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Abstract

Bonus taxes have been implemented to prevent managers from taking excessive risks. This paper analyzes the effects of taxing executives' bonuses in a principal–agent model. Our model shows that, contrary to its intention, the introduction of a bonus tax intensifies managers' risk-taking behavior and decreases their effort. The principal responds to a bonus tax by offering the manager a higher fixed salary but a lower incentive-based component (bonus rate).

Keywords: Principal-agent model, bonus tax, risk-taking, executive compensation, financial regulation

JEL Classification: H24, J30, M52

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1 Introduction

The financial crisis from 2007-2010 was the worst global economic crisis since the Great Depression of the 1930s. Most of the world's largest banks survived only due to unprecedented bailout measures. G-20 member states contributed US$ 7000 billion to save system-relevant financial institutions and approved economic stimulus packages worth US$ 1400 billion in an effort to prevent an ongoing depression.

The excessive risk-taking of corporate executives is commonly considered to be one of the main causes of this crisis (see, e.g., Thanassoulis, 2009). Bank executives' pay has been tied to highly leveraged bets on the value of bank assets, giving executives little incentive to take into account the losses that risk-taking could impose on shareholders and taxpayers. Bebchuk and Spamann (2010) argue that corporate governance reforms alone are not sufficient to reduce the incentives for excessive risk-taking. Other measures are needed to prevent a similar crisis in the future. One prominent proposal in this respect is the taxation of executives' bonuses. Bonus taxes have been implemented in several countries as a response to the crisis. For example, in 2009 the US House of Representatives approved a 90% tax on bonuses in firms that have received federal bailout money. In a similar fashion, Ireland introduced a 90% tax on executives' bonuses in January 2011. In the UK, bankers' bonuses were taxed at 50% for a period of several months in 2010.

Proponents of bonus taxes or pay caps for executives argue that these instruments will prevent greedy managers from excessive risk-taking by limiting the upside potential of any form of risk-taking. On June 30, 2010, Arlene McCarthy, the rapporteur in charge of the negotiations for the European Parliament, said in reaction to the implemented cap on bankers' bonuses:

> Two years on from the global financial crisis, these tough new rules on bonuses will transform the bonus culture and end incentives for excessive risk taking. A high-risk and short-term bonus culture wrought havoc with the global economy and taxpayers paid the price. The public want banks to prioritize stability and lending over their own pay and perks. In the last two years the banks have failed to reform, and we are now doing the job for them.[1]

This paper analyzes the effect of a bonus tax on the manager's risk-taking behavior

[1] See "European Parliament caps bankers' bonuses", European Parliament, June, 30th, 2010.

in a principal-agent model. Our model shows that, contrary to its intention, a bonus tax increases the manager's risk-taking behavior and decreases the manager's effort. Furthermore, we derive that the manager's fixed salary increases, while the incentive-based salary component (bonus rate) decreases.

The principal-agent problem arises through asymmetric information and diverging interests between ownership and control.[2] This agency problem was first formalized by Jensen and Meckling (1976) and subsequently extended in various directions (Mirrless, 1976; Holmstrom, 1979, 1982; Fama, 1980; Lazear and Rosen, 1981; and Grossman and Hart, 1983). The evolving literature on executive compensation has been highly interdisciplinary and has spanned finance, accounting, economics, industrial relations, strategy, organizational behavior, and law.[3]

Even though there is a huge body of literature and numerous theoretical and empirical research on executive pay, only a few papers study the consequences of executive pay regulation. For instance, Dew-Becker (2009) analyzes the government regulation of executive compensation in the US. By discussing disclosure rules, advancements in corporate governance, and say-on-pay, he analyzes the evolution of pay regulation and concludes that mandatory say-on-pay could be the most effective and least harmful measure of controlling executive compensation. Knutt (2005) examines diverse regulatory issues from a legal point of view. In this study, he proposes the installation of independent compensation committees to support current regulation practices. Hall and Liebman (2000) analyzes the extent to which tax policy influences the composition of executive compensation and discusses the consequences of rising stock-based pay.

However, to the best of our knowledge the effects of bonus taxes on executives' risk-taking have not yet been analyzed in the agency literature.[4] Dietl et al. (2010) analyze the incentive effects of bonus taxes. They find that the effect of a bonus tax on the agent's compensation components depends on the product of the agent's level of risk aversion and the variance in the firm value. In contrast to our article, they do not study how a

[2]In the absence of complete contracts, Gaston (1997) finds that the separation of ownership and control may increase the value of the firm's implicit contracts with workers.

[3]For comprehensive surveys of research on executive compensation, see, e.g., Gomez-Mejia et al. (1985), Murphy (1999), Core et al. (2003), and Devers et al. (2007).

[4]A strand of literature exists that analyzes the relation between stock option-based executive compensation and risk taking. For example, based on 591 bank-CEO-year observations from 1992-2000, Chen et al. (2006) find that the stock of option-based wealth leads to higher risk taking in the banking industry. For theoretical models that analyze the incentive effects of executive stock options, see Khoroshilov and Narayanan (2008) and Tang (2012).

bonus tax affects the risk-taking behavior of the agent because in their model the agent's only choice variable is effort. Our model is also related to Holmstrom and Milgrom (1987) and Hirshleifer and Suh (1992) in the following dimensions. We base our principal-agent model on Holmstrom and Milgrom (1987) and introduce a tax that is levied on the agent's variable salary (bonus). To model the firm value, we follow the approach of Hirshleifer and Suh (1992) and assume additive separability between effort and risk in the output function.

The remainder of the paper is structured as follows. In Section 2, we develop our principal-agent model. Section 3 analyzes the problem of the agent and the principal, respectively. Furthermore, the optimality conditions are derived and discussed. In Section 4, we present our results for a specific effort cost function. Moreover, a simulation examines the robustness of the model with respect to the cost specification. Section 5 summarizes the main results and concludes the paper.

2 Analytical Framework

We consider a single-period employment relationship in a firm between a risk-neutral principal and a risk-averse agent. Following Hirshleifer and Suh (1992, p. 321), we assume that the firm value x, i.e., the firm's output, is given by

$$x = a + b(k + \varepsilon),$$

with $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ and $k \in \mathbb{R}^+$. The agent has two unobservable choice variables: effort $a \in \mathbb{R}^+$ and risk-taking behavior $b \in \mathbb{R}^+$. Similarly to Hirshleifer and Suh (1992), we assume that only effort a is costly, where $c(a) \in C^2$ with $c'(a) > 0$, $c''(a) > 0$ for $a > 0$, $c'(0) = 0$, $c''(0) = 0$. The parameter b can be interpreted as the agent's choice of operating risky projects where a higher b represents a riskier project.[5] The agent's risk choice b has two effects: on the one hand, given $k > 0$, a higher value of b increases the expected firm value $E[x] = a + kb$, but on the other hand, it also increases the variance in the firm value $V[x] = b^2\sigma_\varepsilon^2$. That is, the "cost" of the higher expected firm value is the increase in the

