Regulating bankers' pay: Incentive contracts and non-binding salary caps

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Abstract

This paper analyzes the effects of various regulatory caps on bankers' pay. We use a principal–agent model with moral hazard in which a bank and a banker bargain over an incentive contract. Within this framework, we discuss the consequences of (i) a cap on the banker's bonus, (ii) concurrent caps on both the banker's bonus and the fixed payment, and (iii) a cap on the banker's total payment. We find that all the caps negatively affect the banker's effort and the efficiency of the contract, even if the caps are modest and non-binding such that they are introduced at a level above the bargaining outcome without a cap. With regard to social welfare, two concurrent caps on the bonus and the fixed payment have the most negative effect.

Keywords: Regulatory pay caps; incentive contracts; moral hazard; Kalai–Smorodinsky bargaining solution

JEL Classification: C71, D86, G28, J33, H12

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1 Introduction

Demands to regulate the financial sector have been on the political agenda in many countries since the financial crisis of 2008-2009. In this context, it is often argued that the structure of bankers' and executives' remuneration is an important determinant of the riskiness of banks. For example, Thanassoulis (2012) reports that most financial institutions in a sample of 21 systemically important banks paid out more than 20% of shareholder equity as remuneration every year throughout the period from 1998 to 2009. He concludes that remuneration payments of this size significantly increase the default risk of the institution. Consequently, restrictions on bankers' pay are an important and much-discussed factor of the regulatory interventions considered by several governments. In July 2013, following Basel III, the European Union adopted new standards on bankers' pay as part of the fourth Capital Requirements Directive CRD-IV (European Commission, 2013). These standards set, inter alia, caps on bankers' bonus payments such that the sum of variable elements of remuneration shall not exceed the fixed-payment component (see Dittmann et al., 2011, for an overview of proposals to restrict realized compensation payments).

This work contributes to the ongoing debate on regulations in the financial sector in general and restrictions on bankers' payments in particular. We analyze the consequences of various pay caps — (i) a cap on the banker's bonus, (ii) concurrent caps on both the banker's bonus and the fixed payment, and (iii) a cap on the banker's total payment — in a bank–banker agency model with effort choice, moral hazard, and bargaining over an incentive contract. Bargaining over employment contracts is typical for many companies in the financial sector, particularly for high-skilled employees. To model the consequences of pay caps if there is bargaining over contracts, we apply the cooperative bargaining solution proposed by Kalai and Smorodinsky (1975).

Our work particularly focuses on the effects of non-binding pay caps on banker's effort choices and the efficiency of the negotiated incentive contract. We show that even modest pay caps — those introduced at a non-binding level above the market wage — can affect the incentive contract. The Nash solution would predict that pay caps have an effect on the bargaining outcome only if the cap is binding; that is, if the cap is lower than the banker's

pay without a cap. A non-binding pay cap would not change the bargaining outcome because of the axiom of independence of irrelevant alternatives (IIA). However, the plausibility of this axiom has been frequently criticized (see Luce and Raiffa, 1957; Alexander, 1992). Based on this criticism, Kalai and Smorodinsky (1975) substitute the IIA axiom with an individual monotonicity condition, which implies that the players' payoffs must not suffer as a result of an enlargement of the bargaining set that leaves the maximum utilities attainable by both players unchanged. Kalai and Smorodinsky (1975) suggest a solution in which both parties make equal proportional concessions from their best obtainable payoffs, given that the other player receives at least her disagreement payoff.[1] In the Kalai–Smorodinsky solution (henceforth: KS solution), a non-binding pay cap can affect the bargaining outcome because it may reduce the banker's maximum attainable gain, thus reducing the banker's claim to the bargaining set. Our results imply that a non-binding pay cap is, in most cases, harmful to the efficiency of the contract in terms of social welfare. In any case, it is harmful to the banker's payoff. However, the structure of the pay cap is important as, for example, concurrent caps on both the bonus and the fixed payment have a more negative effect on effort and social welfare than a cap on the total payment.

This chapter proceeds as follows. Section 3.2 provides a brief review of the related literature, while Section 3.3 lays out the model. Section 3.4 analyzes the consequences of various forms of pay caps. Finally, Section 3.5 concludes.

2 Related literature

The objective of this work is to study the effects of various forms of regulatory pay caps on effort choice, banks' and bankers' payoffs and social welfare in a principal–agent framework suffering from moral hazard. Our paper is related to a number of studies regarding executive compensation, particularly those investigating compensation in the financial sector at the time of the financial crisis. Bolton, Mehran, and Shapiro (2010) study the connection between

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[1]Empirical and experimental evidence in favor of the Kalai–Smorodinsky solution is provided by, inter alia, Heckathorn (1978), Laroque and Salanié (2004) and Dittrich, Knabe, and Leipold (2014).

risk-taking and executive compensation in financial institutions. Their model demonstrates that excessive risk-taking can be addressed by linking executive pay to both stock price and the price of debt, which may, however, not be optimal from the shareholders' point of view. Cadman, Carter, and Lynch (2010) analyze empirically whether restrictions on executive pay schemes influence firms' willingness to participate in the Troubled Asset Relief Program (TARP). The authors report that firms in which the pay restrictions are likely to be less binding are more likely to engage in the bailout process by applying for and accepting TARP funds.

