pay has the benefit that it varies with the

expected payoff of the strategy. Thus, if the strategy is more profitable, a higher wage can be promised without renegotiation.

Proposition 1 shows that the privately optimal compensation contract is generally not a pure equity contract. Instead, the compensation contract for higher search cost will be close to a very steep equity compensation with a cap. An equity contract on the other hand would only be possible for sufficiently small search costs. The intuition for this is that for very high compensation promises the board will renegotiation the compensation contract and hence the CEO anticipates that these very high promises are in fact empty.

We note that the optimal contract cannot be implemented by a renegotiation proof contract. The reason is that the occurrence of renegotiation depends on the success probability of the strategy that the manger discovers. Hence, the resulting compensation is also conditional on the strategy's success probability.

3.4. Leverage

Given deposit insurance, debt is preferred to equity. Hence, without a regulatory constraint on leverage, the bank chooses $D = I$.

The increase in shareholder value when the board provides the CEO with incentives to search for a new strategy, using the privately optimal contract ω^p, is given by

$$\pi_s(\omega^p, D) = \hat{p}(\hat{H} - D) + f \int_{\underline{H}^p}^{\bar{H}} H - D - \hat{p}(\hat{H} - D)\, dH$$

$$+ f \int_{\underline{p}^p}^{1} p(\bar{H} - D) - \hat{p}(\hat{H} - D)\, dp - (I - D) - c,$$

where $\underline{H}^p = D + \hat{p}(\hat{H} - D)$ and $\underline{p}^p = \hat{p}\frac{\hat{H} - D}{\bar{H} - D}$ determine the sets of strategies that will be implemented under a privately optimal compensation contract.

The debt level affects the board's incentives to implement a new strategy and to provide the CEO with incentives to search.

4. Compensation Regulation

In this section we solve for the optimal compensation regulation. We assume that the objective of compensation regulation is to ensure the implementation of socially efficient strategies. We then discuss the role of capital regulation and its interaction with compensation regulation. In general, the board's objective to engage in risk shifting is key to the problem as the board directly (through approval of strategies) and indirectly (through setting CEO compensation) affects the bank's strategy. Thus, it would be optimal to try to affect the incentives of the board by regulating board member compensation to make sure that the board maximizes the total value of the bank, not shareholder value. However, board members have very heterogeneous objectives and levels of equity stakes in the bank, which makes it difficult to fully align the incentives of board members to maximize total bank value. We focus on the role of CEO compensation

when the board maximizes shareholder value. If the board maximizes total bank value, no additional regulation such as CEO compensation or bank capital requirement is needed.

4.1. Choice of Strategy

The set of strategies that increase social surplus relative to the default strategy can be described by the following inequality for risky strategies,

$$p\bar{H} \geq \hat{p}\hat{H} \Leftrightarrow p \geq \hat{p}\frac{\hat{H}}{\bar{H}}, \tag{10}$$

and safe strategies,

$$H \geq \hat{p}\hat{H}. \tag{11}$$

The difference between the social surplus and the shareholder surplus is that the social surplus accounts for the expected repayment of the bank's depositors by the deposit insurance. Shareholders, on the other hand, weight their payment obligations to depositors with the probability of a strategy's success, because depositors are not paid by the bank in case of failure.

If the default strategy is implemented, shareholders only have to pay back depositors if the strategy is successful, which occurs with probability $\hat{p}$. With a safe strategy, shareholders always have to pay back depositors. Hence implementing a safe strategy results in a transfer from shareholders to the deposit insurance. Conversely, for risky strategies with $p < \hat{p}$, depositors are paid less often, resulting in a transfer from the deposit insurance to shareholders. As a result, the privately optimal contract leads to an implementation of excessively risky strategies and rejection of socially efficient safe strategies. This can be seen by comparing (10) and (11) with (1) and (2). A regulator has an incentive to deter excessively risky strategies and to provide incentives to implement safe strategies.

Regulating CEO compensation can limit excessive risk taking by making it optimal for the CEO not to propose high risk strategies to the board. However, for a fixed level of bank leverage, regulating CEO compensation cannot avoid the problem that some safe strategies are not implemented.