[5]Under the assumption that the risk choice cannot be observed, Degeorge et al. (2004) analyze the risk level chosen by agents who have private information regarding their quality. They find that high-quality agents reduce risks, while low-quality agents increase risk. Kraus and Rubin (2010) examine the interdependence between the riskiness of project and value creation or value destruction for shareholders.

variance. In other words, the agent can choose projects with a low expected return and low risk, or he can choose projects with a high expected return and high risk. We refer to k as the project return parameter. It should be noted that the agent's effort a and risk-taking b cannot be specified in a legally enforceable contract because the principal can only observe the firm value x. We further assume that the agent has an outside option, represented by his exogenous reservation utility $\widehat{u} \in \mathbb{R}^+$.[6]

The agent's salary $p(x)$ has two components: a fixed salary $\delta \in \mathbb{R}^+$ and a variable salary or bonus γx that increase with the firm value x. We follow Gibbons (1998, p. 116) and refer to the incentive-based component γ as the bonus rate.[7] The variable salary (bonus) is taxed by $\tau \in (0, 1)$ such that the agent's (net-of-tax) salary $p(x)$ reduces to

$$p(x) = \delta + (1 - \tau)\gamma x.$$

Since ε is normally distributed and it is the only random variable in $p(x)$, it follows that $p(x)$ is normally distributed, too:

$$p(x) \sim N\left(\delta + (1-\tau)\gamma\left(a + kb\right); b^2(1-\tau)^2\gamma^2\sigma_\varepsilon^2\right).$$

The agent has an expected salary of $E[p] = \delta + (1 - \tau)\gamma\left(a + kb\right) \equiv \bar{p}$ with a variance given by $V[p] = b^2(1-\tau)^2\gamma^2\sigma_\varepsilon^2 \equiv \sigma_p^2$. Note that the gross salary paid by the principal is $\delta + \gamma x$, while the agent receives only a net-of-tax salary of $\delta + (1 - \tau)\gamma x$ and the state receives the difference $\tau\gamma x$.

The agent is assumed to be risk-averse with a constant absolute risk-averse (CARA) utility function $U(p, a) = -e^{-r(p-c(a))}$, where p is the agent's pay-off, $r \in \mathbb{R}^+$ is the agent's level of absolute risk aversion and $c(a)$ is the effort cost function. Hence, the agent's expected utility $E[U_A]$ can be derived as[8]

$$E[U_A] = \delta + (1-\tau)\gamma(a + kb) - b^2\frac{r\sigma_\varepsilon^2}{2}(1-\tau)^2\gamma^2 - c(a).$$

[6] The reservation utility can be interpreted as the utility the agent would receive in another firm or in a country without a bonus tax and therefore is assumed to be exogenous. In Section 4.2, we analyze the implications of an endogenously determined reservation utility.

[7] Note that in the literature on executive compensation γ is also referred to as the pay-performance sensitivity (PPS) or piece rate (see, e.g., Jensen and Murphy, 1990; Murphy, 1999; Conyon and Sadler, 2001; and Faulkender et al., 2010). See Camerer and Hogarth (1999), who review experimental studies regarding the incentive effects of performance-based compensation.

[8] For a derivation of the utility function, see, e.g., Conyon and Sadler (2001).

The principal is assumed to be risk-neutral because she is well diversified. Her expected profit $E[\pi_P]$ is given by the difference between the expected output $E[x]$ and the expected gross salary payment $E[\delta + \gamma x]$:

$$E[\pi_P] = (1-\gamma)(a+kb) - \delta.$$

The timing has the following structure: in $t = 0$, the state sets the bonus tax $\tau \in (0,1)$ that is levied on the agent's bonus. In $t = 1$, the principal offers the agent an employment contract by choosing the fixed salary δ and the bonus rate γ. The agent accepts this contract if it guarantees him at least his reservation utility given by $\widehat{u}$. In $t = 2$, after accepting the contract, the agent chooses effort a and risk-taking b. In $t = 3$, the firm value x is realized and all the payments are made.

3 Analysis

3.1 The Agent's Problem

For a given compensation package (δ, γ) provided by the principal, the agent maximizes his expected net utility $E[U_A]$ with respect to (a, b). Henceforth, we denote by ρ the product of the agent's level of risk aversion r and the variance in the firm value σ_ε^2, i.e., $\rho \equiv r\sigma_\varepsilon^2$. We refer to ρ as the risk parameter. The agent's maximization problem is then formally given by

$$\max_{(a,b)\geq 0} \left\{ E[U_A] = \delta + (1-\tau)\gamma(a+kb) - b^2\frac{\rho}{2}(1-\tau)^2\gamma^2 - c(a) \right\}.$$

From the first-order conditions, we derive the following optimality conditions for the agent:[9]

$$c'(a^*) = (1-\tau)\gamma, \tag{1}$$

$$b^* = \frac{k}{\rho(1-\tau)\gamma} = \frac{k}{\rho c'(a^*)}. \tag{2}$$

We derive the following results:

[9]It is easy to verify that the second-order conditions for the maximum are satisfied.

Lemma 1

(i) A higher bonus rate γ increases the agent's effort a^*.

(ii) A substitution effect between effort a^* and risk-taking b^* is present, i.e., an increase (decrease) in effort a^* yields a decrease (increase) in risk-taking b^*.

Proof. Straightforward and therefore omitted. ■

Result (i) in Lemma 1 is intuitive. A higher bonus rate increases the agent's effort because the marginal revenue of effort increases. The substitution effect derived in (ii) may be more surprising at first sight because a higher bonus rate increases the marginal revenue of risk-taking $(1-\tau)\gamma k$. However, the marginal cost of risk-taking $b\rho(1-\tau)^2\gamma^2$ also increases for a higher bonus rate due to a higher net-of-tax variance in the salary. While a higher bonus rate increases the marginal revenue of risk-taking linearly, it simultaneously increases the marginal cost of risk-taking quadratically. Therefore, the agent decreases his risk-taking to mitigate the (quadratic) effect on the marginal costs for a higher bonus rate.

3.2 The Principal's Problem

The principal maximizes her expected profit $E[\pi_P]$ by choosing an optimal compensation package (δ^*, γ^*) and by taking into account the optimal behavior of the agent. Formally, the principal solves the following maximization problem:

$$\max_{(\delta,\gamma)\geq 0} \left\{ E[\pi_P] = (1-\gamma)(a+kb) - \delta \right\},$$

subject to the participation constraint (PC):

$$E[U_A] = \delta + (1-\tau)\gamma(a^* + kb^*) - (b^*)^2 \frac{\rho}{2}(1-\tau)^2\gamma^2 - c(a^*) \geqslant \widehat{u}, \tag{3}$$

and the incentive compatibility constraint (ICC):

$$(a^*, b^*) \in \arg \max_{(a,b)\geq 0} E[U_A].$$

We derive the corresponding first-order condition in the following lemma.

