The optimal choice of after-tax and pre-tax performance measures in the presence of tax base risks

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Abstract

In practice, both pre- and after-tax performance measures are used to incentivize managers. In this paper, we analyze the optimality of these performance measures in an agency setting, assuming that both the principal and the agent face tax base risks. Switching from a pre-tax to an after-tax measure introduces a risk effect, including an additional variance and a covariance effect, both of which stem from the principal's tax base risk. We show that the after-tax measure is the optimal performance measure if and only if the negative covariance effect dominates the variance effect. If the principal can evade taxes, there is a tax evasion effect in addition to the risk effect, which captures the distortion of tax evasion under the after-tax measure. Now, using the after-tax measure is only optimal, if the weighted risk effect is stronger than the tax evasion effect. Tax revenue may not be maximized by using the optimal performance measure if the agent's tax base risk and the firm's cash flow are positively correlated. While the pay-performance sensitivity of the optimal contract is independent of tax avoidance under the pre-tax measure, under the after-tax measure it is decreasing with increasing incentives for sheltering. If tax evasion is possible, lower levels of tax evasion under the after-tax measure result in an increase in tax revenue relative to the pre-tax measure. The results of our study have implications for contract design, tax political actions and tax revenues.

Keywords: agency theory, performance measures, taxation, tax evasion, tax base risk

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1 Introduction

To incentivize managers to act in the best interest of the firm, their compensation is often tied to one or several performance measures, including accounting earnings. Various definitions of earnings are used in managerial compensation, some being calculated before taxes, others including taxes. As an example, Sloan (1993), p. 66, states: "The definition of earnings performance most frequently used in annual bonus plans is the extent to which reported net income exceeds a pre-specified target net income. However, many plans add back income tax, extraordinary items, or interest,...". Consider the performance metric ROA (Return on Assets), which often uses net earnings in the numerator but sometimes uses earnings before taxes (and interest). Thus, both pre- and after-tax measures are used in incentive contracts, raising the question of whether there are reasons for a surplus-maximizing firm to prefer one type of performance measure over the other. In this paper, we aim to analyze the optimal choice of the agent's performance measure (pre-tax or after-tax) within an agency model. We consider a setting in which both the principal's and the agent's incomes are subject to taxation and both parties face tax base risks. Our primary focus is to investigate how the contracting parties' tax base risks affect the decision between a pre- and an after-tax measure. Furthermore, we demonstrate how the principal's opportunity to evade taxes influences the optimal performance measure choice and under which circumstances the optimal performance measure also generates the higher tax revenue.

In the agency-theoretic literature, some authors use after-tax earnings or cash flows as performance measures (Niemann (2008), Krenn (2017), Ewert and Niemann (2014)), while others use pre-tax measures (Göx (2008), Voßmerbäumer (2013), Martini and Niemann (2015)[1]). In the absence of tax base risks and tax evasion, it does not matter whether a pre-tax or after-tax measure is used. We demonstrate that the optimal incentive rate is simply adjusted for the tax effect; that is, the effective incentive rates under both measures coincide. However, recognizing the tax base risk of the principal,

[1] See also Ortmann and Schindler (2022), who discuss the after-tax and pre-tax approaches in the context of income shifting.

moving from a pre-tax performance measure to an after-tax performance measure has two opposing effects. On the one hand, using an after-tax performance measure incorporates additional risk, as it comprises the principal's tax base risk besides the cash flow risk. On the other hand, if the principal's tax base risk is correlated with the cash flow risk, there might be an insurance effect that reduces the risk premium to be paid to the agent. We show that the optimal performance measure depends on the sign of this overall risk effect that enters the agent's compensation when switching from the pre-tax to the after-tax measure. More specifically, the after-tax measure is the optimal choice if and only if the principal's tax base risk and the cash flow risk are sufficiently positively correlated such that the overall risk effect turns out to be negative. Although the agent's tax base risk might also be correlated with the firm's cash flow, we show that it does not affect the choice of the optimal performance measure. If the principal is able to evade taxes, in addition to the risk effect, the extent of a tax evasion effect determines the optimal performance measure. This tax evasion effect distorts the "efficient" level of tax evasion under the after-tax measure: the principal's ex post manipulation increases the after-tax performance measure so that the agent's variable remuneration increases. To counteract this, the principal reduces manipulation; the higher the agent's incentive rate, the lower the ex post manipulation. This effect does not occur under the pre-tax measure as it is not affected by the manipulation. From the ex ante perspective, at the time the contract is settled, the principal aims to reduce the distortion from the efficient manipulation by reducing the optimal incentive rate. Thus, under the after-tax measure the pay-performance sensitivity of the optimal incentive contract declines if the cost of manipulation is getting lower. Overall, with tax evasion, the use of the after-tax measure is only optimal if the negative risk effect overcompensates the tax evasion effect.

Besides the influence of the two different types of performance measures on the principal's surplus (the agent receives his reservation utility anyway), a comprehensive welfare consideration also needs to study their effect on tax revenue. We show that if tax evasion is not possible, the principal's preferred performance measure always maximizes tax revenue when the agent's tax base risk and the firm's cash flow are either uncorrelated or negatively correlated. The reason is that the principal's preferred performance measure not only generates a higher firm surplus but also higher agent compensation, leading to higher tax revenue. When tax evasion is possible, however, the after-tax measure may maximize tax revenue even if the preferred pre-tax measure induces higher surplus and compensation. This is because tax evasion is less pronounced under the after-tax measure, which in turn increases tax revenue.

Our study has implications for tax policy decisions, performance management and empirical analyses. We show that when deciding between an after-tax or pre-tax performance measure, there is no need for the firm to consider the agent's tax base risk. The only thing that matters is the principal's tax base risk and its correlation with the firm's cash flow (earnings). In this context, a sufficiently positive correlation between the principal's tax base risk and the firm's cash flow is necessary for the optimality of the after-tax measure. Such a positive correlation may be induced by a counter-cyclical tax policy at the firm level. Conversely, from the government's perspective, the agent's tax base risk is important with regard to tax revenue. If the agent's tax base risk and the firm's cash flow are not correlated or are negatively correlated, and the tax audit regime is sufficiently strict, the optimal performance measure chosen by the firm also maximizes tax revenue. In this case, no additional tax policy measures are required. However, with a less strict tax audit regime, higher tax evasion under the pre-tax measure may necessitate tax revenue-increasing policy actions that incentivize firms to adopt after-tax measures. Our results further indicate that while under a pre-tax measure, the problem of designing the optimal incentive contract and the optimal tax evasion decision can be separated, under the after-tax measure, both choices must be jointly determined. Another implication from our study is that higher tax evasion under the pre-tax measure may be efficient in the sense that it maximizes both firm value and tax revenue. The reason is that higher firm output (and higher compensation) under the pre-tax measure not only maximizes firm surplus but may also outweigh the loss in tax revenue due to stronger tax evasion.

Regarding empirical investigations, the results of our study suggest that the use of after-tax measures should be observed less frequently in countries with weaker tax audit regimes. Furthermore, we expect that firms using pre-tax measures in incentive contracts will engage in stronger tax evasion compared to firms using after-tax performance measures. Finally, our findings imply that only under the after-tax measure will pay-performance sensitivities of optimal compensation contracts be higher in countries with stricter tax audit regimes.

The remainder of this paper is organized as follows. In the next section, we introduce the related literature. In section 3, we describe the underlying model assumptions. Subsequently, we present the optimal contracts considering tax base risks, both without (see section 4) and with tax evasion by the principal (see section 5). Finally, we compare the expected tax revenues in the respective cases (see section 6) and discuss our results (see section 7). All proofs are provided in the Appendix.

2 Related literature

The main focus of this paper is the comparison of pre- and after-tax performance measures under two key conditions: the presence of tax base risks for both the principal and the agent, and the opportunity for the principal to engage in tax evasion.