One strand of the literature uses job assignment models to study the consequences of a pay cap policy. Building on the competitive market model for CEOs by Gabaix and Landier (2008), Llense (2010) uses a job assignment model to analyze the wage distribution of the French CEO labor market and to evaluate the costs of a wage cap policy. She reports that caps have a moderate impact on shareholder value. Thanassoulis (2012) presents a model of banker remuneration in a competitive market for banker talent, studying the default risk of banks generated by investment and remuneration pressures. He argues that modest limits on bonuses payable to bank employees yield lower bank default risk and higher bank values. Thanassoulis (2012) concludes that stringent limits on bonuses would increase bank default risk. The reason is that banks would have to substitute bonus payments with fixed payments, leading to high fixed costs independent of their employees' performance. Thanassoulis (2014) studies the effects of a regulatory pay cap for bankers targeted in proportion to the risk-weighted assets they control. He shows that a variable pay cap in proportion to assets leans against the competitive externality that drives up pay. Such a cap acts to lower aggregate remuneration. Hence, banks will have increased resilience to shocks on the value of their assets due to their reduced cost base. These studies, however, do not address effort choices in their models of pay restrictions.

Another strand of the literature builds on incentive contract models. Edmans, Gabaix, and Landier (2009) integrate a moral hazard problem (which gives rise to incentive pay) into a talent assignment model. However, they do not address the consequences of pay caps. Dittmann, Maug, and Zhang (2011) investigate the consequences of restrictions on executive compensation

in a contracting model. The authors find that restrictions on total ex post (i.e. actual realized) payouts lead to higher average compensation, higher rewards for mediocre performance, and lower risk-taking incentives. In other words, some CEOs would be better off with a restriction than without it. Restrictions on total ex ante pay (as opposed to actual realized pay) lead to a reduction in the firm's demand for CEO talent and effort. Restrictions on particular pay components — especially restrictions on cash payouts — can be easily circumvented. While restrictions on option pay lead to lower risk-taking incentives, restrictions on incentive pay result in higher risk-taking incentives. The fact that bankers and banks bargain over an employment contract is not addressed in these studies. Our paper aims to fill this gap.

Our paper is also related to the literature on bargaining behaviour. The Nash solution is the most frequently used solution concept in cooperative bargaining situations. Nash (1950) proposes that the bargaining solution should satisfy the following axioms: (i) invariance to affine transformations, (ii) Pareto optimality, (iii) independence of irrelevant alternatives and (iv) symmetry. The third axiom (IIA) states that eliminating some apparently irrelevant alternatives should not change the point chosen by the solution function. As mentioned before, the plausibility of this axiom has been frequently criticized (see e.g., Luce and Raiffa, 1957; Alexander, 1992), and based on this criticism, Kalai and Smorodinsky (1975) substitute the IIA axiom with an individual monotonicity condition. Moreover, empirical and experimental evidence supports the KS solution over the Nash solution (Heckathorn, 1978; Laroque and Salanié, 2004; Dittrich, Knabe, and Leipold, 2014). However, only a rather small number of theoretical models build on this empirical evidence to use the KS solution to model bargaining situations. This negligence is surprising because — besides the empirical evidence — both the Nash and the KS solutions are derived axiomatically and have game-theoretic foundations (Binmore, Rubinstein, and Wolinsky, 1986, for the Nash solution and Moulin, 1984, for the KS solution). Alexander (1992) characterizes the KS solution in a right-to-manage model of union–firm wage bargaining. Gerber and Upmann (2006) introduce the KS solution in an efficient union–firm bargaining framework, showing that a higher disagreement payoff has negative effects on employment if bargaining follows the Nash solution, while the em-

ployment effect in the KS solution is ambiguous. Dittrich and Knabe (2013) show in a right-to-manage bargaining model that spillover effects from low minimum wages can be explained by the KS solution, but not by the Nash solution. L'Haridon, Malherbet, and Pérez-Duarte (2013) apply the KS solution in a matching framework. Dittrich and Städter (2015) introduce the KS solution in a moral hazard framework, showing that the agents' respective bargaining power determines whether the worker's effort is higher in the Nash or the KS solution.

3   The model

3.1   Key assumptions

We study a standard principal-agent model in which a risk-neutral bank and a risk-neutral banker bargain over an incentive contract (Demougin and Helm, 2006). If bargaining is not successful, both parties receive a disagreement payoff that we assume to be zero. If both parties agree on a contract, the banker exerts effort $e \in [0, 1]$ and produces an output $v(e)$, where $v(e)$ is increasing, concave and satisfies the Inada conditions.[2] The output is not verifiable and therefore not contractible, but it generates a binary signal $\sigma \in \{0, 1\}$ that provides information about the effort exerted. As σ is observable and verifiable, however, the parties can contract on it. The bank receives the signal $\sigma = 1$ with probability $p(e)$, with $p'(e) > 0$ and $p''(e) < 0$. The banker receives a fixed payment F and, in addition, an incentive compatible bonus b if $\sigma = 1$. The probability of receiving the bonus depends positively on the effort exerted, thus potentially making more effort worthwhile for the banker. The banker's effort costs are given by $c(e)$, where $c(e)$ is an increasing convex function with $c(0) = c'(0) = 0$ and $c(1) = c'(1) = \infty$. We assume that the banker is financially constrained and may not make any payments to the bank (limited liability).

Summarizing, we end up with the expected payoff functions for the bank, $\Pi = v(e) - bp(e) - F$, and the banker, $U = bp(e) - c(e) + F$. Social welfare is given by the sum of both players' payoffs, $S(e) = v(e) - c(e)$, and the

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[2]Moreover, we assume that exerting no effort will yield no output, i.e. $v(0) = 0$.

welfare-maximizing (first-best) effort e^* is implicitly given by $v'(e^*) = c'(e^*)$. Maximizing the banker's payoff over e yields the incentive constraint $b = \frac{c'(e)}{p'(e)} \geq 0$, which implicitly defines the banker's optimal effort given the bonus b. We denote the expected incentive compatible bonus with $B(e) = p(e)b = p(e)\frac{c'(e)}{p'(e)}$ and assume $B(e)$ to be convex (Demougin and Helm, 2011).[3] Given that $b \geq 0$, the banker's financial constraint can straightforwardly be reduced to $F \geq 0$.