Lemma 2

The first-order condition of the principal is given by

$$0 = \underbrace{1 - \frac{k^2 c''(a)}{\rho(1-\tau)^2\gamma^2}}_{\text{(a) marg. rev. effect}} - \underbrace{\left(\gamma - \frac{k^2 c''(a)}{\rho(1-\tau)^2\gamma}\right)}_{\text{(b) direct marg. cost effect I}} - \underbrace{\frac{c''(a)}{1-\tau}\left[a + \frac{k^2}{\rho(1-\tau)\gamma}\right]}_{\text{(c) direct marg. cost effect II}}$$
$$+ \underbrace{c''(a)\left[a + \frac{k^2}{\rho(1-\tau)\gamma}\right]}_{\text{(d) income effect I}} + \underbrace{(1-\tau)\gamma - \frac{k^2 c''(a)}{\rho(1-\tau)\gamma}}_{\text{(e) income effect II}} - \underbrace{(1-\tau)\gamma}_{\text{(f) ind. marg. cost effect}}.$$

Proof. See Appendix A.1. ■

Marginally increasing the bonus rate induces a marginal increase in the agent's effort which has the following effects for the principal:

(a) An increase in the agent's effort generates a *marginal revenue effect.* Intuitively, a one-unit increase in the agent's effort (induced by a higher bonus rate) implies one-to-one higher expected revenue for the principal (first term). The second term takes into account that a higher level of effort negatively affects the agent's risk-taking. Because a higher level of effort decreases b (see Lemma 1), the marginal revenue is attenuated by the term $k^2c''(a)/\left(\rho(1-\tau)^2\gamma^2\right)$.

(b) The *direct marginal cost effect I* is composed of two terms. The first term γ represents the marginally higher bonus payment that the principal has to pay if the agent's effort increases by one unit. However, this marginal cost is reduced by the second term $k^2c''(a)/\left(\rho(1-\tau)^2\gamma\right)$ because the higher effort level decreases the agent's risk-taking b, which attenuates the marginal costs. (c) The *direct marginal costs effect II* is as follows. The bonus rate itself is influenced by greater effort. Greater effort increases the bonus rate, which means that the marginal costs of effort increase and therefore the term enters the principal's first-order condition with a negative sign.

(d) Greater effort also implies that there is an *income effect I* for the agent such that the PC is relaxed. Hence, the income effect enters the principal's first-order condition with a positive sign. The term reflects the effort-effect on the net-of-tax bonus rate for the agent, which relaxes the PC. (e) There is an additional *income effect II.* For a given bonus rate, a higher level of effort implies a higher salary for the agent and thus relaxes the PC (first term). This loosening of the PC, however, is attenuated because the agent decreases risk-taking b (second term). The first effect relaxes the PC and therefore enters the principal's first-order condition with a positive sign, while the second effect tightens the PC and thus enters with a negative sign.

(f) The principal has to compensate the agent for his higher effort costs, such that the PC is tightened. Because the agent's costs affect the principal's incentives, we refer to this effect as the *indirect marginal cost effect*. Note that this effect enters the principal's first-order condition with a negative sign.

3.3 Equilibrium

In equilibrium, the principal offers the compensation package (δ^*, γ^*) and the agent responds with effort a^* and risk-taking b^* which are implicitly defined by

$$c'(a^*) = (1-\tau)\gamma^*,\ b^* = \frac{k}{\rho(1-\tau)\gamma^*}, \tag{4}$$

$$\gamma^* = 1 - c''(a^*)\left(\frac{k^2}{\rho(\gamma^*)^2(1-\tau)^2} + a^*\frac{\tau}{1-\tau}\right),\ \delta^* = \widehat{u} - (1-\tau)\gamma^* a^* - \frac{k^2}{2\rho} + c(a^*) \tag{5}$$

The two equations in (4) represent the agent's optimal behavior and the equations in (5) are derived by simplifying the principal's first-order condition and the PC, respectively.

4 Results

To derive further insights, we specify the effort cost function and assume quadratic effort costs, i.e., $c(a) = (1/2)a^2$. This assumption is common in the corresponding principal-agent literature (see, e.g., Schaefer, 1998; Baker, 2002; Marino and Zabojnik, 2008). We proceed as follows. First, we show the conditions under which equilibrium exists and is unique. Second, we analyze the effects of a bonus tax on the principal's and the agent's behavior. We further show that our results are robust with respect to the specification of the cost function and examine the effects of relaxing the assumption regarding the exogenous outside option. Finally, we analyze the effect of the risk and project return parameters on the principal's and the agent's behavior.

4.1 Existence and Uniqueness

In this case, the equations (4) and (5) simplify to

$$(a^*, b^*) = \left((1-\tau)\gamma^*, \frac{k}{\rho(1-\tau)\gamma^*} \right) \tag{6}$$

$$(\gamma^*, \delta^*) = \left(1 - \frac{k^2}{\rho(a^*)^2} - a^* \frac{\tau}{1-\tau}, \widehat{u} - \frac{1}{2}(1-\tau)^2(\gamma^*)^2 - \frac{k^2}{2\rho} \right) \tag{7}$$

It should be noted that the equilibrium $(a^*, b^*, \gamma^*, \delta^*)$ is still defined only implicitly. We establish the following lemma, which holds for quadratic effort cost functions.

Lemma 3

(i) The principal's second-order condition is satisfied if $k^2 < k_{SOC} \equiv \frac{1}{2}\rho\gamma^3(1-\tau)^2(1+\tau)$.

(ii) A unique equilibrium exists if $k^2 < k_{\max} \equiv \frac{4}{27}\frac{\rho(1-\tau)^2}{(1+\tau)^2}$.

Proof. See Appendix A.2. ■

Lemma 3 states that the project return parameter k must satisfy an upper bound defined by $k^2 < \min\{k_{SOC}, k_{\max}\}$ for a unique maximum. The reason for this bound is as follows. A higher k increases the marginal revenue of risk-taking such that b increases. A higher b, in turn, decreases effort a due to the substitution effect between a and b derived in Lemma 1. The lower effort a then decreases the bonus rate γ (see equation 1), which yields a lower variance in the agent's salary. As a result, the "cost" of risk-taking decreases and converges to zero as the bonus rate converges to zero. The agent would now have incentives to choose an infinitely high level of risk-taking behavior b. Therefore, an upper bound must be imposed on the project return parameter k. In the subsequent analysis, we assume that $k^2 < \min\{k_{SOC}, k_{\max}\}$ to ensure that a unique equilibrium γ^* exists and that the second-order condition for a maximum is satisfied.

4.2 The Effect of Bonus Taxes

In this subsection, we analyze the effects of a higher bonus tax on the compensation package (δ^*, γ^*) and the agent's behavior (a^*, b^*). We establish the following proposition, which summarizes our results.

Proposition 1

(i) A higher bonus tax τ *induces the agent to reduce his effort* a^*, *i.e.,* $\frac{\partial a^*}{\partial \tau} < 0$, *and to*

increase his risk-taking behavior b^*, i.e., $\frac{\partial b^*}{\partial \tau} > 0$.