In analyzing uncertain tax policies, Alm (1988) distinguishes between tax base risk and tax rate risk. Tax base risk refers to the tax payer's uncertainty whether the government changes the basic nature of the tax base. Alm (2014) shows that aggressive tax planning declines if tax base risk increases. Ewert and Niemann (2014) and Spaeth (2024) use a similar understanding of tax base risk, and include it in an agency model. Our agency setting is related to their models. In Spaeth (2024) tax base risks are regarded as part of the tax policy's scope of action. She shows that a counter-cyclical tax base policy at the agent's and a pro-cyclical one at the principal's level can raise the agent's variable share of profit and thus the agent's effort, if both contracting parties are risk-averse. Ewert and Niemann (2014) emphasize the correlation between tax base and operational risk as one crucial factor of tax avoidance. Niemann (2011) investigates the effect of tax uncertainty on irreversible investment decisions. He considers tax (base) uncertainty not only as resulting from legislation but also from, for example, different interpretations of tax law by tax courts and taxpayers. Chen et al. (2022) also present a multi-dimensional understanding of tax uncertainty. They refer to tax policy reforms and debates and unclear tax audit outcomes as potential sources of uncertainty. Advance tax rulings (ATRs) are considered as a tool to weaken multi-dimensional uncertainty. Turnbull (1992) considers various sources of tax uncertainty in analyzing the flypaper effect. Tax base risks in his model may be regarded as reflecting taxpayers' limited knowledge of how fiscal decisions translate into the valuation of taxable assets. In our study, we also employ a broader understanding of tax base risks. Besides being a consequence of tax policy, tax base risks may also result from tax ambiguity, firm- or industry-specific risks, as well as individual risks of the agent.

Alm (1988) combines tax evasion and tax base risk. In his model, the underreported income by the taxpayer that is detected by the auditor is a random variable, where higher tax base risk is associated with a mean-preserving spread of this variable. Desai and Dharmapala (2006) consider an agent who can engage in costly tax sheltering. They show that increased incentive compensation reduces the level of tax sheltering. Crocker and Slemrod (2005) consider shareholders signing a contract with a chief financial officer, who can engage in tax evasion. They derive optimal compensation contracts also including fiscal authorities' enforcement policies. Additionally, in contrast to Desai and Dharmapala (2006), who consider only the cost of sheltering at the agent's level, Crocker and Slemrod (2005) also include penalties at the level of the chief financial officer and shareholders. Ortmann and Schindler (2022) investigate income shifting of multinational companies and their effect on management incentivization. Like the present paper, Chen and Chu (2005) assume that the owner of a firm (principal) decides on tax evasion and then distinguish whether or not the manager (agent) is liable for tax evasion. If the agent is not liable for tax evasion, no efficiency losses occur. However, if the agent is liable, he must be compensated for being penalized. As the agent's contract cannot be conditioned on illegal actions, it is necessarily incomplete, and efficiency losses occur. In contrast, we do not assume that the agent is liable for tax evasion at any time. In the present paper, tax evasion is only a matter of the principal. Nonetheless, tax evasion may affect the agent's incentive contract, if the principal's after-tax cash flow is used as a performance measure. Thus, like in Chen and Chu (2005), under the after-tax measure there is a trade-off between internal control and tax evasion.

In modeling tax evasion, our paper is related to the earnings management (manipulation) models by Feltham and Xie (1994) and Goldman and Slezak (2006): tax evasion is modeled as an unobservable, costly action that reduces the principal's taxable cash flow. While Feltham and Xie (1994) model manipulation as a window-dressing action in a multi-task incentive problem that causes similar personal costs as the productive effort, in Goldman and Slezak (2006) the agent can manipulate a report that affects the firm's market price with the cost of manipulation including resource costs and potential costs associated with fraud detection. We also assume that the cost of tax evasion arises from personal costs related to effort and reputation, as well as from penalties incurred when detected. In both cited papers, incentive compensation is a mixed blessing, as it motivates productive effort on the one hand but also incentivizes the agent to manipulate accounting reports. As a consequence, the performance sensitivity of the optimal contract is reduced. In contrast, in our setting, a similar finding arises from the principal's desire to increase ex post manipulation.

Finally, our study is related to the literature that emphasizes trade-offs regarding welfare consequences in analyzing tax compliance. Becker (1968) considers socially optimal law enforcement strategies and shows a trade-off between audit probability and the fine rate. Allingham and Sandmo (1972) indicate the general tension between audit probability and tax revenue. Blaufus et al. (2024) investigate the efficiency effects of information sharing between the statutory auditor and the tax auditor in an extended tax compliance game. They consider tax audit frequency and tax revenue as efficiency measures and show that information sharing may induce a trade-off between both measures. In contrast, depending on the characteristics of the after-tax and pre-tax measures, we demonstrate a potential trade-off between firm surplus and tax revenue associated with the choice of the optimal performance measure.

3 The model

We consider a single-period LEN[2]-agency model in which the principal's gross cash flow (also referred to as output) at the end of the period depends on the agent's effort a, the agent's productivity b and a random term ϵ_x:

$$x = ba + \epsilon_x,$$

where $\epsilon_x \sim N(0, \sigma_x^2)$. The principal's cash flow is subject to taxation with constant tax rate $\tau \in (0,1)$. The tax base is $\widehat{x} = x + \theta_P$ which includes the principal's tax base risk $\theta_P \sim N(0, \sigma_P^2)$. The agent conducts effort a and suffers personal cost $a^2/2$ from performing it. As agent effort is unobservable, the principal must incentivize effort via a performance-based contract. We distinguish two performance measures for the compensation contract: the principal can either use x as a pre-tax performance measure or she can use $x - \widehat{x}\tau$ as an after-tax performance measure in the agent's incentive contract.[3] We consider linear contracts: the agent's compensation is given by $S_p = f + vx$ if the pre-tax measure is used and $S_a = f + v\,(x - \widehat{x}\tau)$ if the after-tax measure is used. f is a fixed payment and v the incentive rate. The agent also has a constant tax rate $t \in (0,1)$. His tax base $\widehat{S}_i = S_i + \theta_A$ for $i = a, p$ includes his personal tax base risk θ_A such that his after-tax compensation obtains as

$$\begin{aligned} \overline{S}_i &= S_i - \widehat{S}_i t \\ &= S_i\,(1-t) - \theta_A t. \end{aligned}$$

with $\theta_A \sim N\left(0, \sigma_A^2\right)$ so that $E(\overline{S}_i) = E(S_i)$.

[2]See Holmström and Milgrom (1987) and Spremann (1987).

[3]We do not consider incentive contracts that rely on both measures x and $x - \widehat{x}\tau$ as such contracts will not be observed in practice. This can be sustained theoretically by assuming that the (unmodeled) costs for the design of an optimal compensation contract relying on both measures is sufficiently high.

In what follows we denote

$$\nu_a := v(1-\tau)(1-t), \tag{1}$$
$$\nu_p := v(1-t)$$

the effective incentive rates under the after-tax measure and the pre-tax measure. These incentive rates characterize the effective pay-performance sensitivities of the contract after all tax effects, i.e., the increase in the agent's wealth, if the principal's expected gross cash flow (x) increases by one Euro or Dollar.

We assume that tax base risks might be correlated with the cash flows risk, i.e., $Corr(\epsilon_x, \theta_P) = \rho$ and $Corr(\epsilon_x, \theta_A) = \mu$, while both individual tax base risks are uncorrelated, i.e., $Corr(\theta_A, \theta_P) = 0$. More specifically, we assume that $(\epsilon_x, \theta_A, \theta_P)$ have a joint (three-dimensional) normal distribution with positive definite covariance matrix

$$\begin{pmatrix} \sigma_x^2 & \mu\sigma_x\sigma_A & \rho\sigma_x\sigma_P \\ \mu\sigma_x\sigma_A & \sigma_A^2 & 0 \\ \rho\sigma_x\sigma_P & 0 & \sigma_P^2 \end{pmatrix},$$

which requires $1 - \mu^2 - \rho^2 > 0$.