3.2   Bargaining over the incentive contract

To describe the outcome of bargaining between the bank and the banker, we use the solution proposed by Kalai and Smorodinsky (1975). The KS solution is determined by the KS curve

$$\frac{U^+}{\Pi^+} = \frac{U(e)}{\Pi(e)}, \tag{1}$$

where $U(e)$ and $\Pi(e)$ denote the agents' payoffs and U^+ and Π^+ denote the agents' bliss points.

Lemma 1 *The bank's and the banker's bliss points in a situation without any pay cap are given by $\Pi^{+w} = v(e^{**}) - B(e^{**})$ and $U^{+w} = v(e^*) - c(e^*)$, respectively.*

Proof. To derive the bank's bliss point, we maximize the bank's expected payoff subject to the banker's incentive constraint $(b = \frac{c'(e)}{p'(e)})$, the participation constraint $(U \geq 0)$ and the limited liability constraint $(F \geq 0)$. Inserting the incentive constraint and setting up the Lagrangian yields:

$$\max_{e,F,\rho,\sigma} \mathcal{L} = v(e) - B(e) - F + \rho[B(e) - c(e) + F] + \sigma F. \tag{2}$$

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[3]$B' = c' + px > c'$, with $x \equiv \frac{c''p' - c'p''}{p'^2} > 0$, and $B'' = c'' + p'x - \frac{2pp''x}{p'} + \frac{p[c'''p' - c'p''']}{p'^2}$. Hence, the sign of B'' depends on c''' and p'''.

Maximizing (2) yields the first-order conditions for effort e^{**} (3), the fixed payment (4) and the complementary slackness conditions (5) and (6):

$$v'(e^{**}) - B'(e^{**}) + \rho[B'(e^{**}) - c'(e^{**})] = 0 \qquad (3)$$

$$-1 + \rho + \sigma = 0 \qquad (4)$$

$$B(e^{**}) - c(e^{**}) + F^{**} \geq 0, \rho \geq 0, \rho[B(e^{**}) - c(e^{**}) + F^{**}] = 0 \qquad (5)$$

$$F^{**} \geq 0, \sigma \geq 0, \sigma F^{**} = 0 \qquad (6)$$

From (5) we know that $\rho = 0$ has to hold; otherwise, $F^{**} = c(e^{**}) - B(e^{**}) < 0$ would contradict the limited liability constraint.[4] From (4) it follows that $\sigma = 1$; thus, from (6) we have $F^{**} = 0$. Finally, (3) implicitly defines the effort e^{**} that equalizes the marginal output and the marginal expected bonus. The corresponding bonus is given by $b^{**} = \frac{c'(e^{**})}{p'(e^{**})}$, and the bank's bliss point is $\Pi^+ = v(e^{**}) - B(e^{**})$.

To derive the banker's bliss point, we maximize the banker's expected payoff subject to her incentive constraint, the limited liability constraint and the bank's participation constraint ($\Pi \geq 0$). Inserting the incentive constraint and setting up the Lagrangian yields:

$$\max_{e,F,\lambda_w,\mu_w} \mathcal{L} = B(e) - c(e) + F + \lambda_w[v(e) - B(e) - F] + \mu_w F. \qquad (7)$$

Maximizing (7) yields the first-order conditions for effort $\widehat{e}^w$ (8), the fixed payment $\widehat{F}$ (9) and the complementary slackness conditions (10) and (11):

$$B'(\widehat{e}^w) - c'(\widehat{e}^w) + \lambda_w[v'(\widehat{e}^w) - B'(\widehat{e}^w)] = 0 \qquad (8)$$

$$1 - \lambda_w + \mu_w = 0 \qquad (9)$$

$$v(\widehat{e}^w) - B(\widehat{e}^w) - \widehat{F}^w \geq 0, \lambda_w \geq 0, \lambda_w[v(\widehat{e}^w) - B(\widehat{e}^w) - \widehat{F}^w] = 0 \qquad (10)$$

$$\widehat{F}^w \geq 0, \mu_w \geq 0, \mu_w \widehat{F}^w = 0 \qquad (11)$$

From (9) it follows that $\lambda_w > 0$, and from (10), we have $\widehat{F}^w = v(\widehat{e}^w) - B(\widehat{e}^w) > 0$. Inserting $\mu_w = 0$ from (11) into (9) yields $\lambda_w = 1$. Then, (8) simplifies to $v'(\widehat{e}^w) = c'(\widehat{e}^w)$. Effort at the banker's bliss point is at the socially optimal

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[4]Note that $B(e) = p(e)\frac{c'(e)}{p'(e)} = p(e)\frac{ec'(e)}{ep'(e)} > c(e)$, with $ec'(e) > c(e)$ and $ep'(e) < p(e)$ by the curvature assumptions.

level, $\widehat{e}^w = e^*$, with the corresponding bonus payment $\widehat{b}^w = b^* = \frac{c'(e^*)}{p'(e^*)}$. Moreover, the banker receives a fixed payment $\widehat{F}^w = v(e^*) - B(e^*)$. Social welfare is maximized and, by means of the fixed payment, the banker extracts the entire welfare, leaving the bank with zero payoff. The banker's bliss point is therefore given by $U^+ = v(e^*) - c(e^*)$. ■