(ii) A higher bonus tax τ induces the principal to reduce the bonus rate, i.e., $\frac{\partial \gamma^*}{\partial \tau} < 0$, *and to increase the fixed salary, i.e.,* $\frac{\partial \delta^*}{\partial \tau} > 0$.

Proof. See Appendix A.3. ■

The intuition for part (i) of Proposition 1 is as follows. A higher bonus tax has two effects on the agent's effort. First, a higher tax directly decreases the marginal revenue of effort. Second, a higher tax indirectly affects effort because a higher tax decreases the bonus rate in equilibrium such that the marginal revenue of effort decreases even more. As a result, the agent decreases a^* in equilibrium with a higher tax.

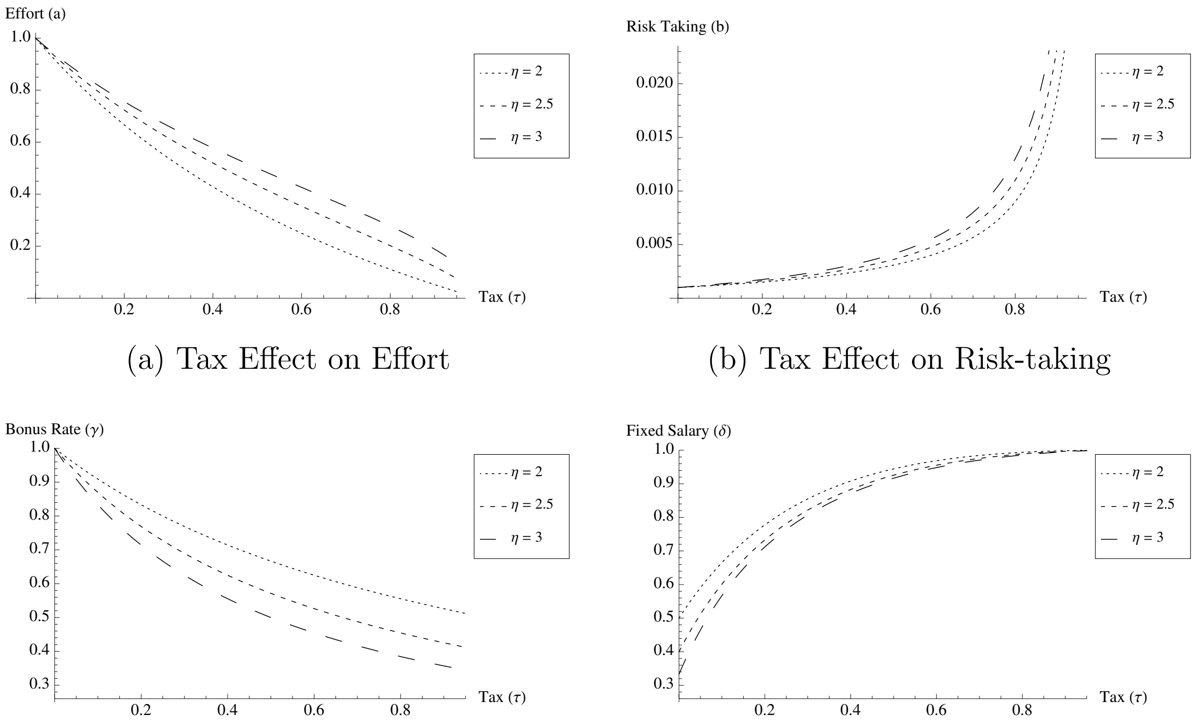
Moreover, a higher bonus tax has the following effects on the agent's risk-taking. On the one hand, a higher tax linearly reduces the marginal revenue of risk-taking. On the other hand, a higher tax quadratically decreases the marginal costs (i.e., the income uncertainty) and overcompensates for the linear decrease in the marginal revenue. As a result, the agent increases his risk-taking behavior b^* in equilibrium.

Part (ii) is also intuitive from observing the different effects identified in Lemma 2. On the one hand, a higher tax decreases the marginal revenue effect. On the other hand, all the remaining effects cancel each other out except for the first term of the direct marginal cost effects I and II and the first term of the income effect I. Since a higher tax has a larger effect on the direct marginal cost effects I and II than on the income effect I, the marginal costs increase in the bonus tax τ.[10] To balance the marginal revenue and the marginal cost, the bonus rate must decrease to amplify the decrease in the marginal revenue effect and to diminish the increase in the marginal cost effect. Therefore, the principal lowers the bonus rate γ for a higher bonus tax.

The principal chooses the fixed salary such that the PC is satisfied. A bonus tax increase induces lower bonus payments but, on the other hand, also lower the costs for the agent because the effort decreases. In equilibrium, the bonus payments decrease more strongly than the agent's costs such that the fixed salary must increase for a higher bonus tax. Therefore, the introduction of a bonus tax shifts the compensation package from the incentive-based component (bonus rate) to the fixed salary.

[10] Note that a higher bonus tax increases the marginal cost effect more strongly than the income effect because a higher tax increases the costs one to one, while the agent's income only increases them less than one to one due to the taxation.

Figure 1: Bonus Tax Effects for Different Polynomial Cost Functions



(a) Tax Effect on Effort (b) Tax Effect on Risk-taking

(c) Tax Effect on Bonus Rate (d) Tax Effect on Fixed Salary

Simulation: We illustrate the results of Proposition 1 in Figure 1, which shows the effect of the bonus tax τ on the agent's effort and risk-taking, and the principal's choice of the bonus rate and the fixed salary. Because the solutions to the model are only implicit, we need to run a simulation. For the simulation, we set the parameters as follows: $\widehat{u} = 1, \rho = 1, \tau \in [0, 0.95]$, and $k = 0.005$. To verify the robustness of our model regarding the specification of the cost function, in addition to the quadratic effort costs, we simulate the solutions to equations (4) and (5) for polynomial cost functions $c(a) = \frac{1}{\eta}a^{\eta}$ with $\eta \in \{2.5, 3\}$. Qualitatively, the results from Proposition 1 derived for a quadratic cost function with $\eta = 2$ also hold for a cost function with $\eta \in \{2.5, 3\}$.

Endogenous reservation utility: So far, we have assumed that the agent's reservation utility $\widehat{u}$ is exogenously given. Recall that the agent always has the possibility to leave the country that has introduced a bonus tax. However, one could argue that the agent's value of his outside option decreases with a higher bonus tax because (i) finding new employment in another country generates costs for the agent and/or (ii) the value of the (new) outside option decreases if the agent changes his job. In the case of an endogenously given reservation utility $\widehat{u}(\tau)$, we establish the following corollary.