Proposition 2. *With an active board, there exists no compensation contract such that all socially efficient safe strategies with $H < \hat{p}(\hat{H} - D) + D)$ get implemented.*

Proof. For any compensation contract, the increase in the joint payoff to shareholders and the CEO from switching to a safe strategy is given by

$$H - D - w'(H) - [\hat{p}(\hat{H} - D) - \hat{w}_F] + [w'(H) - \hat{w}_F] = H - D - \hat{p}(\hat{H} - D),$$

which is equivalent to the increase in gross shareholder value. Thus, there does not exist a contract that will lead to the implementation of a safe strategy that does not satisfy (2). $\square$

The intuition for the proposition is the interaction between the CEO's willingness to propose a new strategy and the board's incentive to approve it: Unless the CEO's expected compensation decreases when a safe strategy is implemented, the board will not approve a strategy that violates (2). However, if the CEO's expected compensation decreases, he will not propose this strategy to the board.

4.2. Deferred Compensation With Bonus Cap and Linear Wages

Overinvestment into risky strategies will be deterred if the CEO's compensation from a new risky strategy is lower than the expected compensation from the default strategy as in this case, the CEO will not propose such a strategy to the board. A prerequisite for the CEO to present only socially efficient risky strategies to the board is that the CEO shares in the risk. Thus, without deferred compensation that is forgone if the bank fails, the CEO will either present all risky strategies or no new strategies at all. Such a compensation contract can be privately optimal as discussed in section 3.3.3.

Proposition 3. *For any compensation contract without deferred compensation, either all risky strategies that increase shareholder value or no new strategy will be implemented.*

Proof. For $\hat{w} = w(H) = 0 \forall H$, the CEO is either willing to present all new strategies ($w_F \geq \hat{w}_F$) or no new strategies at all ($w_F < \hat{w}_F$). Since renegotiation is possible, a presented strategy will be implementedif and only if it increases shareholder surplus.Hence, it is optimal for the regulator to require that compensation is deferred. In what follows we will thus focus on the case where all compensation is deferred. Regulatory requirements to defer compensation have been introduced into the European bank regulation framework by the latest EU capital requirements directive known as CRD IV (DIRECTIVE 2013/36/EU, Art. 94(m)). $\qquad\square$

However, deferred compensation is not sufficient to prevent risk shifting as the board could compensate the CEO for the higher risk through a higher bonus in the case of success. Thus, the regulator also needs to impose a bonus cap.

We define a bonus as any compensation that the CEO receives in excess of the CEO's minimum wage (unless the bank defaults). We refer to the minimum wage that the CEO receives if the bank is solvent as the base salary

$$w_{base} \equiv \min\{\hat{w}, \min_H w(H)\}$$

and the variable component (bonus) of the CEO's compensation is given by $w(H) - w_{base}$. A regulatory bonus cap puts a limit on the maximum bonus relative to the base salary, which has to be satisfied for all possible wages. Given non-decreasing wages, $w(\bar{H})$ is the CEO's maximum wage, and the constraint that a bonus cap puts on the CEO's wage structure implies that $w(\bar{H}) \leq b w_{base}$, where $b \geq 1$ is the regulatory bonus cap. Bonus caps have also been introduced by the EU's CRD IV (DIRECTIVE 2013/36/EU, Art. 94(g)).

Given the constraints of a bonus cap and mandatory deferred compensation, the board chooses a privately optimal compensation contract. As before, this compensation contract

can be renegotiated. The renegotiated contract is also subject to the bonus cap and mandatory deferred compensation requirements.

To analyze the effect of a bonus cap and mandatory deferred compensation on the choice of strategy, we first derive the compensation contract that the board will choose. To simplify the notation, let the additional gross shareholder surplus of a safe strategy be denoted by $v_S(H) \equiv H - D - \hat{p}(\hat{H} - D)$. Lemma 2 focuses on bonus caps where $b \leq \bar{H}/\hat{H}$. These bonus caps ensure that the manager only presents those risky projects that increase the social surplus or a subset thereof. In Proposition 4 below we will show that the optimal bonus cap set by the regulator lies in this range.