Inserting the bliss points into the KS curve (1) yields:

$$\frac{v(e^*) - c(e^*)}{v(e^{**}) - B(e^{**})} = \frac{B(e^w) - c(e^w) + F^w}{v(e^w) - B(e^w) - F^w} \tag{12}$$

$$\text{s.t. } F^w \geq 0, \tag{13}$$

implicitly determining the effort. The corresponding bonus is $b^w = \frac{c'(e^w)}{p'(e^w)}$. Whether the limited liability constraint (13) is binding depends on the output function and the effort-cost function. If (13) is binding, $F^w = 0$ and (12) simplifies to:

$$\frac{v(e^*) - c(e^*)}{v(e^{**}) - B(e^{**})} = \frac{B(e^w) - c(e^w)}{v(e^w) - B(e^w)}. \tag{14}$$

If (13) does not bind, we end up with $F^w > 0$, and effort remains at the socially optimal level, $e^w = e^*$. Until effort reaches the first-best level, the respective contract would define a fixed payment of zero, as only the bonus incentivizes the banker to exert effort. Any effort greater than e^*, however, would not be Pareto efficient. Therefore, from this level onwards, the contract would specify a bonus so as to induce e^* and a positive fixed payment. In the following, we assume that the efficient solution is not reached; thus, $e^w < e^*$ and $F^w = 0$ applies.

4 Effects of regulatory pay caps

4.1 Cap on the bonus

The consequences of a regulatory cap on the bonus depend on the level at which the cap is introduced. First, it is straightforward that a weak bonus cap, one which exceeds both the bonus that would result from bargaining without a regulatory cap as well as the banker's bliss point, will have no effect. Second, it is also straightforward that a stringent bonus cap below

the bargained bonus would be binding and would change the bargaining outcome independent of the specific bargaining solution. Third, a modest bonus cap may affect the bargaining outcome — even if it is non-binding at the bonus — as long as it changes the banker's bliss point. We are interested in the consequences of such a modest bonus cap, $\bar{b}$, that is only binding at the banker's bliss point but is non-binding at the bargained bonus, that is, $b^w < \bar{b} < \widehat{b}^w = b^*$.[5]

Lemma 2 *The banker's bliss point with a modest bonus cap is given by $U^{+bc} = v(\widehat{e}^{bc}) - c(\widehat{e}^{bc}) < U^+$. The bliss point bonus is smaller than in a situation without a bonus cap, $\widehat{b}^{bc} < \widehat{b}^w$, and the bliss point fixed payment is higher, $\widehat{F}^{bc} > \widehat{F}^w$. The bank's bliss point is not affected by the bonus cap.*

Proof. To calculate the banker's bliss point with the bonus cap $\bar{b}$, we introduce this additional constraint into the maximization problem (2):

$$\max_{e,F,\lambda_{bc},\mu_{bc},\theta_{bc}} \mathcal{L} = B(e) - c(e) + F + \lambda_{bc}[v(e) - B(e) - F] + \mu_{bc}F$$
$$+ \theta_{bc}\left[\bar{b} - \frac{B(e)}{p(e)}\right]. \tag{15}$$

Maximizing (15) yields the first-order conditions for effort $\widehat{e}^{bc}$ (16), the fixed payment $\widehat{F}^{bc}$ (17) and the complementary slackness conditions (18)-(20):

$$B'(\widehat{e}^{bc}) - c'(\widehat{e}^{bc}) + \lambda_{bc}[v'(\widehat{e}^{bc}) - B'(\widehat{e}^{bc})]$$
$$-\theta_{bc}\left[\frac{B'(\widehat{e}^{bc})p(\widehat{e}^{bc}) - B(\widehat{e}^{bc})p'(\widehat{e}^{bc})}{p(\widehat{e}^{bc})^2}\right] = 0 \tag{16}$$

$$1 - \lambda_{bc} + \mu_{bc} = 0 \tag{17}$$

$$v(\widehat{e}^{bc}) - B(\widehat{e}^{bc}) - \widehat{F}^{bc} \geq 0, \lambda_{bc} \geq 0, \lambda_{bc}[v(\widehat{e}^{bc}) - B(\widehat{e}^{bc}) - \widehat{F}^{bc}] = 0 \tag{18}$$

$$\widehat{F}^{bc} \geq 0, \mu_{bc} \geq 0, \mu_{bc}\widehat{F}^{bc} = 0 \tag{19}$$

$$\bar{b} - \frac{B(\widehat{e}^{bc})}{p(\widehat{e}^{bc})} \geq 0, \theta_{bc} \geq 0, \theta_{bc}\left[\bar{b} - \frac{B(\widehat{e}^{bc})}{p(\widehat{e}^{bc})}\right] = 0 \tag{20}$$

As $\bar{b}$ is binding at the banker's bliss point, from (20) it holds that $\theta_{bc} > 0$. From (17) it follows that $\lambda_{bc} > 0$ must hold, and from (18) we have

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[5] As $b^{**} < b^w$, the bonus cap is also not binding at the bank's bliss point, $\bar{b} > b^{**}$.