While there might be parameter settings where optimal incentive rates become negative, in what follows, we concentrate on cases where the optimal v, and thus ν_a and ν_p, are non-negative.[4]

Tax base uncertainty as well as the assumed correlations need further clarification and interpretation. We consider basically three sources of uncertainty with regard to the principal's and the agent's tax bases represented by the random variables θ_P and θ_A. The first source is related to tax policy. As an example for tax base risks related to tax policy, consider a tax-free amount that depends on the economic cycle/crisis. In this respect, positive and negative correlations may be regarded as counter- or pro-cyclical

[4] With the parameters of our model, this holds true whenever $b^2(1-t) + \mu rt\sigma_x\sigma_A > 0$, which we will assume from now on.

tax policies. In the model, a positive value of the correlation coefficient ρ then implies a counter-cyclical tax policy on the firm level, as a low value of ϵ_x goes along with a low level of θ_P (low taxes in the crisis). We notice, however, that a positive correlation ρ induces a negative covariance in the agent's risk premium under the after-tax measure, because the higher the principal's tax base θ_P is, the lower is the agent's performance measure $x - \widehat{x}\tau$. Similarly, a positive value of the correlation coefficient μ also induces a negative covariance in the agent's risk premium as a higher value of θ_A increases his tax payment and thus reduces the after-tax compensation. Tax base changes during the Covid-19 pandemic in Germany are a current example for a counter-cyclical tax policy at the level of private individuals and companies. For example, at the level of individuals, a home office lump sum was introduced by the Annual Tax Act 2020 and at the company level, investment deductions according to Section 7g of the German Income Tax Act increased by the Annual Tax Act 2020. In times of crises (low value of ϵ_x), the tax base was reduced by these measures.[5] The second source of uncertainty is related to tax ambiguity.[6] Due to the ambiguity of tax law, firms and employees often do not have precise information regarding the correct interpretation of tax law which might result in tax base uncertainty. As an example, the deductibility of some kind of business expenses might be uncertain due to tax ambiguity and therefore induces additional tax base risks on the firm's side.[7] The third source of uncertainty is related to firm- and industry-specific risks and individual characteristics of the agent. For example, on the agent's side, personal circumstances (e.g., children, alimony payments) affect the tax base risk. In what follows, we treat the random variables θ_P and θ_A as resulting from a combination of all three sources of tax base uncertainty. We note again that, as taxes reduce the principal's and the agent's wealth, positive values of the correlation coefficients ρ and μ induce negative covariances,

[5] We assume that the inclusion of tax policy measures (such as tax relief during the COVID-19 pandemic) at the agent and principal levels does not involve complex tax structuring. Therefore, we do not consider the effort of implementation or bureaucratic costs at the agent and principal levels. For an investigation of the bureaucratic costs of tax policy measures during the COVID-19 pandemic, see, e.g., Heile et al. (2020).

[6] See, e.g., Long and Swingen (1987).

[7] See, e.g., Diller et al. (2017). They refer to cash flows from investments that are expected to be tax-deductible but are not recognized as such by the tax authority. Examples include real estate investments, where it may be impossible to determine in advance which portion of the investment costs is attributed to non-depreciable land.

and vice versa.

The risk-averse agent has exponential utility $u\left(\overline{S}_i, a\right) = -\exp\left(-r\left(\overline{S_i} - a^2/2\right)\right)$ with Arrow-Pratt measure $r > 0$. We set his reservation wage to zero without loss of generality. The principal is risk-neutral and maximizes $\Pi_i = E\left(x\right) - E\left(\widehat{x}\right)\tau - E\left(S_i\right)\left(1-\tau\right) = E\left(x - S_i\right)\left(1-\tau\right)$ because $E(x) = E(\widehat{x})$. Thus, we assume that salaries are fully tax-deductible.[8]

4 Analysis: Optimal Contracts with tax base risks

4.1 Pre-tax measure

If the pre-tax cash flow x is used as a performance measure for the agent's compensation contract, the principal's optimization problem is given by

$$\begin{aligned}
&\max_{f,v} \Pi_p = E\left(x - S_p\right)\left(1-\tau\right) \\
&\text{subject to} \\
&CE = E\left(\overline{S}_p\right) - \frac{a^2}{2} - \frac{r}{2} Var\left(\overline{S}_p\right) \geq 0, \\
&a = \underset{a'}{\operatorname{argmax}}\, CE\left(a'\right).
\end{aligned}$$

The first constraint to the principal's optimization problem is the participation constraint that is binding at the optimum. With $E\left(\overline{S}_i\right) = E(S_i)(1-t)$, the binding participation constraint can alternatively be written as $E\left(S_p\right) = \frac{\frac{a^2}{2} + \frac{r}{2} Var\left(\overline{S}_p\right)}{1-t}$. Substituting for $E\left(S_p\right)$ within the principal's objective function, the principal's problem can be rewritten as

$$\begin{aligned}
&\max_{v} \Pi_p = \left(E(x) - \frac{\frac{a^2}{2} + \frac{r}{2} Var\left(\overline{S}_p\right)}{1-t}\right)\left(1-\tau\right) \qquad (2) \\
&\text{subject to} \\
&a = \underset{a'}{\operatorname{argmax}}\, CE\left(a'\right).
\end{aligned}$$

[8] As usual in agency models, we define the agent's performance measure gross of his compensation. Therefore, we do not consider $\left(\widehat{x} - S_i\right)$ as a performance measure.

The second constraint to the principal's problem, the incentive compatibility constraint, can be rewritten from solving the agent's first-order condition for optimal a, $dCE/da = 0$, as $a = vb(1-t)$. For the variance term we obtain $Var\left(\overline{S}_p\right) = v^2(1-t)^2\sigma_x^2 + t^2\sigma_A^2 - 2v(1-t)t\mu\sigma_x\sigma_A$, so that the principal's problem finally reduces to

$$\max_v \Pi_p = \left(b^2 v(1-t) - \frac{\frac{(vb(1-t))^2}{2} + \frac{r}{2}\left(v^2(1-t)^2\sigma_x^2 + t^2\sigma_A^2 - 2v(1-t)t\mu\sigma_x\sigma_A\right)}{1-t}\right)(1-\tau). \tag{3}$$

Lemma 1 *Under the pre-tax performance measure the optimal incentive rate and the principal's corresponding surplus are given by*

$$\begin{aligned} v_p^\dagger &= \frac{b^2(1-t) + r\mu\sigma_x\sigma_A t}{(b^2 + r\sigma_x^2)(1-t)}, \\ \Pi_p^\dagger &= \frac{(1-\tau)\left[r^2\sigma_A^2\sigma_x^2 t^2(\mu^2-1) + 2b^2\mu r\sigma_A\sigma_x t(1-t) + b^2\left(b^2(1-t)^2 - rt^2\sigma_A^2\right)\right]}{2(b^2 + r\sigma_x^2)(1-t)}. \end{aligned}$$

4.2 After-tax measure

If the after-tax measure $x - \widehat{x}\tau$ is used as a performance measure for the agent's compensation contract, the principal's optimization problem is:

$$\begin{aligned} &\max_{f,v} \Pi_a = E(x - S_a)(1-\tau) \\ &\text{subject to} \\ &CE = E\left(\overline{S}_a\right) - \frac{a^2}{2} - \frac{r}{2}Var\left(\overline{S}_a\right) \geq 0, \\ &a = \operatorname*{argmax}_{a'} CE(a'). \end{aligned}$$