Lemma 2. *If the board is constrained to use deferred compensation and a bonus cap $b \leq \bar{H}/\hat{H}$, the board will choose a compensation contract*

$$w^b(H) = \begin{cases} b\hat{w}^b & b\hat{w}^b < v_S(H) + \hat{p}\hat{w}^b \\ \hat{w}^b & \hat{w}^b > v_S(H) + \hat{p}\hat{w}^b \\ v_S(H) + \hat{p}\hat{w}^b & otherwise \end{cases}$$

and set $\hat{w}^b$ such that the CEO's incentive constraint for search is satisfied with equality.

A risky strategy gets implemented if and only if $p \geq \hat{p}/b$.

Proof. See Appendix A. $\qquad\qquad\square$

A bank that is subject to a bonus cap is still able to provide search incentives to the CEO by setting both $w(\bar{H})$ and $\hat{w}$ high enough. The reason is that by construction of $w^b(H)$, the increase in expected compensation for the marginal risky strategy is the same as for the default strategy. Hence for any risky strategy with a higher success probability the increase in compensation is higher than for the default strategy.

Proposition 4. *The regulator can induce the board to choose a CEO compensation structure where a risky strategy gets implemented if and only if it increases the social surplus by requiring deferred compensation with a bonus cap $b = \bar{H}/\hat{H}$.*

Proof of Proposition 4. From Lemma 2, it follows that for $w^b(\bar{H}) = b\hat{w}^b$, the CEO will only present risky strategies where $pb\hat{w}^b \geq \hat{p}\hat{w}^b \Leftrightarrow p > \hat{p}/b$ and all safe strategies. As shown in the proof of Lemma 2, the board is willing to implement all risky strategies that the CEO presents for $b \leq \bar{H}/\hat{H}$ and all safe strategies where (2) holds. Hence, for $b = \bar{H}/\hat{H}$, a risky strategy will be implemented if and only if it increases the social surplus. $\qquad\square$

Given the compensation contract ω^b, a bonus cap will be be able to restrict the set of risky strategies that get implemented. It works, because the board cannot compensate the CEO for higher risk ex ante through a higher bonus. Thus, the CEO has no incentive to propose a high risk strategy to the board. After the CEO has presented a strategy, the board has all the decision making power. Hence, without commitment the board can never credibly promise to make side payments to the CEO after a strategy has been presented. Unenforceable side payments thus cannot be used to change the CEOs

incentives. However, the regulator needs to be able to observe all enforceable contract between the board and the CEO.

The optimal form of regulation of CEO compensation is not unique. Instead of a bonus cap, the regulator could require that the CEO receives compensation that is linear in the bank's total payoff i.e., $w(H) = \alpha H$ and $\hat{w} = \alpha \hat{H}$ for some $\alpha > 0$.

Lemma 3. *A linear compensation contract has the same effect on the implementation of strategies as the efficient bonus cap.*

Proof. When the compensation contract is linear the CEO will present a strategy if and only if $p\alpha H > \hat{p}\alpha\hat{H} \Leftrightarrow pH > \hat{p}\hat{H}$, i.e., when the strategy increases the social surplus.

The board will implement all safe strategies that increase gross shareholder surplus, which requires the board to renegotiate the compensation when

$$H - D - \alpha H < \hat{p}(\hat{H} - D - \alpha\hat{H})$$

This is possible subject to the requirement of a linear contract by offering a new linear contract α' where $\alpha'H = \hat{p}\alpha\hat{H}$.

The board is willing to implement all risky strategies that the CEO presents.[2] The CEO will engage in search if α is chosen high enough to satisfy the IC constraint. $\qquad \square$

The intuition behind this result is that linear contract always provides the right incentives for the CEO to present risky strategies. As in the case of a bonus cap the compensation for safe strategies will be renegotiated such that the board can implement all safe strategies that increase gross shareholder value. The ability to renegotiate the linear contract is important. In our setting it would not be optimal for the regulator to require that the sharing rule must not be changed.