$\widehat{F}^{bc} = v(\widehat{e}^{bc}) - B(\widehat{e}^{bc}) > 0$. Inserting $\mu_{bc} = 0$ from (19) into (17) yields $\lambda_{bc} = 1$. Thus, (16) simplifies to $v'(\widehat{e}^{bc}) - c'(\widehat{e}^{bc}) = \theta_{bc} \left[\frac{B'(\widehat{e}^{bc})p(\widehat{e}^{bc}) - B(\widehat{e}^{bc})p'(\widehat{e}^{bc})}{p(\widehat{e}^{bc})^2} \right]$, implicitly defining the effort at the banker's bliss point $\widehat{e}^{bc}$. Since the right-hand side is positive,[6] we end up with $v'(\widehat{e}^{bc}) > c'(\widehat{e}^{bc})$ and $\widehat{e}^{bc} < \widehat{e} = e^*$. Compared to $v'(\widehat{e}) = c'(\widehat{e})$ in the situation without a bonus cap, the expected bonus at the banker's bliss point is smaller. However, the fixed payment at the banker's bliss point with a bonus cap is larger, $\widehat{F}^{bc} = v(\widehat{e}^{bc}) - B(\widehat{e}^{bc}) > \widehat{F} = v(e^*) - B(e^*)$,[7] but the increase in the fixed payment does not fully compensate the loss in expected bonus. The banker extracts the whole social surplus via the fixed payment to receive her bliss point. However, as $\widehat{e}^{bc} < \widehat{e} = e^*$, the social surplus at the banker's bliss point is smaller with a bonus cap. We therefore end up with $U^{+bc} = v(\widehat{e}^{bc}) - c(\widehat{e}^{bc}) < U^+$. ∎

To derive the bargaining outcome with a modest bonus cap, we insert the banker's bliss point U^{+bc} and the bank's bliss point Π^+ into (1):

$$\frac{v(\widehat{e}^{bc}) - c(\widehat{e}^{bc})}{v(e^{**}) - B(e^{**})} = \frac{B(e^{bc}) - c(e^{bc}) + F^{bc}}{v(e^{bc}) - B(e^{bc}) - F^{bc}} \qquad (21)$$

$$\text{s.t. } F^{bc} \geq 0. \qquad (22)$$

(21) and (22) implicitly define the effort e^{bc} and the bonus $b^{bc} = \frac{c'(e^{bc})}{p'(e^{bc})}$. The same logic applies as in a situation without a bonus cap. Depending on the specific functional forms of output and effort costs, the limited liability constraint may be binding and effort will be socially optimal. However, as we assume that without a bonus cap the socially efficient effort will not be obtained, it will also not be obtained in a situation with a bonus cap. Thus, effort is $e^{bc} < e^*$, and $F^{bc} = 0$ applies. Comparing the bargaining outcomes in both situations gives our first result.

Proposition 1 *With a modest bonus cap, the banker exerts less effort than without a bonus cap, $e^{bc} < e^w < e^*$, and the social surplus is smaller, $S(e^{bc}) < S(e^w) < S(e^*)$. The banker's utility is smaller, $U(e^{bc}) < U(e^w)$, and the bank's profit is higher, $\Pi(e^{bc}) > \Pi(e^w)$, than without a bonus cap.*

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[6]This is seen straightforwardly if we multiply the bracket term by $\frac{\widehat{e}^{bc}}{\widehat{e}^{bc}}$. By the convexity of $B(e)$, it holds that $\widehat{e}^{bc}B'(\widehat{e}^{bc}) > B(\widehat{e}^{bc})$, and by the concavity of $p(e)$, it holds that $p(\widehat{e}^{bc}) > \widehat{e}^{bc}p'(\widehat{e}^{bc})$. Thus, the numerator is positive, and, because of $\theta_{bc} > 0$, the whole term is strictly positive.

[7]Note that $v'(e) < B'(e)$ and $\widehat{e}^{bc} < \widehat{e}$.

Proof. The KS curve (1) implies that the ratio of the banker's and the bank's bliss points has to equal the ratio of the banker's and the bank's payoffs. Since $U^{+bc} < U^+$ and $\Pi^{+bc} = \Pi^+$, the left-hand side of (1) is smaller with a bonus cap; thus, the right-hand side must be smaller, too. Differentiating the right-hand side of (1), $\frac{B(e)-c(e)}{v(e)-B(e)}$, with respect to e yields $\frac{[B'(e)-c'(e)]\Pi(e)-[v'(e)-B'(e)]U(e)}{\Pi(e)^2} > 0$, because $v'(e) < B'(e) > c'(e)$. Thus, to satisfy the equation, effort must be smaller. The bargaining outcome shifts to the left on the Pareto frontier (PF), which implies that the banker's payoff is smaller and the bank's payoff is larger than without a bonus cap. ∎

Note that in a situation in which the efficient effort is reached without the bonus cap, we have $e^{bc} \le e^w = e^*$. Depending on the level of the bonus cap and the specific functional forms of output and effort costs, there are two possible scenarios. First, effort may remain at the socially efficient level, $e^{bc} = e^w = e^*$, in which case the reduction in the banker's payoff results from a reduced fixed payment. Second, effort may decrease below the socially efficient level, $e^{bc} < e^w = e^*$, in which case the fixed payment is zero.

4.2 Concurrent caps on the bonus and the fixed payment

In this section, we analyze the effects of a modest cap on the fixed payment, $\overline{F}$, in addition to the bonus cap, $\overline{b}$. Thus, there are two concurrent caps. We again assume that this additional cap is not binding for the bargaining outcome but is binding for the banker's bliss point, $F^w < \overline{F} < \widehat{F}^w$.[8] The additional restriction has no direct effect on the bargaining outcome, but it will influence the banker's bliss point and, thus, alter the bargained contract.