Corollary 4

Suppose that $\widehat{u}(\tau)$ negatively depends on tax, i.e., $\partial\widehat{u}(\tau)/\partial\tau < 0$. In this case, the results of Proposition 1 remain unchanged except for the effect of a bonus tax on the fixed salary δ^*. If $|\partial\widehat{u}(\tau)/\partial\tau| > a^* |\partial a^*/\partial\tau|$ then, a higher bonus tax also induces a decrease in the fixed salary, i.e., $\partial\delta^*/\partial\tau < 0$.

Proof. The proof is straightforward, by noting that $\delta^* = \widehat{u}(\tau) - \frac{1}{2}(a^*)^2 + \frac{3k^2}{2\rho}$ and $\frac{\partial\delta^*}{\partial\tau} = \frac{\partial\widehat{u}(\tau)}{\partial\tau} - a^*\frac{\partial a^*}{\partial\tau}$. Hence, $\frac{\partial\delta^*}{\partial\tau} < 0 \Leftrightarrow |\partial\widehat{u}(\tau)/\partial\tau| > a^* |\partial a^*/\partial\tau|$. ■

The result of the corollary is intuitive. We know that in the case of an exogenous outside option, a higher bonus tax induces a shift in the compensation package from the incentive-based component (bonus rate) to the fixed salary. If, however, the outside option depends on the bonus tax and a higher tax induces a sufficiently strong decrease in the value of the outside option, i.e., $|\partial\widehat{u}(\tau)/\partial\tau| > a^* |\partial a^*/\partial\tau|$, then the principal can decrease both the bonus rate and the fixed salary and still satisfy the agent's PC.

4.3 The Effects of the Risk and Project Return Parameters

In this subsection, we analyze the effects of the risk parameter and the project return parameter. We establish Proposition 2, which summarizes our results.

Proposition 2

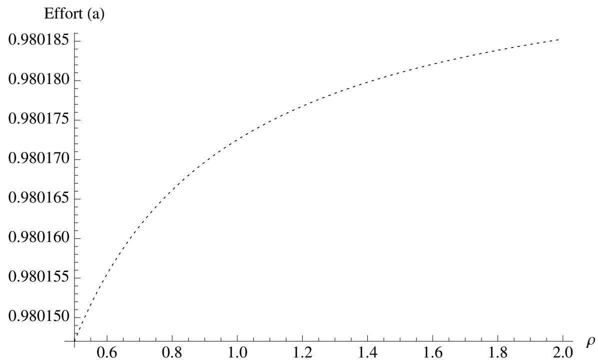
(i) A higher risk parameter ρ induces the agent to increase his effort a^* and to decrease his risk-taking behavior b^*, i.e., $\frac{\partial a^*}{\partial\rho} > 0$ and $\frac{\partial b^*}{\partial\rho} < 0$. The principal increases the bonus rate, i.e., $\frac{\partial\gamma^*}{\partial\rho} > 0$.

(ii) A higher project return parameter k induces the agent to decrease his effort a^* and to increase his risk-taking behavior b^*, i.e., $\frac{\partial a^*}{\partial k} < 0$ and $\frac{\partial b^*}{\partial k} > 0$. The principal decreases the bonus rate, i.e., $\frac{\partial\gamma^*}{\partial k} < 0$.

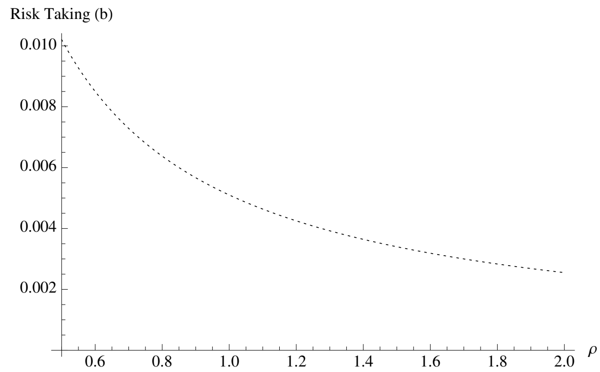
Proof. See Appendix A.4. ■

Regarding part (i) of the proposition, it should be noted that a higher risk parameter ρ is the result of a higher risk aversion r of the agent and/or a higher level of uncertainty in the economic environment reflected by a higher variance σ_ε^2. It is intuitive that a

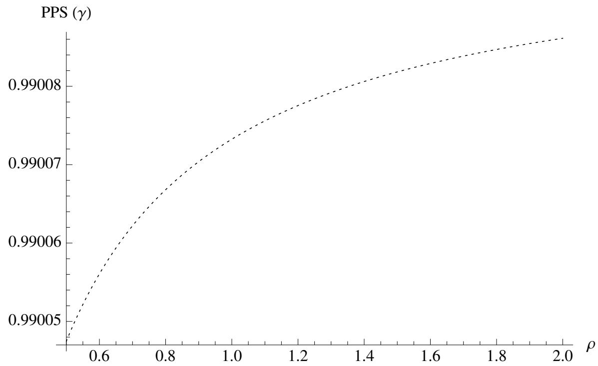
Figure 2: Risk Parameter Effects with Quadratic Effort Costs



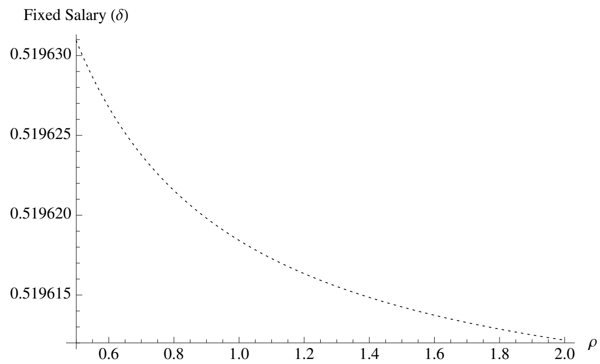
(a) Risk Effect on Effort



(b) Risk Effect on Risk-Taking



(c) Risk Effect on Bonus Rate



(d) Risk Effect on Fixed Salary

higher risk parameter induces the agent to decrease his risk-taking b. However, the effect of the risk parameter on the bonus rate is not obvious because there are several effects according to Lemma 2. A higher risk parameter (a) increases the marginal revenue effect, (b) increases the direct marginal cost effect I, (c) decreases the direct marginal cost effect II, (d) decreases the income effect I, and (e) increases the income effect II. In aggregate, all the effects cancel each other out except for the increase in the marginal revenue effect. Therefore, we find that a higher risk parameter induces the principal to increase the bonus rate. Then, it is easy to see that the agent reacts with greater effort (see equation 1).

We provide a simulation to illustrate the results of part (i) in Figure 2. For the simulation, we set $\widehat{u} = 1$, and $k = 0.005$. Furthermore, we fix $\tau = 0.01$ and now continuously vary $\rho \in [0.5, 2]$ on the x-axis. The figure shows the effect of the risk parameter ρ on the agent's (a) effort and (b) risk-taking, and the principal's choice of

(c) the bonus rate and (d) the fixed salary in the case of a quadratic effort cost function. The qualitative effects of the risk parameter are in line with part (i) of Proposition 2. The additional insight achieved from the simulation is as follows. By taking into account the scale on the y-axis, we find that the effect of the risk parameter on the effort, the bonus rate, and the fixed salary is quantitatively much smaller than the corresponding effect on risk-taking.