An important advantage of a linear compensation contract is that its design is more robust and less sensitive to information. To set an optimal bonus cap, the regulator needs to know the characteristics of the bank's default strategy and the maximum possible payoff, i.e., $\hat{p}$, $\hat{H}$, and $\bar{H}$. If any of these parameters is not specified correctly, then a bonus cap will not induce the CEO to propose strategies that involve efficient risk taking and thus may result in too much or too little risk taking. In contrast, a compensation contract that is linear in the bank's total payoff always provide the CEO with incentives to propose only strategies that are socially optimal

4.3. Regulatory Leverage Constraint

Regulating CEO compensation can limit the risk shifting problem and constrains the CEO's willingness to, for example, propose using financial innovations to take excessive risk. The reason is that the CEO compensation is adversely affected by the increased risk

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[2]The manager is willing to implement any project without renegotiation where the inverse of (3) holds. For $p\bar{H} = \hat{p}\hat{H}$ this simplifies to equation (2). It is clear that for $\alpha < 1$ the shareholder profit generated by a risky project increases in p. Hence the board is willing to implement all risky projects that increase the social surplus ($p\bar{H} \geq \hat{p}\hat{H}$).

and regulating CEO compensation limits the board's ability to compensate the CEO for the higher risk. However, with an active board that acts in the interest of shareholders, regulating CEO compensation cannot assure that financial innovations are used to reduce risk whenever it is socially optimal. The reason is that the board will not approve a strategy that lowers the bank's risk unless shareholders benefit from it (or are at least not worse off). Board approval of a strategy that reduces risk depends on the level of leverage. A constraint on the leverage ratio allows the regulator to set a maximum amount of debt D that the bank can use, which affects the set of safe strategies that the board is willing to approve.

To discuss the optimal level of a possible regulatory leverage constraint, we need to model the regulator's objective function. We assume that there is a positive value to insured deposits; for example, households may associate a positive utility with insured deposits. Let $\gamma(D)$ be the monetary equivalent value of households' utility from insured deposits, where $\gamma(D)$ is an increasing and weakly concave function.[3] We believe that merely requiring zero deposits is not a realistic solution to the regulator's problem and by introducing a social value of deposits we want to capture the trade-off between improved risk taking of the bank and lower deposits in the most simple way. Our objective is not to carve out a specific optimal level of leverage, but to discuss the trade-offs involved when choosing this level in the presence of regulatory constraints on CEO compensation.

The objective function of the regulator can be written as the sum of the bank's expected payoff (total bank value and CEO compensation), search costs, and the value of insured deposits:

$$\hat{p}\hat{H} + \int_{\underline{p}}^{1} (p\bar{H} - \hat{p}\hat{H})\, dp + \int_{\underline{H}}^{\bar{H}} (H - \hat{p}\hat{H})\, dH - c + \gamma(D),$$

where the integration bounds $\underline{p}$ and $\underline{H}$ describe the set of strategies that get implemented. Regulation has a direct effect on $\underline{p}$ and $\underline{H}$ as the set of strategies that get implemented depends on the CEO compensation and the leverage D.

Optimal compensation regulation eliminates incentives to increase risk, and $\underline{p}$ does not depend on D given optimal compensation regulation. However, the board's incentive to approve a risk reduction strategy depends on the leverage and $\underline{H} = \hat{p}\hat{H} + (1 - \hat{p})D$. Hence the regulator's first order condition for the optimal D is given by

$$-(1 - \hat{p})^2 D + \gamma'(D) = 0,$$

and it is socially optimal to restrict leverage when $(1 - \hat{p})^2 I > \gamma'(I)$.

The socially optimal leverage is positive when $\gamma'(0) > 0$, which holds by assumption. The reason is that for very low D only those safe projects do not get implemented that would only marginally increase firm value anyway. In contrast, the marginal value of deposits is strictly positive.

Without compensation regulation, $\underline{p}$ also depends on the level of D, and any $D > 0$ results in the implementation of some risky strategies that are socially inefficient. Hence,

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[3]See, for example,**?** for a model that explicitly introduces the value of guaranteed deposits into households utility function.

any regulation that relies exclusively on a leverage constraint implies an inefficient cutoff for the implementation of risky strategy.