From the binding participation constraint, we derive $E\left(S_a\right) = \frac{\frac{a^2}{2}+\frac{r}{2}Var\left(\overline{S}_a\right)}{1-t}$, so that the problem reduces to

$$\max_v \Pi_a = \left(E(x) - \frac{\frac{a^2}{2} + \frac{r}{2}Var\left(\overline{S}_a\right)}{1-t}\right)(1-\tau)$$
$$\text{subject to}$$
$$a = \underset{a'}{\operatorname{argmax}}\, CE\left(a'\right).$$

Furthermore, the incentive compatibility constraint can now be written as $a = vb\left(1-\tau\right)\left(1-t\right)$. Substituting these elements into the principal's objective function, we obtain the following unconstrained problem:

$$\max_v \Pi_a = \left(b^2 v\left(1-t\right)\left(1-\tau\right) - \frac{\frac{\left(vb(1-t)(1-\tau)\right)^2}{2} + \frac{r}{2}\left(Var\left(\overline{S}_a\right)\right)}{1-t}\right)\left(1-\tau\right), \qquad (4)$$

with $Var\left(\overline{S}_a\right) = v^2\left(1-\tau\right)^2\left(1-t\right)^2\sigma_x^2 + v^2\left(1-t\right)^2\sigma_P^2\tau^2 + t^2\sigma_A^2 - 2\rho v^2\left(1-\tau\right)\left(1-t\right)^2\tau\sigma_x\sigma_P - 2\mu v(1-\tau)(1-t)t\sigma_x\sigma_A$.

Lemma 2 *Under the after-tax performance measure the optimal incentive rate and the principal's corresponding surplus are given by*

$$v_a^\dagger = \frac{\left(b^2\left(1-t\right) + r\mu\sigma_x\sigma_A t\right)\left(1-\tau\right)}{\left(1-t\right)\left(b^2\left(1-\tau\right)^2 + r\left(\sigma_x^2\left(1-\tau\right)^2 - 2\sigma_x\sigma_P\rho\left(1-\tau\right)\tau + \sigma_P^2\tau^2\right)\right)},$$

$$\Pi_a^\dagger = \frac{\left(1-\tau\right)\left[\begin{array}{c} b^4\left(1-t\right)^2\left(1-\tau\right)^2 - b^2\sigma_A r t\left(-2\sigma_x\mu\left(1-t\right) + \sigma_A t\right)\left(1-\tau\right)^2 \\ +\sigma_A^2 r^2 t^2\left(-\sigma_x^2\left(1-\mu^2\right)\left(1-\tau\right)^2 + 2\sigma_x\sigma_P\rho\left(1-\tau\right)\tau - \sigma_P^2\tau^2\right)\end{array}\right]}{2\left(1-t\right)\left[b^2\left(1-\tau\right)^2 + r\left(\sigma_x^2\left(1-\tau\right)^2 - 2\rho\sigma_x\sigma_P\left(1-\tau\right)\tau + \sigma_P^2\tau^2\right)\right]}.$$

4.3 Results

By understanding the principal's optimization problems and their solutions under both performance measures, we can now determine the circumstances in which each performance measure is the optimal choice:

Proposition 1 *(i) If there is no tax base risk at the principal's level ($\sigma_P = 0$), the principal's surplus under the after-tax measure and the pre-tax measure coincide.*

(ii) If there is tax base risk at the principal's level ($\sigma_P > 0$), the principal's surplus under the after-tax measure is higher than under the pre-tax measure if and only if $\rho > \frac{\sigma_P \tau}{2\sigma_x(1-\tau)}$.

The findings in Proposition 1 result solely from the (potentially) different risk premiums induced by the two performance measures. To see this[9], consider the effective incentive rates under both performance measures, given in (1). Then, the principal's optimization problems under both regimes, given by (3) and (4), coincide except for the agent's tax adjusted risk premiums, which become

$$\frac{r(1-\tau)}{2(1-t)} Var\left(\overline{S}_a\right) = \frac{r(1-\tau)}{2(1-t)}(\nu_a^2\sigma_x^2 + t^2\sigma_A^2 - 2\nu_a t\sigma_x\sigma_A\mu + \frac{\nu_a^2\tau}{(1-\tau)^2}(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho))$$

under the after-tax measure, and

$$\frac{r(1-\tau)}{2(1-t)} Var\left(\overline{S}_p\right) = \frac{r(1-\tau)}{2(1-t)}\left(\nu_p^2\sigma_x^2 + t^2\sigma_A^2 - 2\nu_p t\sigma_x\sigma_A\mu\right) \tag{5}$$

under the pre-tax measure. For a given effective incentive rate $\nu_a = \nu_p = \nu_0$, the surplus difference can then be written as

$$\begin{aligned}\Pi_a(\nu_0) - \Pi_p(\nu_0) &= -\frac{r(1-\tau)}{2(1-t)}(Var\left(\overline{S}_a(\nu_0)\right) - Var\left(\overline{S}_p(\nu_0)\right)) \\ &= -\nu_0^2\omega\underbrace{\left(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho\right)}_{\text{risk effect}},\end{aligned} \tag{6}$$

with $\omega \equiv \dfrac{r\tau}{2(1-\tau)(1-t)}$.

Thus, (6) implies that transitioning from a pre-tax to an after-tax measure makes managerial compensation dependent on the principal's tax base risk, θ_P, which induces an additional variance effect ($\tau\sigma_P^2$) and a covariance effect ($-2(1-\tau)\sigma_x\sigma_P\rho$). In what follows, we call the total variance/covariance effect ($\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho$) the "risk effect";

[9] For a complete analysis, see the Appendix.

it can be positive or negative (or zero). For a given effective incentive rate the risk effect is weighted by ω. Therefore, we call the factor ω the risk effect's "weight".

If and only if the covariance effect is negative and stronger than the variance effect, the risk effect is negative and the risk premium to be paid to the agent is lower under the after-tax measure for a given effective incentive rate. This is the case, if and only if $\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho < 0$, or equivalently, $\rho > \frac{\sigma_P\tau}{2\sigma_x(1-\tau)}$. If this condition holds true, the agent's risk premium is lower (and thus the firm's surplus is higher) under the after-tax measure. As this holds true for any value of ν_0, it must also hold true at the optimum values for the (effective) incentive rates under both regimes.

We can thus conclude from Proposition 1, that a positive correlation (that induces a negative covariance effect) between the cash flow and the principal's tax base risk is a necessary condition for the optimality of the after-tax measure. For example, a counter-cyclical tax policy on the firm level induces such a positive correlation and thus favors the use of an after-tax measure.

Notice also that while the agent's tax base risk and his tax rate affect the surpluses under each performance measure (see Lemmas 1 and 2), it does not affect the choice of the optimal performance measure. This is due to the effect that the agent's tax base risk and his tax rate ceteris paribus affect the optimization problems under both performance measure regimes in the same fashion. Thus, the difference between using an after-tax or a pre-tax measure is only material, if the principal faces tax base risks. If this is not the case ($\sigma_P = 0$), optimization problems under both regimes coincide leading to the same optimal effective incentive rates and the same surplus.

While the agent's tax rate has no effect, the principal's tax rate τ affects the choice of the optimal performance measure, as it influences both the variance effect and the covariance effect when transitioning from a pre-tax to an after-tax measure. In particular, if the principal's tax rate τ approaches its maximum value $\tau = 1$, the induced additional compensation variance ($\tau\sigma_P^2$) takes its maximum value and the covariance effect vanishes. Thus, in general, high corporate tax rates for the principal favor using the pre-tax measure. Further investigation of condition ii) of Proposition 1 shows that if the principal's tax base risk is sufficiently high $\sigma_P > 2\sigma_x (1-\tau)/\tau$, so that the critical value for ρ exceeds one, the pre-tax measure is always the optimal choice. In this case, the variance effect is stronger than the covariance effect, independently of the correlation ρ, so that the overall risk effect becomes positive. In contrast, a high value of cash flow risk σ_x is sufficient for the optimality of the after-tax measure if correlation ρ is positive, since it decreases the covariance effect without affecting the variance effect.