Regarding part (ii), it is intuitive that the agent substitutes effort with risk-taking for a higher project return parameter k. The effect of a higher k on the bonus rate is as follows. The marginal revenue effect decreases, while the other effects are exactly balanced out (see Lemma 2). Therefore, the principal lowers the bonus rate for a higher k.

5 Conclusion

This paper has analyzed the effect of a bonus tax on the risk-taking behavior of corporate executives in a principal-agent model. In our paper, the firm value (output) depends on the manager's behavior in two dimensions. First, the manager can increase the firm value by exerting more effort. Second, the manager can choose a project with specific exposure. A project choice with a higher expected return simultaneously implies a higher risk. Therefore, the project choice influences the expected value as well as the variance in the output. For instance, bank managers dealing with credits face this kind of trade-off. Credit at low interest rates can be assigned to firms with high ratings. Therefore, the bank has low expected profits but also low risks. Otherwise, credit at higher interest rates can be assigned to a start-up firm operating in a promising area but with high uncertainty. Thus, a higher expected return can be achieved by being exposed to higher risks. We assume that the principal offers a salary package consisting of a fixed salary and an incentive-based component (bonus rate). The bonus rate increases with the manager's output. As the manager can only influence the output by his effort choice and the degree of exposure, the realization or failure of the project is stochastic.

Our model shows that the introduction of a bonus tax unintentionally intensifies the manager's risk-taking behavior and decreases the manager's effort. On the one hand, a higher tax decreases the marginal revenue of risky projects, but on the other hand, it also decreases the variance in the manager's salary, implying lower marginal costs. The second effect dominates the first and therefore a higher bonus tax induces the manager to increase his risk-taking behavior. Simultaneously, the manager decreases his effort because a higher bonus tax decreases the marginal revenue of effort. We further show that a higher bonus tax shifts the compensation package from the incentive-based component to the fixed salary. Finally, a higher risk aversion of the manager and/or a higher variance in the firm value induces the manager to increase his effort and to decrease his risk-taking behavior, while the principal increases the bonus rate.

Our results imply that a government should be careful when evaluating whether a bonus tax is an accurate instrument to introduce in order to prevent the excessive risk-taking behavior of corporate executives. This article is a first step in analyzing the effects of a bonus tax on risk-taking behavior. We encourage further research in this area.

A Appendix

A.1 Proof of Lemma 2

With PC, the expected profit of the principal is given by

$$E[\pi_P] = (1-\gamma)(a+kb) - \widehat{u} + (1-\tau)\gamma(a+kb) - b^2\frac{\rho}{2}(1-\tau)^2\gamma^2 - c(a)$$

Together with ICC, $\gamma = \frac{c'(a)}{1-\tau}$ and $b = \frac{k}{\rho c'(a)}$, we obtain

$$E[\pi_P] = \left(1 - \frac{c'(a)}{1-\tau}\right)\left[a + \frac{k^2}{\rho c'(a)}\right] - \widehat{u} + c'(a)\left[a + \frac{k^2}{\rho c'(a)}\right] - \frac{k^2}{2\rho} - \ c(a). \tag{8}$$

It is interesting to see that the so-called risk effect identified by Dietl et al. (2010) does not appear in the principal's first-order condition given in Lemma 2. Dietl et al. (2010) find that a higher effort implies higher uncertainty for the agent regarding his expected salary because the salary variance increase such that the PC is tightened. In our model, however, this risk effect is a constant given by $\frac{k^2}{2\rho}$ and depends neither on effort nor on the bonus rate. The reason for this result is that higher effort (or equivalently a higher bonus rate) implies a higher variance of the agent's salary. This increase in the agent's salary variance, however, is exactly compensated for by a lower variance due to lower risk-taking by the agent.[11] Overall, the principal's expected profits is reduced by the constant $k^2/(2\rho)$, but it does not affect the optimal behavior implicitly derived in Lemma 2.

We derive the first-order condition of the principal as

$$\begin{aligned}\frac{\partial E[\pi_P]}{\partial a} = &\left(1 - \frac{c'(a)}{1-\tau}\right)\left[1 - \frac{k^2 c''(a)}{\rho c'(a)^2}\right] - \frac{c''(a)}{1-\tau}\left[a + \frac{k^2}{\rho c'(a)}\right] \\ &+ c''(a)\left[a + \frac{k^2}{\rho c'(a)}\right] + c'(a)\left[1 - \frac{k^2 c''(a)}{\rho c'(a)^2}\right] - c'(a) = 0\end{aligned}$$

Re-substitution of $c'(a) = (1-\tau)\gamma$ yields the first-order condition of the principal as

$$\begin{aligned}&(1-\gamma)\left[1 - \frac{k^2 c''(a)}{\rho(1-\tau)^2\gamma^2}\right] - \frac{c''(a)}{1-\tau}\left[a + \frac{k^2}{\rho(1-\tau)\gamma}\right] \\ +c''(a)&\left[a + \frac{k^2}{\rho(1-\tau)\gamma}\right] + (1-\tau)\gamma\left[1 - \frac{k^2 c''(a)}{\rho(1-\tau)^2\gamma^2}\right] - (1-\tau)\gamma = 0\end{aligned}$$

[11] We know from part (ii) in Lemma 1 that a higher a implies a lower b.

Rearranging of the first-order condition produces the claim.

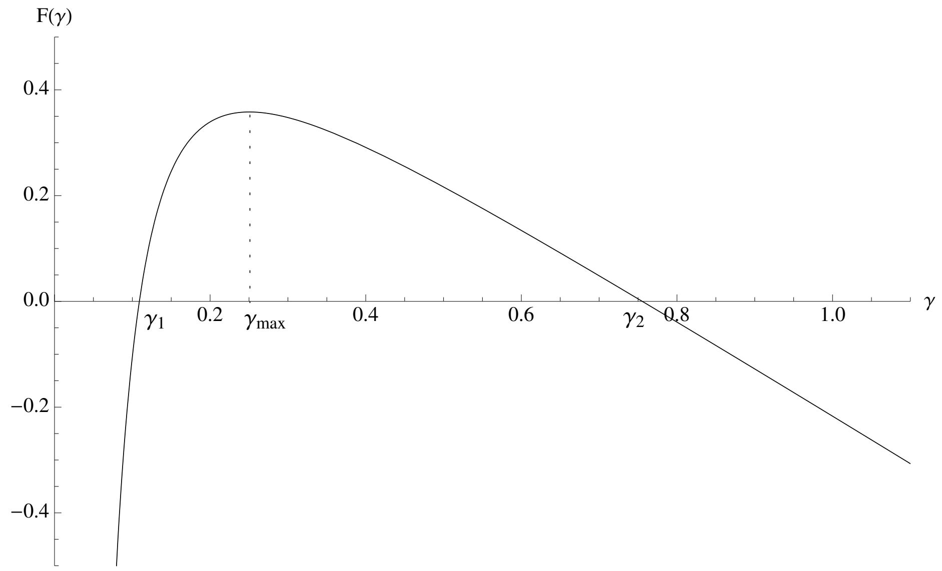
A.2 Proof of Lemma 3

Part (i): The principal's first-order condition $\gamma^* = 1 - \frac{k^2}{\rho(a^*)^2} - a^* \frac{\tau}{1-\tau}$, can also be written as