Proposition 5. *The optimal regulation combines compensation regulation and a leverage constraint.*

Since combining both instruments allows to achieve higher welfare they should not be regarded as substitutes. Compensation regulation alone is not optimal as it is not sufficient to provide the CEO with the "right" incentives. With an active board, the board's incentives are also important, and restricting leverage assures that boards, acting in the interest of shareholders, are more willing to approve a risk reduction. A pure leverage constraint is also not optimal as compensation regulation allows a higher level of leverage. The reason is that without compensation regulation, an increase in leverage increases the overinvestment into risky strategies. This effect vanishes when compensation is regulated and hence the socially optimal D increases. However, we do not want to suggest that introducing regulation of CEO compensation should reduce the level of regulatory capital requirement that we observe in practice. The reason is that capital requirements in the past are likely to have been too low, which has resulted in excessive risk taking.

Although it is optimal to combine both instruments, the combination of capital regulation and compensation regulation cannot achieve first-best.

Proposition 6. *The optimal regulation of capital and CEO compensation cannot implement the first best.*

The reason is that the optimal compensation regulation does not ensure the efficient implementation of safe strategies. As shown in Proposition 2, for any positive leverage, there are safe strategies that are socially efficient but that the board will not approve. The discussion above has shown that optimal capital regulation entails $D > 0$. The limits to regulation are caused by a corporate governance structure where both, the board and CEO must agree to a new strategy. Interestingly, the problem is not active risk shifting, which can be prevented, but the resistance to actively reduce bank risk.

Our finding suggests that when a bank's risk and leverage increase in a financial crisis, it is difficult for a regulator to assure that the bank shifts to a strategy with lower risk again. Forcing the bank to increase its equity in this case is more important than regulating CEO compensation.

4.4. Search and Regulation

An aspect of regulating CEO compensation that has been extensively discussed in the general press (Schumpeter, 2013; Schäfer, 2013) is its impact on the amount of CEO compensation. The concern is that bonus caps will increase the size of banker's fixed compensation component and their overall compensation package. We show that this concern is well taken.

Corollary 1. *Introducing a bonus cap increases the base wage $\hat{w}$ and total expected CEO compensation required to induce the CEO to search for a new strategy.*

Proof. Follows directly from Proposition 1 and Lemma 2. $\qquad\square$

To the extent that the increase in CEO compensation is a pure transfer from shareholders to the CEO, it is of no concern for the regulator. However, the increase in CEO pay makes it more costly to provide the CEO with search incentives. Moreover, CEO pay regulation reduces the set of risky strategies that the CEO will propose to the board, which decreases the expected benefit of search for shareholders. Thus, regulating CEO compensation increases the costs and reduces the benefits of search for shareholders. As a consequence, the board may no longer provide the CEO with incentives to search if a regulation on CEO compensation is introduced.

Reducing incentives to search for a new strategy is socially optimal if, without pay regulation, search was mainly motivated by a search for risk shifting opportunities. Indeed, the reduced value of search for shareholders that stems from the unwillingness of the CEO to propose risk shifting opportunities to the board in the presence of CEO pay regulation is socially beneficial. However, reduced incentives for search that stem from the higher rent that the CEO earns with compensation regulation, can be socially costly. Thus, the regulator might be concerned with the rent that the CEO earns.

Whether an optimal bonus cap or a linear wage structure is associated with a higher CEO rent depends on the characteristics of the strategies' payoffs, the distribution, the bank's leverage ratio, and the cost of search. For the regulator it can thus be optimal to leave the choice of using a bonus with a bonus cap set by the regulator or a linear sharing rule to the board. The board will then choose the contract that implements search at the lowest expected wage cost.

5. Compensation Regulation With a Passive Board

It is interesting to compare the results in the previous section with the case of an uninformed, passive board that delegates the implementation of the strategy to the CEO so that the CEO decides which strategy to pursue. Now, a linear compensation where the CEO receives a fixed fraction α of the bank's total payoff assures that the CEO implements the socially optimal strategy after search. Indeed, regulating CEO compensation is in this case so effective that no regulatory leverage constraint is needed.