Lemma 3 *With concurrent caps on the bonus and the fixed payment, the banker's bliss point is smaller than in the situation with the bonus cap, $U^{+cc} < U^{+bc}$. The bliss point bonus is the same as with the bonus cap, but the bliss point fixed payment is smaller, $\widehat{F}^{cc} = \overline{F} < \widehat{F}^w < \widehat{F}^{bc}$.*

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[8]We assume that the bargaining outcome entails $F^w = 0$. Thus, a (positive) cap on the fixed payment will not be binding for the bargaining outcome.

Proof. To calculate the banker's bliss point with concurrent caps on the bonus and the fixed payment, we set up the following Lagrangian:

$$\max_{e,F,\lambda_{cc},\mu_{cc},\theta_{cc},\phi_{cc}} \mathcal{L} = B(e) - c(e) + F + \lambda_{cc}[v(e) - B(e) - F] + \mu_{cc}F$$

$$+ \theta_{cc}\left[\bar{b} - \frac{B(e)}{p(e)}\right] + \phi_{cc}\left[\overline{F} - F\right]. \tag{23}$$

Maximizing (23) yields the first-order conditions for effort $\hat{e}^{cc}$ (24), the fixed payment $\widehat{F}^{cc}$(25) and the complementary slackness conditions (26)-(29):

$$B'(\hat{e}^{cc}) - c'(\hat{e}^{cc}) + \lambda_{cc}[v'(\hat{e}^{cc}) - B'(\hat{e}^{cc})]$$

$$-\theta_{cc}\left[\frac{B'(\hat{e}^{cc})p(\hat{e}^{cc}) - B(\hat{e}^{cc})p'(\hat{e}^{cc})}{p(\hat{e}^{cc})^2}\right] = 0 \tag{24}$$

$$1 - \lambda_{cc} + \mu_{cc} - \phi_{cc} = 0 \tag{25}$$

$$v(\hat{e}^{cc}) - B(\hat{e}^{cc}) - \widehat{F}^{cc} \geq 0, \lambda_{cc} \geq 0, \lambda_{cc}[v(\hat{e}^{cc}) - B(\hat{e}^{cc}) - \widehat{F}^{cc}] = 0 \tag{26}$$

$$\widehat{F}^{cc} \geq 0, \mu_{cc} \geq 0, \mu_{cc}\widehat{F}^{cc} = 0 \tag{27}$$

$$\bar{b} - \frac{B(\hat{e}^{cc})}{p(\hat{e}^{cc})} \geq 0, \theta_{cc} \geq 0, \theta_{cc}\left[\bar{b} - \frac{B(\hat{e}^{cc})}{p(\hat{e}^{cc})}\right] = 0 \tag{28}$$

$$\overline{F} - \widehat{F}^{cc} \geq 0, \phi_{cc} \geq 0, \phi_{cc}\left[\overline{F} - \widehat{F}^{cc}\right] = 0 \tag{29}$$

Because the caps on the bonus and on the fixed payment are binding at the banker's bliss point, we have $\theta_{cc}, \phi_{cc} > 0$. Moreover, $\lambda_{cc} = 0$ has to hold. If there is only a bonus cap, the banker reaches her bliss point by extracting the entire social surplus by means of the fixed payment. Because of the reduction in the bonus, the fixed payment increases compared to the situation without any cap. If an additional cap on the fixed payment is introduced, the banker is no longer able to substitute the reduced bonus with an increased fixed payment and, hence, cannot extract the entire surplus. Rather than being pushed down to zero payoff, the bank is left with part of the surplus. The constraint on the bank's payoff ($\Pi \geq 0$) is not binding in the case with concurrent caps on the bonus and the fixed payment. Moreover, $\mu_{cc} = 0$, as when the upwards constraint on the fixed payment is binding, the downwards constraint will clearly not be. Inserting $\lambda_{cc} = 0$, effort at the bank's bliss point is implicitly given by (24). Effort will not change

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because of the additional constraint on the fixed payment, $\widehat{e}^{cc} = \widehat{e}^{bc}$, and the expected bonus also does not change, $B(\widehat{e}^{cc}) = B(\widehat{e}^{bc})$. The banker gets the same variable compensation at her bliss point as in the situation with only a bonus cap, but the fixed payment is smaller, $\widehat{F}^{cc} = \overline{F} < \widehat{F}^{w} < \widehat{F}^{bc}$. Hence, the banker's bliss point is smaller than with only a bonus cap, $U^{+cc} < U^{+bc}$.
∎

Proposition 2 *With concurrent, non-binding caps on the bonus and the fixed payment, the banker exerts less effort, $e^{cc} < e^{bc} < e^*$, and the social surplus is smaller, $S(e^{cc}) < S(e^{bc}) < S(e^*)$, than with only a bonus cap. The banker's utility is smaller, $U(e^{cc}) < U(e^{bc})$, and the bank's profit is higher, $\Pi(e^{cc}) > \Pi(e^{bc})$.*

The same logic as in Proposition 1 applies. Because the banker's bliss point is smaller, the ratio of the banker's and the bank's bliss points is smaller as well. Hence, the ratio of the banker's and the bank's payoffs must be smaller, too, and effort decreases.

Proposition 2 holds for the case that in the absence of any cap the efficient effort is not obtained. Otherwise, there are two possible scenarios: if the effort with a bonus cap is still socially efficient, then, depending on the strength of the fixed payment cap, the effort with concurrent caps may remain socially efficient or may drop below the socially efficient level, $e^{cc} \leq e^{bc} = e^*$. If effort with a bonus cap is already below e^*, then effort with concurrent caps will drop further, $e^{cc} < e^{bc} < e^*$. In either case, the banker's payoff is smaller and the bank's payoff is higher because of the caps.