$$F(\gamma) \equiv (1-\tau) - \gamma(1-\tau^2) - \frac{k^2}{\rho\gamma^2(1-\tau)} = \frac{\rho\gamma^2(1-\tau)^2\left[1-\gamma(1+\tau)\right] - k^2}{\rho\gamma^2(1-\tau)} = 0 \quad (9)$$

taking into account that $a = (1-\tau)\gamma$. We illustrate equation (9) as a function of γ in Figure 3 for $k = 0.005, \tau = 0.3$ and $\rho = 1$.

Figure 3: Principal's FOC



The principal's second-order condition is given by

$$\frac{\partial F(\gamma)}{\partial \gamma} = \frac{2k^2}{\rho\gamma^3(1-\tau)} - (1-\tau^2) \overset{\gamma=a/(1-\tau)}{=} (1-\tau)\left[\frac{2k^2(1-\tau)}{\rho a^3} - (1+\tau)\right].$$

Hence, the SOC is satisfied if and only if

$$k^2 < k_{SOC} \equiv \frac{\rho(1+\tau)}{2(1-\tau)} a^3 \overset{a=(1-\tau)\gamma}{=} \frac{1}{2}\rho\gamma^3(1-\tau)^2(1+\tau)$$

Part (ii): We derive the following properties of the principal's first-order condition $F(\gamma) = 0$:

1. $F(\gamma)$ is a continuous function in $\gamma \in (0,1)$.

2. $\lim_{\gamma\to 0} F(\gamma) = -\infty$ and $F(1) = -\tau(1-\tau) - \frac{k^2}{\rho(1-\tau)} < 0$.

3. $\frac{\partial F(\gamma)}{\partial \gamma} = -(1-\tau^2) + \frac{2k^2}{\rho\gamma^3(1-\tau)} = 0 \Leftrightarrow \gamma = \gamma_{\max} \equiv \left(\frac{2k^2}{\rho(1-\tau)^2(1+\tau)}\right)^{1/3}$. We further derive $F(\gamma_{\max}) > 0 \Leftrightarrow k^2 < k_{\max} \equiv \frac{4}{27}\frac{\rho(1-\tau)^2}{(1+\tau)^2}$ and $\gamma_{\max} \in (0,1)$ for $k^2 < k_{\max}$.[12]

4. $\gamma_{\max}$ is a local maximum of $F(\gamma)$ because $\frac{\partial^2 F(\gamma)}{\partial \gamma^2} = -\frac{6k^2}{\rho\gamma^4(1-\tau)} < 0$. Hence, $\frac{\partial F(\gamma)}{\partial \gamma} > 0$ for $\gamma < \gamma_{\max}$ and $\frac{\partial F(\gamma)}{\partial \gamma} < 0$ for $\gamma > \gamma_{\max}$.

From 1.-4., we derive that for $k^2 < k_{\max}$ the first-order condition $F(\gamma) = 0$ has exactly two roots (γ_1, γ_2) in the unit interval with $\gamma_1 < \gamma_{\max} < \gamma_2$. Because $\frac{\partial F(\gamma)}{\partial \gamma}$ represents the second-order condition of our initial maximization problem, the root γ_2 is the maximum and characterizes the unique equilibrium γ^*. The equilibrium values (a^*, b^*, δ^*) directly follows from equations (6) and (7).

A.3 Proof of Proposition 1

Part (i): First, we will show that a higher bonus tax induces the agent to reduce effort a^*. To prove this claim, recall that $F(\gamma, \tau) = (1-\tau) - \gamma(1-\tau^2) - \frac{k^2}{\rho\gamma^2(1-\tau)} = 0$ represents the principal's first-order condition. With the implicit function theorem, we derive

$$\frac{\partial \gamma^*}{\partial \tau} = -\frac{\partial F/\partial \tau}{\partial F/\partial \gamma} = -\frac{-1 + 2\gamma\tau - \frac{k^2}{\rho\gamma^2(1-\tau)^2}}{-(1-\tau^2) + \frac{2k^2}{\rho\gamma^3(1-\tau)}}$$

With $a^* = (1-\tau)\gamma^*$, we obtain

$$\frac{\partial a^*}{\partial \tau} = (1-\tau)\frac{\partial \gamma^*}{\partial \tau} - \gamma^* = \frac{\gamma\left(k^2 - \rho\gamma^2(1-\tau)^2\left[1 + \gamma(1-\tau)\right]\right)}{-2k^2 + \rho\gamma^3(1-\tau)^2(1+\tau)} =: \frac{A}{B}$$

For $k^2 < k_{SOC} = \frac{1}{2}\rho\gamma^3(1-\tau)^2(1+\tau)$, it holds $B > 0$. Moreover,

$$A < 0 \Leftrightarrow k^2 < k^* \equiv \rho\gamma^2(1-\tau)^2\left[1 + \gamma(1-\tau)\right]$$

[12] Formally, $\gamma_{\max} < 1 \Leftrightarrow k^2 < \frac{1}{2}\rho(1-\tau)^2(1+\tau)$ and $k_{\max} < \frac{1}{2}\rho(1-\tau)^2(1+\tau)$.

We further derive that

$$k^* > k_{SOC} \Leftrightarrow 2 > \gamma(3\tau - 1) \Leftrightarrow \underbrace{\frac{2}{\gamma} + 1}_{\in(3,\infty)} > \underbrace{3\tau}_{\in(0,3)}.$$

The last inequality is always fulfilled and therefore we have shown that $\frac{\partial a^*}{\partial \tau} < 0$ for $k^2 < k_{SOC}$.

According to Lemma 1, a substitution effect between effort and risk-taking is present. Because the agent always reduces effort a^* through a higher bonus tax, it follows that he increases risk-taking b^*, i.e., $\frac{\partial b^*}{\partial \tau} > 0$. This proves part (i) of the proposition.