Proposition 7. *With a passive (uninformed) board, a linear compensation, where the CEO receives a fixed fraction α of the bank's total payoff, assures that the CEO implements the socially optimal strategy; and the CEO searches for a new strategy if*

$$f \int_{\underline{p}^\alpha}^{1} p(\bar{H} - D) - \hat{p}(\hat{H} - D)\, dp + f \int_{\underline{H}^\alpha}^{\bar{H}} H - D - \hat{p}(\hat{H} - D)\, dH - c \geq 0 \qquad (12)$$

where $\underline{p}^a = \hat{p}\hat{H}/\bar{H}$ and $\underline{H}^\alpha = \hat{p}\hat{H}$.

Proof. If the compensation contract is linear, the CEO will implement a new strategy if and only if

$$p\alpha H > \hat{p}\alpha\hat{H} \Leftrightarrow pH > \hat{p}\hat{H}$$

which is equivalent to the set of strategies that increase the social surplus (eq. 10 and 11).

The CEO will engage in search if α is chosen high enough to satisfy the IC constraint.
□

A compensation that is linear in the bank's total payoff assures that the CEO always chooses the strategy that maximizes the total value of the bank. In contrast, deferred compensation with a bonus cap cannot always implement first best.

Lemma 4. *A deferred compensation with a bonus cap does not assure that the CEO always maximizes total bank value if the board delegates the choice of strategy to the CEO.*

Proof. See Appendix B.
□

The intuition is that a bonus cap only targets the maximum bonus and thus the amount of risk taking incentive that the board can provide. In contrast, the compensation for sound projects $w(H)$ relative to the default compensation $\hat{w}$ is determined by the board and thus will not reflect the social optimum. Thus, from a regulatory perspective, a linear contract dominates a bonus cap when the board is passive and is as good as a bonus cap if the board is active.

6. Discussion and Conclusion

We have shown that combining the regulation of bank capital and CEO compensation allows to achieve higher efficiency than any of the two in isolation if the board actively represents shareholders' interests. Restricting the maximum bonus of bank CEOs effectively curtails overinvestment into a risky strategy while capital regulation prevents excessive leverage and makes sure that the board is more willing to accept strategies that reduce the bank's risk. The limited effectiveness of regulating CEO compensation results from a shareholder friendly board that retains the ultimate power to approve a new bank strategy that the CEO proposes. While the regulator can limit the CEO's willingness to propose high risk strategies to the board, compensation regulation does not affect the board's willingness to approve risk reduction strategies.

If a passive board delegates the choice of bank strategy to the CEO, regulating the pay of the bank CEO has more bite and can implement first-best risk taking by the CEO. Indeed, in our setting, no regulatory leverage constraint is needed to curtail risk shifting incentives as the CEO will maximize total bank value, not shareholder value.

A regulatory constraint on CEO pay limits the board's ability to align the interests of the CEO with those of shareholders. This is consistent with the objective of the regulator, but also limits the board's willingness to delegate decisions to the CEO. Indeed, it provides incentives to the board to become more active. We thus predict that board

activism and the number of CEO decisions on which the board wants to have a say will increase as regulation of CEO compensation becomes more effective in constraining the privately optimal contract. The increase in board activism might be advertised as improved governance, but actually aim at countervailing the CEO's willingness to put the total bank value over the interest of shareholders.

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A. Lemma 2

Proof of Lemma 2. When it is mandatory to defer the entire amount of compensation, then $w_F, \hat{w}_F = 0$, and $w_{base} = \min\{\hat{w}, \min_H w(H)\}$. Hence a bonus cap requires that $\hat{w} \geq w(\bar{H})/b$ and $\min_H w(H) \geq w(\bar{H})/b$.

From the CEO's incentive constraint (8) it follows that the the amount of compensation is increasing in $\hat{w}$. All else equal it is thus profitable for the board to minimize $\hat{w}$. In order to minimize $\hat{w}$ the board must thus minimize $w(\bar{H})$, while preserving the mangers incentive to search and present profitable strategies. To preserve the CEO with search incentives

the board must maximize the expected increase in compensation from implementing new strategies subject to $w(\bar{H})$, $\hat{w}$, the bonus cap, and the monotonicity of the compensation contract.