4.3   Cap on the total payment

Finally, we analyze the consequences of a modest regulatory cap on the total payment, $\overline{P} = \overline{b} + \overline{F}$; that is, a cap on the sum of the bonus and the fixed payment which in sum equals the two concurrent caps. We again assume the cap to be non-binding, such that the cap is higher than the banker's payoff but smaller than her bliss point without a cap, respectively.

Lemma 4 *With a non-binding cap on the total payment, the banker's bliss point is higher than with concurrent caps on the bonus and the fixed payment,*

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$U^{+tc} > U^{+cc}$. *The bliss point bonus is higher than in a situation with two concurrent caps,* $\widehat{b}^{tc} > \widehat{b}^{cc}$, *and the bliss point fixed payment is smaller,* $\widehat{F}^{tc} < \widehat{F}^{cc}$.

Proof. Setting up the Lagrangian yields:

$$\max_{e,F,\lambda_{tc},\mu_{tc},\tau_{tc}} \mathcal{L} = B(e) - c(e) + F + \lambda_{tc}[v(e) - B(e) - F] + \mu_{tc}F$$
$$+ \tau_{tc}\left[\overline{P} - \frac{B(e)}{p(e)} - F\right]. \tag{30}$$

Maximizing (30) yields the first-order conditions for effort $\widehat{e}^{tc}$ (31), the fixed payment $\widehat{F}^{tc}$ (32) and the complementary slackness conditions (33)-(35):

$$B'(\widehat{e}^{tc}) - c'(\widehat{e}^{tc}) + \lambda_{tc}[v'(\widehat{e}^{bc}) - B'(\widehat{e}^{bc})]$$
$$-\tau_{tc}\left[\frac{B'(\widehat{e}^{tc})p(\widehat{e}^{tc}) - B(\widehat{e}^{tc})p'(\widehat{e}^{tc})}{p(\widehat{e}^{tc})^2}\right] = 0 \tag{31}$$

$$1 - \lambda_{tc} + \mu_{tc} - \tau_{tc} = 0 \tag{32}$$

$$v(\widehat{e}^{tc}) - B(\widehat{e}^{tc}) - \widehat{F}^{tc} \geq 0, \lambda_{tc} \geq 0, \lambda_{tc}[v(\widehat{e}^{tc}) - B(\widehat{e}^{tc}) - \widehat{F}^{tc}] = 0 \tag{33}$$

$$\widehat{F}^{tc} \geq 0, \mu_{bc} \geq 0, \mu_{tc}\widehat{F}^{tc} = 0 \tag{34}$$

$$\overline{P} - \frac{B(\widehat{e}^{tc})}{p(\widehat{e}^{tc})} - \widehat{F}^{tc} \geq 0, \tau_{tc} \geq 0, \tau_{tc}\left[\overline{b} - \frac{B(\widehat{e}^{tc})}{p(\widehat{e}^{tc})} - \widehat{F}^{tc}\right] = 0 \tag{35}$$

From $\overline{P} = \overline{b} + \overline{F} < \widehat{b}^w + \widehat{F}^w$, we know that the non-negativity constraint for the bank's payoff is not binding; thus, $\lambda_{tc} = 0$. Furthermore, two scenarios are possible. First, if $\overline{P} \leq b^*$, $\widehat{b}^{tc} = \overline{P}$ holds, and we have $\widehat{F}^{tc} = 0$. The whole possible payment is used for the bonus, as up to $b = b^*$, an increase in b increases the banker's payoff more than an increase in F. As $\overline{P} > \overline{b} = \widehat{b}^{cc}$, it holds that $\widehat{b}^{tc} > \widehat{b}^{cc}$ and $F^{tc} < F^{cc}$. Second, if $\overline{P} > b^*$, the bonus is increased up to the socially optimal level, $\widehat{b}^{tc} = b^*$. The remaining possible payment is used to increase the fixed payment; hence, $\widehat{F}^{tc} = \overline{P} - b^*$. The reason is that from b^* onwards, the banker profits more from an increase in the fixed payment than from an increase in the bonus. Since $\widehat{b}^{cc} < b^*$, it also holds that $\widehat{b}^{tc} < \widehat{b}^{cc}$ and $F^{tc} < F^{cc}$. Therefore, in either of the two cases, the banker's bliss point is higher than with two concurrent caps, $U^{+tc} > U^{+cc}$. The reason is that with a total payment cap, it is possible to substitute the

better instrument for the worse over the whole range of the cap. If there are two separate caps—of, in sum, the same amount—this flexibility does not exist. ■

Proposition 3 *With a non-binding cap on the total payment, the banker exerts more effort, $e^{tc} > e^{cc}$, and the social surplus is higher, $S(e^{tc}) > S(e^{cc})$, than in a situation with two concurrent caps on the bonus and the fixed payment of, in sum, the same amount. The banker's utility is higher, $U(e^{tc}) > U(e^{cc})$, and the bank's profit is lower, $\Pi(e^{tc}) < \Pi(e^{cc})$.*

Proposition 3 again follows the logic of Proposition 1. Because of the banker's bliss point is higher, the ratio of the banker's and the bank's bliss points is higher. Thus, the ratio of the banker's and the bank's payoffs has to be higher, too, which requires more effort.

If effort with the two concurrent caps is still socially efficient, then effort will not increase in the situation with a total payment cap. However, in any case, the banker's payoff is higher as a result of the more flexible constraint, and the bank's payoff is lower.