5 Tax evasion by the principal

In line with Chen and Chu (2005), we now incorporate the possibility of tax evasion by the principal. This assumption is appropriate for settings where the principal is responsible for the firm's tax policy, for example, if the principal is an owner-manager and the agent a lower level manager. More specifically, we denote the principal's amount of tax evasion by m, which causes costs of $C(m) = \frac{\alpha m^2}{2}$. $\alpha > 0$ is a measure of how costly tax evasion is for the principal; if the principal evades an additional monetary unit of taxes, marginal costs increase by α. These costs comprise efforts to camouflage tax evasion as well as expected costs (penalties) from detected tax evasion and psychic or reputation costs.[10] By choosing m, the principal reduces her tax base so that the taxable cash flow amounts to $\widehat{x} = x + \theta_P - m$, which implies that $E(x) = E(\widehat{x})$ is no longer true.

Notice that, of course, the principal cannot commit to a specific value m ex ante. Rather, she must choose the value of m sequentially optimal. Thus, we have in fact a double moral hazard problem, where the principal needs to consider an incentive compatibility constraint for her own m-choice.

In what follows, we first consider the solution to the problem without tax base risks for the principal and the agent. This approach allows us to disentangle the impact of tax evasion on the equilibrium solution from the effects of tax base risks. In the second step,

[10] See Fischer and Verrecchia (2000).

we then introduce tax base risks for both players and identify the combined effect of tax evasion and tax base risks on the choice of the optimal performance measure.

5.1 Benchmark: No tax base risks

If no tax base risks exist, i.e., if θ_P and θ_A vanish, resulting in $\widehat{S}_i = S_i$, then the second-best solutions (including effective incentive rates, efforts, and surpluses) under both the after-tax and pre-tax measures coincide when tax evasion is not possible. This implies that any deviations between the two performance measurements we derive in this section must result from the principal's tax evasion. We start with the analysis of the pre-tax measure.

5.1.1 Pre-tax measure

If the pre-tax measure is used as a performance measure, the principal's objective function in the presence of tax evasion is given by $\Pi_{p,e} = E(x) - E(\widehat{x})\tau - E(S_p)(1-\tau) - C(m)$. We can extract the terms related to tax evasion to write the principal's surplus as $\Pi_{p,e} = E(x - S_p)(1-\tau) + \tau m - C(m)$, where the definition of S_p is the same as in the base model. Thus, the principal's objective function consists of her surplus without tax evasion ($E(x - S_p)(1-\tau)$) and the net benefit from tax evasion ($\tau m - C(m)$), that includes the expected tax savings and the tax evasion costs. Given that the agent has accepted the contract and started working, the principal chooses m to maximize $\Pi_{p,e}$, which boils down to maximizing the net benefit of tax evasion. From the first-order optimality condition $d(\tau m - C(m))/dm = 0$, we obtain the sequentially optimal tax evasion level $m^{\dagger}_{p,e} = \tau/\alpha$, which turns out to be independent of the incentive rate v. The principal's optimization problem to find the optimal incentive contract under tax evasion can now be stated as:

$$\max_{f,v} \Pi_{p,e} = E\left(x - S_p\right)\left(1-\tau\right) + \tau m - C\left(m\right) \tag{7}$$

subject to

$$CE = E\left(\overline{S}_p\right) - \frac{a^2}{2} - \frac{r}{2}Var\left(\overline{S}_p\right) \geq 0,$$

$$a = b(1-t)v,$$

$$m = \tau/\alpha,$$

with $\overline{S}_p = S_p(1-t)$. For the variance term we obtain without tax base risks ($\theta_P = 0$ and $\theta_A = 0$), $Var\left(\overline{S}_p\right) = v^2\left(1-t\right)^2\sigma_x^2$. As opposed to the optimization problems in the previous sections, the principal recognizes her own sequentially optimal tax evasion behavior when determining the optimal contract. However, as under the pre-tax measure the choice of tax evasion is not affected by the incentive rate, and vice versa, the same incentive rate as without tax evasion results (here: without tax base risks):

Lemma 3 *Without tax base risks, if the principal can evade taxes, the following equilibrium values result under the pre-tax measure:*

$$v_{p,e}^{\dagger} = \frac{b^2}{b^2 + r\sigma_x^2}, \qquad m_{p,e}^{\dagger} = \tau/\alpha,$$

$$\Pi_{p,e}^{\dagger} = \frac{b^2\tau^2 + \sigma_x^2 r\tau^2 + b^4(1-t)(1-\tau)\alpha}{2(b^2 + \sigma_x^2 r)\alpha}.$$

Lemma 3 demonstrates that under the pre-tax measure the level of tax evasion will be "first-best". As there is no connection between the internal control problem (solved by the incentive rate v) and the tax evasion, also the optimal incentive rate is not distorted by the principal's tax evasion.

5.1.2 After-tax measure

If the principal can engage in tax evasion and the after-tax cash flow is used as a performance measure, then without tax base risks, the measure is calculated as $x - \widehat{x}\tau =$

$x-(x-m)\,\tau = x(1-\tau)+\tau m$. The principal's objective function can now be stated as:

$$\begin{aligned}\Pi_{a,e} &= E(x) - E(\widehat{x})\tau - E(S_a(m))(1-\tau) - C\,(m) \\ &= E\,(x - S_a\,(m))\,(1-\tau) + \tau m - C\,(m)\,.\end{aligned}$$

With $S_a\,(m) = f + v(x - \widehat{x}\tau) = f + v\big(x\,(1-\tau) + m\tau\big)$, the principal's objective function becomes

$$\Pi_{a,e} = E\,(x)\,(1-\tau) - (f + v(E(x)(1-\tau) + \tau m))(1-\tau) + \tau m - C\,(m) \tag{8}$$

$$= E\,(x)\,(1-\tau) - (f + vE(x)(1-\tau))(1-\tau) - v\tau m(1-\tau) + \tau m - C\,(m)\,. \tag{9}$$

In equation (9), we have again isolated all tax evasion-related effects, and the net benefit of tax evasion in the surplus function is now given by $-v\tau m(1-\tau) + \tau m - C\,(m)$. Given the agent has accepted the compensation contract, maximizing $\Pi_{a,e}$ for m is equivalent to maximizing the net benefit of tax evasion which results in $m = \frac{\tau-(1-\tau)\tau v}{\alpha}$. In contrast to the pre-tax measure, the optimal tax evasion level depends on the agent's incentive rate so that both have to be jointly determined in equilibrium. The reason is that while the pre-tax measure is not affected by the principal's tax evasion, the after-tax measure increases in the level of tax evasion m. Thus, more tax evasion under the after-tax measure increases the variable compensation to be paid to the agent ex post. To account for this effect, the principal reduces her level of tax evasion under the after-tax measure accordingly, which is captured by the term $-(1-\tau)\tau v$ in the principal's choice of m. Thus, the higher the pay-performance sensitivity of the optimal contract, the lower the extent of tax evasion. We can now formulate the principal's optimization problem as follows:

$$\max_{f,v} \Pi_{a,e} = E\left(x - S_a\left(m\right)\right)\left(1-\tau\right) + \tau m - C\left(m\right) \tag{10}$$

subject to

$$\begin{aligned} CE &= E\left(\overline{S}_a\left(m\right)\right) - \frac{a^2}{2} - \frac{r}{2} Var\left(\overline{S}_a\left(m\right)\right) \geq 0, \\ a &= vb\left(1-\tau\right)\left(1-t\right), \\ m &= \frac{\tau - (1-\tau)\tau v}{\alpha}, \end{aligned}$$

with $\overline{S}_a\left(m\right) = S_a\left(m\right)\left(1-t\right)$ and $Var\left(\overline{S}_a\left(m\right)\right) = v^2\left(1-\tau\right)^2\left(1-t\right)^2\sigma_x^2$. The following lemma presents the solution to the problem:

Lemma 4 *With the after-tax performance measure, assuming there are no tax base risks, if the principal can evade taxes, the following equilibrium values result:*

$$\begin{aligned} v_{a,e}^{\dagger} &= \frac{b^2(1-t)\alpha}{\tau^2 + \left(b^2 + \sigma_x^2 r\right)\left(1-t\right)\alpha(1-\tau)}, \qquad m_{a,e}^{\dagger} = \frac{\tau - (1-\tau)\tau v_{a,e}^{\dagger}}{\alpha} \\ \Pi_{a,e}^{\dagger} &= \frac{\tau^4 + (b^2 + \sigma_x^2 r)(1-t)(1-\tau)\tau^2\alpha + b^4(1-t)^2(1-\tau)^2\alpha^2}{2\alpha\Big(\tau^2 + \left(b^2 + \sigma_x^2 r\right)\left(1-t\right)\alpha(1-\tau)\Big)}. \end{aligned}$$

Lemma 4 shows that there is a trade-off between internal control and tax evasion under the after-tax measure that has to be solved by the optimal incentive rate. Efficient (first-best) tax evasion $m = \tau/\alpha$ requires setting $v = 0$. However, then no productive effort can be induced. Similarly, efficient second-best effort would require that the effective incentive rate is the same as under the pre-tax measure: $\nu_{a,e}^{\dagger} = \nu_{p,e}^{\dagger}$. However, to mitigate the distortion in tax evasion, the principal sets $\nu_{a,e}^{\dagger} < \nu_{p,e}^{\dagger}$. While in Chen and Chu (2005) the trade-off between internal control and tax evasion involves the liability risk imposed on the agent by the principal's tax evasion decision, in our setting it is related to the principal's own sequentially optimal choice of tax evasion.

5.1.3 Results

We now compare the equilibrium surpluses under both performance measurement regimes when no tax base risks are present.

Proposition 2 *The level of tax evasion under the pre-tax measure always exceeds that under the after-tax measure. Therefore, in the absence of tax base risks, the pre-tax measure is always the principal's optimal choice.*

The reason for the result in Proposition 2 is due to the trade-off between internal control and tax evasion that occurs (only) under the after-tax measure. This trade-off is induced by the principal's wish to keep the agent's compensation low under the after-tax measure which distorts the "efficient" level of tax evasion downwards. This effect is captured by the principal's choice $m = \frac{\tau-(1-\tau)\tau v}{\alpha}$ for tax evasion under the after-tax measure, which depends on the agent's incentive rate v. This interdependency between tax evasion and the incentive rate ultimately distorts both the agent's effort and the principal's choice of tax evasion, reducing them compared to the pre-tax measure. As as consequence, the surplus is reduced, too.

In the Proof of Proposition 2 we show that for a given effective incentive rate ν_0 under both performance measures the principal's surplus difference is given by

$$\Pi^{\dagger}_{a,e} - \Pi^{\dagger}_{p,e} = -\nu_0^2 \underbrace{\frac{\tau^2}{2\alpha(1-t)^2}}_{\text{tax evasion effect}} < 0. \tag{11}$$

The loss in surplus under the after-tax measure is proportional to the term $\frac{\tau^2}{2\alpha(1-t)^2}$, which we call the "tax evasion effect" in what follows. It is a measure for the distortion in tax evasion caused by the after-tax measure compared to the pre-tax measure if no tax base risks are present.

5.2 The effect of tax base risks

The presence of tax base risks does not alter the first part of Proposition 2 concerning the levels of tax evasion: the level of tax evasion under the after-tax measure is always distorted downward compared to the pre-tax measure. However, compared to the optimization programs analyzed in the previous section, (only) the variances $Var\left(\overline{S}p\right)$ and $Var\left(\overline{S}a\left(m\right)\right)$ change due to the incorporation of tax base risks, which may have implications for the comparison of surpluses. The variances are now given by

$$Var\left(\overline{S}_p\right) = v^2\left(1-t\right)^2\sigma_x^2 + t^2\sigma_A^2 - 2v\left(1-t\right)t\mu\sigma_x\sigma_A,$$

and

$$\begin{aligned}Var\left(\overline{S}_a(m)\right) &= v^2\left(1-\tau\right)^2\left(1-t\right)^2\sigma_x^2 + v^2\left(1-t\right)^2\sigma_P^2\tau^2 + t^2\sigma_A^2\\ &\quad -2\rho v^2\left(1-\tau\right)\left(1-t\right)^2\tau\sigma_x\sigma_P - 2\mu v(1-\tau)(1-t)t\sigma_x\sigma_A.\end{aligned}$$

By recognizing the effects of the changed variances on the equilibrium solutions, we obtain the following result:

Proposition 3 *If the agent and the principal face tax base risks and the principal can evade taxes, the principal prefers the after-tax measure if and only if the weighted risk effect overcompensates the tax evasion effect, i.e., if and only if*

$$\frac{\tau^2}{2\alpha(1-t)^2} < -\omega\left(\tau\sigma_P^2 - 2\left(1-\tau\right)\sigma_x\sigma_P\rho\right).$$

According to Proposition 3 the after-tax cash flow is the optimal performance measure if and only if the weighted risk effect at least compensates for the tax evasion effect, which implies that the risk effect $(\tau\sigma_P^2 - 2\left(1-\tau\right)\sigma_x\sigma_P\rho)$ must be negative, or, equivalently, $\rho > \frac{\sigma_P\tau}{2\sigma_x(1-\tau)}$. Thus, if tax evasion is possible, a negative risk effect (see Proposition 1), is necessary for the optimality of the after-tax measure, but not sufficient anymore.

Given the risk effect is negative, the after-tax measure is the optimal performance measure if the weight of the risk effect $\omega = \frac{r\tau}{2(1-\tau)(1-t)}$ is sufficiently high and/or the tax evasion effect $\frac{\tau^2}{2\alpha(1-t)^2}$ is sufficiently weak. The tax evasion effect becomes weak if the marginal cost of tax evasion, α, is high. This is evident because a higher cost of evading taxes reduces the overall level and significance of tax evasion, thereby diminishing the impact of its distortion under the after-tax measure. Thus, the better the tax evasion opportunities (the lower α), the stronger the correlation must be between cash flows and the principal's tax base risk. A sufficiently strong counter-cyclical tax policy at the firm level can induce this kind of correlation.

Clearly, the more risk-averse the agent is (higher r) the stronger is the impact of the risk effect on the principal's surplus. Thus, given the risk effect is negative, a sufficiently risk-averse agent ensures the optimality of the after-tax measure. Notice further that ω decreases in $(1-t)$ while the tax evasion effect decreases in the square of $(1-t)$. Thus, if t becomes smaller, the relation between ω and the tax-evasion effect becomes larger. Therefore, a lower agent tax rate t makes the after-tax measure relatively more profitable or less disadvantageous, given that the risk effect is negative. In contrast, the overall effect of the principal's tax rate τ is more complex: τ affects the tax evasion effect, the risk effect and its weight. If τ becomes sufficiently high, the risk effect becomes positive so that using the pre-tax measure is always optimal. For a negative risk effect, on the one hand, the higher τ the less strong is the risk effect but on the other hand, its weight ω increases in τ. In addition, the tax evasion effect gets stronger with higher τ so that the overall effect of a marginal increase in τ on the comparison of the after- and pre-tax measure is ambiguous and depends on the specific parameters of the model. Finally, the principal's tax base risk σ_P^2 and the cash flow risk σ_x^2 affect only the risk effect so that effects are similar as those derived in the setting without manipulation (Proposition 1): while higher cash flow risk increases the covariance between the cash flow and the principal's tax base risk, thereby favoring the after-tax measure, a sufficiently high variance in the principal's tax base risk induces a positive risk effect, making the pre-tax measure optimal.