The maximum additional increase in compensation that the board can credibly promise to the CEO for finding a safe strategy with return H is given by the increase in shareholder surplus v_S. This requires that the board promises a wage $w(H) = v_S(H) + \hat{p}\hat{w}$. The monotonicity of the compensation contract requires that $w(H) \le w(\bar{H}) \forall H$ and hence $w(H) = w(\bar{H})$ for all $v_S(H) + \hat{p}\hat{w} \ge w(\bar{H})$. The bonus cap requires that $\min_H w(H) \ge w(\bar{H})/b$. Since a compensation above $v_S(H) + \hat{p}\hat{w}$ will be renegotiated by the board, reducing the CEOs expected compensation, this constraint will be binding i.e., $w(H) = w(\bar{H})/b$, for all $v_S(H) + \hat{p}\hat{w} < w(\bar{H})/b$. The compensation that CEO expects to obtain from risky strategies is uniquely determined by $w(\bar{H})$.

Lowering $\hat{w}$ will c.p. increase the additional expected compensation that the CEO receives from safe and risky strategy. Hence the constraint of the bonus cap on the compensation for the will be binding i.e., $\hat{w} = w(H)/b$. It thus follows that ω^b maximizes the search incentives for given a given $w(\bar{H})$ and conversely $w(\bar{H})$ and $\hat{w}$ are is minimized for a given level of search incentives.

The compensation ω^b for $b \le \bar{H}/\hat{H}$ is such that the CEO will presents a risky strategy for $p \ge \hat{p}/b$. The board will never successfully renegotiate the compensation for these strategies.[4] The CEO will present all safe strategies since $w(H) \ge w(\bar{H})/b = \hat{w} > \hat{p}\hat{w}$. The compensation will be renegotiated when $v_S(H) + \hat{p}\hat{w} < \hat{w}$. Hence the CEO's expected additional compensation from search is given by

$$f\left(\int_{\underline{H}}^{\tilde{H}} v_S(H)\,dH + \int_{\tilde{H}}^{\bar{H}} b\hat{w} - \hat{p}\hat{w}\,dH + \int_{\underline{p}}^{1} pb\hat{w} - \hat{p}\hat{w}\,dp\right) \tag{13}$$

where $\underline{H} = D + \hat{p}(\hat{H} - D) + (1-\hat{p})\hat{w}$, $\tilde{H} = D + \hat{p}(\hat{H} - D) + (b-\hat{p})\hat{w}$, and $\underline{p} = \hat{p}/b$. Consider the derivative of 13 with respect to $\hat{w}$ at $\hat{w} = 0$. The derivatives of all three terms must be positive. Since the derivatives are continuous the derivative must be increasing for $\hat{w}$ small enough. Hence there exists a $\hat{w}$ such that ω^b satisfies the CEO's incentive constraint for c small enough. Since the CEOs expected additional compensation from search must be an increasing function of the search cost $\hat{w}^b(c)$ will be an increasing function of c.

The total cost of providing search incentives to the CEO is given by $\hat{p}\hat{w}^b(c) + c$: The expected additional compensation from implementing new strategies must equal c and the CEO receives $\hat{p}\hat{w}^b$ as a rent. It is thus optimal to provide search incentives when the expected increase in shareholder surplus from search exceeds the total cost i.e.,

$$c + \hat{p}\hat{w}^b(c) < f\left(\int_{\underline{H}}^{\bar{H}} H - D - \hat{p}(\hat{H} - D)\,dH + \int_{\underline{p}}^{1} p(\bar{H} - D) - \hat{p}(\hat{H} - D)\,dp\right)$$

where $\underline{H} = D + \hat{p}(\hat{H} - D)$ and $\underline{p} = \hat{p}/b$. This is always satisfied when the search cost is low enough. $\qquad\square$

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[4]The board is willing to implement a risky strategy without renegotiation if $p \ge \hat{p}\frac{\hat{H}-D-\hat{w}}{\bar{H}-D-b\hat{w}}$. Comparing the expressions yields that $\hat{p}\frac{\hat{H}-D-\hat{w}}{\bar{H}-D-b\hat{w}} \le \hat{p}/b \,\forall D$ and $b \le \bar{H}/\hat{H}$.