Finally, we compare a bonus cap with a total pay cap. The results are ambiguous and depend on the magnitude of the bonus cap $\bar{b}$ and the fixed payment cap $\overline{F}$. If $\bar{b}$ is rather high and $\overline{F}$ is rather low, we have $U^{+bc} > U^{+tc}$ and $e^{bc} > e^{tc}$. Then, it is straightforward that $U(e^{bc}) > U(e^{tc})$ and $\Pi(e^{bc}) < \Pi(e^{tc})$. If, however, $\bar{b}$ is rather small and $\overline{F}$ is rather high, we have $U^{+bc} < U^{+tc}$, in which case the opposite results may hold. The reason is that with a bonus cap, the bonus must not exceed the cap, so, from there on, any further increase in the banker's payoff — up to her bliss point — is realized through an additional fixed payment. When the salary cap is designed as a cap on the total payment, $\overline{P}$, an increase in the banker's payoff can be realized with a higher bonus until the bonus reaches b^* (or, if $\overline{P} < b^*$, until the bonus reaches $\overline{P}$). The remaining possible payment $\overline{P} - b^*$ is used to further increase the banker's payment up to her bliss point via a fixed payment. In this case, the additional fixed payment is limited in contrast to the bonus cap. However, this limit on the fixed payment can be overcompensated by a higher bonus payment under a total payment cap.

Our findings show that if a modest regulatory cap is introduced, effort is always lower and so is social welfare. This result implies that caps do not have to be binding to have an effect on social welfare and bankers' pay. The most negative effect with regard to effort, and social welfare, results from concurrent caps on the bonus and the fixed payment. These findings are summarized as follows.

Corollary 1 *Various regulatory caps affect the effort exerted by the banker, such that* $e^{cc}, e^{tc}, e^{bc} < e^w$ *and* $e^{cc} < e^{tc}, e^{bc}$ *and* $e^{tc} \gtreqless e^{bc}$.

Figure 1 shows the bargaining outcomes under the different caps. The KS curve connects the disagreement point (0) with the respective bliss points $(B^{cc}, B^{tc}, B^{bc}, B^w)$. The further the bliss points is located to right, the further is the KS located to the right on the PF.[9] As before, Figure 1 also assumes that the efficient solution (SO) is not reached without any cap. However, as Dittrich and Städter (2015) show, raising the banker's bargaining power can increase effort to the socially optimal level and can increase social welfare. Our model, however, abstracts from the possible effects of changing the bank's and the banker's bargaining power, as we apply the symmetric KS solution.

5 Discussion

We have shown that caps on bankers' payments change the incentive contracts and their efficiency, even if the caps are modest and non-binding. In general, non-binding caps affect incentive contracts because they change the banker's bliss point, assuming bargaining follows the Kalai–Smorodinsky solution instead of the commonly applied Nash solution.

We have analyzed three types of pay caps to investigate their influence on banker's payoffs and on the efficiency of the negotiated contract. We found that with regard to efficiency, non-binding pay caps may be detrimental, depending on the actual bargaining outcome in the absence of any cap. If (even

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[9]Figure 1 depicts a situation in which the banker's bliss point is higher with the bonus cap compared to the case of the total payment cap. As Corollary 1 shows, the opposite result may also hold.
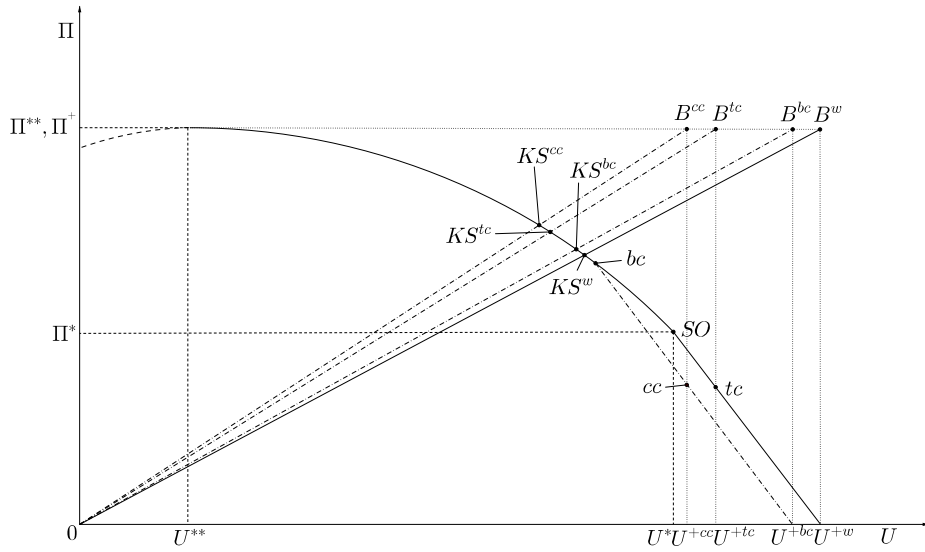
Figure 1: Pareto frontier and bargaining outcomes under various regulatory caps.

without any cap) the sum of the bank's and the banker's payoffs is below the socially optimal level, any pay cap will reduce social welfare. Concurrent caps on the bonus and the fixed payment have the most negative effect. The banker will always be worse off when a non-binding salary cap is introduced. Again, concurrent caps on the bonus and the fixed payment are most harmful for the banker's payoff.

Our findings contribute to the ongoing debate on the optimal design of regulations in the financial sector. For example, the results presented in this paper can be seen as complementary to Thanassoulis (2012), who concludes that modest regulation of remuneration is optimal, and to Dittmann, Maug, and Zhang (2011), who report that many pay restrictions have unintended consequences.

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