Part (ii): To show that a higher bonus tax induces the principal to reduce the bonus rate, i.e., $\frac{\partial \gamma^*}{\partial \tau} < 0$, we provide a proof by contradiction. Suppose that $\frac{\partial \gamma^*}{\partial \tau} \geq 0$. The principal's first-order condition is given by $\gamma^* = 1 - \frac{k^2}{\rho(a^*)^2} - a^* \frac{\tau}{1-\tau}$. Using the condition $a^* = (1-\tau)\gamma^*$, we obtain

$$\gamma^* = 1 - \underbrace{\frac{k^2}{\rho(a^*)^2}}_{\text{inc. in } \tau} - \underbrace{\gamma^* \tau}_{\text{inc. in } \tau} \tag{10}$$

Because $\frac{\partial a^*}{\partial \tau} < 0$, the term $\frac{k^2}{\rho(a^*)^2}$ increases in τ. Under the assumption that $\frac{\partial \gamma^*}{\partial \tau} \geq 0$, the term $\gamma^*\tau$ increases in τ as well. Hence, the right hand side (rhs) of (10) decreases in τ. It follows that the left hand side (lhs) of (10) must decrease as well in equilibrium. This result, however, contradicts the assumption $\frac{\partial \gamma^*}{\partial \tau} \geq 0$. Hence, our assumption was wrong and it must be the case that $\frac{\partial \gamma^*}{\partial \tau} < 0$.

To show that a higher bonus tax induces the principal to increase the fixed salary, i.e., $\frac{\partial \delta^*}{\partial \tau} > 0$, recall that the fixed salary is given by

$$\delta^* = \widehat{u} - \frac{1}{2}(1-\tau)^2(\gamma^*)^2 - \frac{k^2}{2\rho} = \widehat{u} - \frac{1}{2}(a^*)^2 - \frac{k^2}{2\rho}. \tag{11}$$

Because $\frac{\partial a^*}{\partial \tau} < 0$, the rhs of (11) increases in τ and hence the lhs must increase as well, i.e., $\frac{\partial \delta^*}{\partial \tau} > 0$. This proves part (ii) of the proposition.

A.4 Proof of Proposition 2

Recall that (a^*, b^*) is given by (6) and (γ^*, δ^*) is given by (7).

Part (i): Total differential of γ^* with $d\tau = 0$ and $dk = 0$ yields

$$d\gamma = \frac{k^2}{\rho^2(a^*)^2}d\rho + \frac{2k^2}{\rho(a^*)^3}da - \frac{\tau}{1-\tau}da$$

Total differential of a^* with $d\tau = 0$ produces $da = (1-\tau)d\gamma$. Combining the two differentials, we obtain

$$d\gamma = \frac{k^2}{\rho^2(a^*)^2}d\rho + \left(\frac{2k^2}{\rho(a^*)^3} - \frac{\tau}{1-\tau}\right)(1-\tau)d\gamma \Leftrightarrow \frac{d\gamma}{d\rho} = \frac{k^2a^*}{(1+\tau)\rho^2(a^*)^3 - 2\rho k^2(1-\tau)}$$

It is obvious that the numerator is positive in the last equation. At first sight, it seems that the denominator is ambiguous. However, a closer look at the denominator shows that it is unambiguously positive because

$$\frac{d\gamma}{d\rho} > 0 \Leftrightarrow (1+\tau)\rho^2(a^*)^3 - 2\rho k^2(1-\tau) > 0 \Leftrightarrow \frac{1}{2}\rho\gamma^3(1-\tau)^2(1+\tau) > k^2.$$

The last inequality always holds because the second-order condition states that $k^2 < k_{SOC} \equiv \frac{1}{2}\rho\gamma^3(1-\tau)^2(1+\tau)$. The risk parameter has therefore a positive effect on the bonus rate. It is easy to see that the risk parameter also has a positive effect on effort because $a^* = (1-\tau)\gamma^*$ such that

$$\frac{da}{d\rho} = (1-\tau)\underbrace{\frac{d\gamma^*}{d\rho}}_{>0} > 0$$

Next, we derive the effect of the risk parameter on $b^* = \frac{k}{\rho(1-\tau)\gamma^*}$. Total differential of b^* with $d\tau = 0$ and $dk = 0$ yields

$$db = -\frac{k}{\rho^2(1-\tau)\gamma^*}d\rho - \frac{k}{\rho(1-\tau)\gamma^2}d\gamma \tag{12}$$

We substitute the above-calculated differential $d\gamma = \frac{k^2a^*}{(1+\tau)\rho^2(a^*)^3 - 2\rho k^2(1-\tau)}d\rho$ into (12) and after rearranging, we obtain

$$\frac{db}{d\rho} = -\frac{k}{\rho^2(1-\tau)\gamma^*} - \frac{k}{\rho(1-\tau)\gamma^2}\frac{k^2a^*}{\underbrace{(1+\tau)\rho^2(a^*)^3 - 2\rho k^2(1-\tau)}_{>0}} < 0.$$

This proves the claim that the risk parameter has a negative effect on risk-taking.

Part (ii). Total differential of γ^* with $d\tau = 0$ and $d\rho = 0$ yields $d\gamma = -\frac{2k}{\rho(a^*)^2}dk + \frac{2k^2}{\rho(a^*)^3}da - \frac{\tau}{1-\tau}da$. Total differential of a^* with $d\tau = 0$ produces $da = (1-\tau)d\gamma$. Combining the two differentials, we obtain

$$d\gamma = -\frac{2k}{\rho(a^*)^2}dk + \left(\frac{2k^2}{\rho(a^*)^3} - \frac{\tau}{1-\tau}\right)(1-\tau)d\gamma \Leftrightarrow \frac{d\gamma}{dk} = \frac{-2ka^*}{(1+\tau)\,\rho(a^*)^3 - 2(1-\tau)k^2}$$

We derive that the bonus rate depends negatively on the project return parameter because

$$\frac{d\gamma}{dk} < 0 \Leftrightarrow (1+\tau)\,\rho(a^*)^3 - 2(1-\tau)k^2 > 0 \Leftrightarrow \frac{1}{2}\rho\gamma^3(1-\tau)^2\,(1+\tau) > k^2$$

The last inequality always holds because the second-order condition states that $k^2 < k_{SOC} \equiv \frac{1}{2}\rho\gamma^3(1-\tau)^2(1+\tau)$. Therefore, a higher return of the project implies a lower bonus rate. Moreover, a higher return of the project k has also a negative effect on effort $a^* = (1-\tau)\gamma^*$ because

$$\frac{da}{d\rho} = (1-\tau)\underbrace{\frac{d\gamma^*}{dk}}_{<0} < 0$$

Next, we derive the effect of the project return parameter k on risk-taking $b^* = \frac{k}{\rho(1-\tau)\gamma^*}$. We derive

$$db = \frac{1}{\rho(1-\tau)\gamma^*}dk - \frac{k}{\rho(1-\tau)\gamma^2}d\gamma \tag{13}$$

and substitute the above-calculated differential $d\gamma = \frac{-2ka^*}{(1+\tau)\rho(a^*)^3 - 2(1-\tau)k^2}dk$ into (13). After rearranging, we obtain

$$\frac{db}{dk} = \frac{1}{\rho(1-\tau)\gamma^*} + \frac{1}{\rho(1-\tau)\gamma^2}\frac{2k^2a^*}{\underbrace{(1+\tau)\,\rho(a^*)^3 - 2(1-\tau)k^2}_{>0}} > 0$$

This proves the claim that a higher project return parameter increases risk-taking.

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