B. Lemma 4

Proof of Lemma 4. A bonus cap requires that $\hat{w} \geq w(\bar{H})/b$ and $\min_H w(H) \geq w(\bar{H})/b$. Distinguish two cases:

Case 1: Suppose that $\min_H w(H) > \hat{p}\hat{w}$. In this case, the CEO will implement all safe strategies which results in overinvestment into safe projects.

Case 2: Suppose that $\min_H w(H) \leq \hat{p}\hat{w}$. In this case, the CEO will never implement a safe strategy when $w(H) = \min_H w(H)$.

From the CEO's incentive constraint (8), it follows that the the amount of compensation is increasing in $\hat{w}$. All else equal, it is thus profitable for the board to minimize $\hat{w}$ while preserving the CEO's incentive to search and implement profitable strategies. Since for $\min_H w(H) \leq \hat{p}\hat{w}$ the constraint $\hat{w} \geq w(\bar{H})/b$ is never binding, it is always optimal to set $\hat{w} = \min_H w(H)/\hat{p}$. Hence, in order to minimize $\hat{w}$, the board must minimize $\min_H w(H)$ which implies that $\min_H w(H) \geq w(\bar{H})/b$ will hold with equality. Hence order to minimize $\hat{w}_F$ subject to a bonus cap, the board must thus minimize $w(\bar{H})$.

If $\hat{p}\hat{w} = w(\bar{H})/b$ a bonus cap can only implement the efficient implementation of risky strategies if $b = \bar{H}/\hat{H}$.

Let **H** denote the set of safe strategies that the CEO is willing to implement, i.e., $\{H : w(H) > \hat{p}\hat{w}\}$. Note that when the CEO optimally chooses $w(H)$, **H** must be an interval $[\underline{H}, \bar{H}]$. Otherwise, there would exist a safe strategy not included in **H** with $H' > \underline{H}$ and the board could increase shareholder value by setting $w(H') = w(\underline{H})$ and $w(\underline{H}) = 0$, without changing the CEO's incentives to search for new strategies. Given $\underline{H}$, the compensation contract that maximizes the CEO's compensation for search subject to the bonus cap is given by

$$w(H) = \begin{cases} w(\bar{H}) & \text{if } H > \underline{H} \\ \hat{p}\hat{w} & \text{otherwise} \end{cases}$$

Hence, this compensation contract allows the board to choose the lowest $w(\bar{H})$ and $\hat{w}$ conditional on $\underline{H}$. The CEO's incentive constraint can thus be written as

$$f \int_{\hat{p}/b}^{1} pb\hat{p}\hat{w} - \hat{p}\hat{w} \, dp + f \int_{\underline{H}}^{\bar{H}} b\hat{p}\hat{w} - \hat{p}\hat{w} \, dH \geq c \tag{14}$$

When this constraint holds with equality, the shareholder value is given by

$$f \int_{\hat{p}/b}^{1} p(H - D) - \hat{p}(\hat{H} - D) \, dp + f \int_{\underline{H}}^{\bar{H}} H - D - \hat{p}(\hat{H} - D) \, dH + \hat{p}(\hat{H} - D) - c - \hat{p}\hat{w}$$

The first order conditions for maximizing the shareholder profit subject to the CEO's incentive constraint yield

$$\frac{(\hat{p}\hat{w})^2}{c}(b - 1) = \hat{p}(\hat{H} - D) - (\underline{H} - D) \tag{15}$$

Thus, for generic parameter values, the solutions to equations (14) and (15) will be such that $\underline{H} \neq \hat{p}\hat{H}$ for $b = \bar{H}/\hat{H}$ and thus the set of safe strategies that get implemented

will not coincide with the set of socially efficient strategies. This implies that a bonus cap generically cannot implement the first best. $\qquad\square$