Summarizing our results from Proposition 3 , we can state that if tax evasion is possible, a negative risk effect is necessary but not sufficient for the after-tax measure to be the optimal performance metric. Therefore, in the presence of tax evasion opportunities, the pre-tax measure becomes optimal for a broader range of parameters. In other words, the requirements for the after-tax measure to be the optimal choice are more stringent; the negative risk effect must also outweigh the tax evasion effect.

The next proposition shows how the pay-performance sensitivity of the optimal contract varies with the cost of tax evasion under both performance measures.

Proposition 4 *While under the pre-tax measure the pay-performance sensitivity of the optimal contract does not depend on the cost of manipulation, under the after-tax measure the pay-performance sensitivity is increasing with inecreasing cost of manipulation:* $\frac{\partial v^{\dagger}_{p,e}}{\partial \alpha} = 0$, $\frac{\partial v^{\dagger}_{a,e}}{\partial \alpha} > 0$.

Proposition 4 shows that less favorable tax evasion opportunities, captured by a higher cost parameter α, lead to a higher pay-performance sensitivity of the optimal contract under the after-tax measure. This result mirrors findings from the earnings management literature, particularly in Feltham and Xie (1994) and Goldman and Slezak (2006), where higher incentive pay increases both productive effort and manipulation. Consequently, the pay-performance sensitivity of the optimal incentive contract increases when manipulation incentives decrease. We obtain a similar result, though for different reasons: A higher cost of tax evasion reduces the principal's benefit from evading taxes. As a result, the principal does not need to significantly reduce the distortion in her sequentially optimal tax evasion choice by offering an excessively low incentive rate. In contrast, under the pre-tax measure, the choice of the incentive rate and the tax evasion decision are fully separable. Finally, under both the pre-tax and after-tax measure, tax evasion m decreases if its costs, captured by α, increase. While this is obvious under the pre-tax measure, under the after-tax measure it also holds true because, according to Proposition 4, $\frac{\partial v^{\dagger}_{a,e}}{\partial \alpha} > 0$.

6 Tax Revenue Considerations

We now take the perspective of the revenue agency and investigate whether the firm's optimal performance measure, as determined in the previous sections, also generates the highest tax revenue. For convenience, we denote the expected output under performance measure $i = a, p$, as $E(x_i)$. We start with the basic setting without tax evasion.

6.1 Tax revenue without tax evasion

With the two taxpayers (the firm and the manager) in our model, tax revenue TR_i under performance measure $i = a, p$ is defined as

$$TR_i = \tau(E(x_i) - E(S_i)) + tE(\widehat{S}_i) \quad \text{for } i = a, p,$$

which can be rewritten because of $E(S_i) = E(\widehat{S}_i)$ as

$$TR_i = \tau(E(x_i)) + (t - \tau)E(S_i) \quad \text{for } i = a, p,$$

where $E(x_i)$ and $E(S_i)$ must be evaluated at their respective equilibrium values. The difference in tax revenues is then defined as

$$\Delta TR = TR_a - TR_p = \tau \Delta E(x) + (t - \tau)\Delta E(S), \tag{12}$$

with $\Delta E(x) = E(x_a) - E(x_p)$ and $\Delta E(S) = E(S_a) - E(S_p)$.

Based on ΔTR, we determine whether tax revenue is higher under the after-tax or pre-tax performance measure. Before we present the result, we define the agent productivity factor $B \equiv b^2(1 - t)$ and the agent tax base/cash flow correlation factor $U = \mu r t \sigma_x \sigma_A$. Our assumption of positive incentive rates implies $U + B > 0$.

Proposition 5 *The principal's preferred performance measure also maximizes tax revenue, except when* $t > \frac{\tau(U+B)}{U-B}$*, with* $U - B > 0$ *and* $t > \tau$*.*

To build intuition for Proposition 5, we express the difference in tax revenue, ΔTR, as defined in (12), as follows:

$$\Delta TR = \tau(\Delta E(x) - \Delta E(S)) + t\Delta E(S). \tag{13}$$

The first term in (13), $\tau(\Delta E(x) - \Delta E(S))$, represents the difference in the principal's surpluses under the two performance measures.[11] Surplus is higher for the principal's preferred performance measure. Consequently, $\tau(\Delta E(x) - \Delta E(S))$ is strictly positive, if the use of the after-tax measure is optimal, and strictly negative, if the use of the pre-tax measure is optimal. The second term, $t\Delta E(S)$, is proportional to the difference in the expected compensations under both measures. If the principal's preferred performance not only induces higher surplus but also higher expected compensation, according to (13), it always generates higher tax revenue. In contrast, if the expected compensation under the preferred performance measure is lower, the sign of ΔTR depends on tax rates t and τ. Tax revenue under the dominated performance measure is higher if and only if the conditions in Proposition 5 are met, which we now consider in more detail. The agent's expected compensation, due to the binding participation constraint, consists of his disutility of effort and his risk premium (divided by $1-t$). The optimal performance measure enables a better trade-off of risks and incentives. Due to the better risk-sharing opportunities, the effective incentive rate is higher under the preferred performance measures. This leads to a higher effort and thus to higher disutility of effort. The effect of the higher effective incentive rate on the risk premium, however, is ambiguous. In the proof of Proposition 5 we show that expected compensation under the non-optimal performance measure is higher than under the preferred measure if and only if the covariance factor exceeds the productivity factor, $U - B > 0$, or $U > B$. This requires a positive correlation coefficient μ between the agent's tax base risk and the firm's cash flow. A positive correlation induces an insurance effect for the agent and reduces the risk premium that must be paid to the agent. If this correlation factor U is sufficiently

[11] More precisely, $\tau(\Delta E(x) - \Delta E(S)) = \frac{\tau}{1-\tau}(\Pi_a^\dagger - \Pi_p^\dagger)$.

strong relative to the influence of the effort's productivity B, the risk premium under the optimal performance measure, despite the higher effective incentive rate, is reduced so much compared to the suboptimal measure that the expected compensation becomes lower. If the influence of expected compensation on tax revenue is stronger than that of firm surplus, tax revenue will be lower under the preferred measure. According to (13), this occurs when the agent's tax rate sufficiently exceeds the firm's tax rate, as indicated by the condition $t > \frac{\tau(U+B)}{U-B}$, with $t > \tau$, in Proposition 5.

In all other cases, tax revenue is higher under the firm's optimal performance measure. This can occur either because expected compensation is also higher under this measure ($U - B < 0$), or if the agent's tax rate is low. In these scenarios, the principal's surplus, tax revenue, and consequently, overall welfare are maximized by the principal's optimal choice of performance measures.[12]

6.2 Tax Revenue with Tax Evasion

If the principal can engage in tax evasion, her taxable cash flow is given by $\widehat{x} = x - m + \theta_P$, such that tax revenues under both performance measures can be stated as:

$$TR_{p,e} = \tau(E(x_p) - E(S_p)) + tE(S_p) - \tau m_{p,e}$$

in the case of the pre-tax performance measure and

$$TR_{a,e} = \tau(E(x_a) - E(S_a(m))) + tE(S_a(m)) - \tau m_{a,e}$$

in the case of the after-tax measures; and let $\Delta TR_e = TR_{a,e} - TR_{p,e}$. Again, all variables have to be considered at their equilibrium values. As opposed to the benchmark setting without tax evasion the terms $\tau m_{p,e}$ and $\tau m_{a,e}$ ceteris paribus reduce the tax revenues generated under both performance measures. In what follows we define $\Delta m = m_{a,e} - m_{p,e} < 0$ as the difference in tax evasion under both perfor-

[12] The agent always receives his reservation utility in equilibrium under any measure so that welfare can be measured in terms of the revenue agency's and the principal's payoffs.

mance measures. From Proposition 3 we know that the after-tax measure is optimal if and only if $\frac{\tau^2}{2\alpha(1-t)^2} < -\omega\left(\tau\sigma_P^2 - 2\left(1-\tau\right)\sigma_x\sigma_P\rho\right)$, which can be rewritten as $C \equiv \alpha(t-1)r\sigma_p(\tau\sigma_p - (1-\tau)2\rho\sigma_x) + \tau(\tau-1) > 0$. Thus, for $C > (<)0$ the after-tax (pre-tax) measure is the optimal performance measure and for $C = 0$ the principal is indifferent between both performance measurement regimes.

To capture the main differences from the setting without tax evasion, in what follows, we consider the generated tax revenue for two distinct scenarios. First, we consider the case $t = \tau$ and second, we analyze tax revenue if no tax base risks are present. These settings allow us to capture the additional effects of tax evasion on tax revenue in a straightforward way, thereby avoiding the overlapping of several different effects in the full model.

We first consider the case of identical tax rates. With $t = \tau$, in the benchmark setting without tax evasion, the firm's preferred performance measure always maximizes tax revenue (Proposition 5), depending solely on the sign of C. In the presence of tax evasion, however, we obtain the following result:

Proposition 6 *For $t = \tau$, the after-tax measure induces higher tax revenues if and only if* $\frac{\tau b^2 C}{b^2 + r\sigma_x^2} + \tau(1-\tau)^2 > 0$.

If the agent's and the principal's tax rates are identical, the difference in tax revenues generated under both performance measure reduces to $\Delta TR_e = \tau(\Delta E(x) - \Delta m)$. The first term $\frac{\tau b^2 C}{b^2 + r\sigma_x^2}$ stems from the difference in expected outputs $\Delta E(x)$. As the effective incentive rate is higher, similar to the base setting, the preferred performance measure (captured by the sign of C) generates the higher expected output. The second term $\tau(1-\tau)^2$ results from the difference in tax evasion under both measures, Δm. Notice that $-\Delta m = \frac{(1-\tau)\tau v_{a,e}^{\dagger}}{\alpha}$. This term is increasing in $\tau(1-\tau)^2$ (see the proof). Thus, the higher $\tau(1-\tau)^2$, the stronger the tax evasion under the pre-tax measure compared to the after-tax measure, resulting in a less pronounced loss in tax revenue under the after-tax measure. The condition in Proposition 6 then implies that the after-tax measure may also generate higher tax revenues if it is not the principal's preferred performance measure, or, equivalently, the pre-tax measure may generate lower tax revenue even if is the optimal performance measure. This happens if the lower expected output under the after-tax measure (for $C < 0$) is compensated by the lower level of tax evasion under this measure. Given the pre-tax measure is optimal ($C < 0$), a sufficiently low effort productivity b ensures that the influence of expected output on tax revenue is smaller than the effect of tax evasion so that finally the after-tax measure maximizes tax revenue.

The second scenario we consider is characterized by the absence of tax base risks ($\theta_A = \theta_P = 0$), which implies $U = 0$. Consequently, in the benchmark setting without tax evasion, the firm's preferred performance measure would once again maximize tax revenue. From Lemma 3 and 4 we can determine the difference in tax revenues when no tax base risks are present as:

$$\Delta TR_e = TR_{a,e} - TR_{p,e} = \tau\Delta E(x) + (t-\tau)E\left(\Delta S\right) - \tau\Delta m \tag{14}$$

with

$$\tau\Delta E(x) + (t-\tau)\Delta E\left(S\right) = \frac{b^4(1-t)\tau^2\big(-\tau^2(t+\tau) - 2(b^2+\sigma_x^2 r)(1-t)t(1-\tau)\alpha\big)}{2(b^2+\sigma_x^2 r)\big(\tau^2 + (b^2+\sigma_x^2 r)(1-t)\alpha(1-\tau)\big)^2}, \tag{15}$$

and

$$-\tau\Delta m = \frac{b^2\left(1-t\right)\left(1-\tau\right)\tau^2}{\tau^2 + \left(b^2+\sigma_x^2 r\right)\left(1-t\right)\alpha\left(1-\tau\right)}. \tag{16}$$

We know from Proposition 2 that without tax base risks, the principal always prefers the pre-tax measure if she can evade taxes. Under the after-tax measure, the principal reduces the agent's incentive rate to mitigate the distortion in her ex post decision regarding tax evasion. Therefore, the effective incentive rate and hence the managerial effort and the expected output are higher under the pre-tax measure. Furthermore, due to the higher incentive rate and increased effort, the agent's expected remuneration is also higher under the pre-tax measure.[13] Therefore, according to (15), $\tau\Delta E(x) + (t-\tau)\Delta E(S) = \tau(\Delta E(x) - \Delta E(S)) + t\Delta E(S) < 0$, similar to the effect described in Proposition 5 with $U = 0$.

In contrast, as the principal chooses a lower level of tax evasion under the after-tax measure, forgone tax revenue due to tax evasion is lower under the after-tax measure, i.e., (16) is strictly positive.

Overall, whether tax revenue is higher under the after-tax or pre-tax measure depends on which effect dominates, (15) or (16).

Proposition 7 *If no tax base risks are present and the principal can evade taxes, the after-tax measure generates the higher tax revenue* ($\Delta TR_e > 0$) *if and only if*

$$\left[(1-t)(1-\tau)\left(b^2 + r\sigma_x^2\right)\left(b^2(t+\tau-1) + r\sigma_x^2(\tau-1)\right)\right]\alpha + \frac{\tau^2}{2}\left[b^2(t+3\tau-2) + 2r\sigma_x^2(\tau-1)\right] < 0.$$

Proposition 7 characterizes the parameter settings under which the lower manipulation under the after-tax measure overcompensates the higher tax revenue from expected output and compensation under the pre-tax measure in terms of tax revenue. Let us consider under which circumstances the condition from Proposition 7 holds true:

Tax revenue is higher under the after-tax measure if the agent's risk aversion r or the output variance σ_x^2 are sufficiently high. High values of r and σ_x^2 reduce the agency's value, leading to closer alignment of the expected outputs and compensation payments under both performance measures, which causes (15) to increase (i.e., become less negative). Notice that the tax revenue term related to (15) depends on r and σ_x^2 directly and indirectly via the optimal incentive rates. The term related to manipulation in (16), depends only indirectly on on r and σ_x^2 through the optimal incentive rate $v_{a,e}^{\dagger}$: $-\tau\Delta m = \frac{\tau^2(1-\tau)v_{a,e}^{\dagger}}{\alpha}$. Since $-\tau\Delta m$ increases with $v_{a,e}^{\dagger}$, and higher values of r and σ_x^2 decrease $v_{a,e}^{\dagger}$, $-\tau\Delta m$ will decrease with increasing r and σ_x^2 as well. However, due to the direct and

[13] Given that there are no tax base risks (implying $U = 0$), the preferred pre-tax measure, due to $U = 0$, also induces higher expected compensation.

indirect effects, the overall impact of high r and σ_x^2 is more pronounced in expected output and compensation (15) compared to manipulation (16), resulting in higher tax revenue under the after-tax measure.

A similar effect results for a sufficiently low value of the agent's effort productivity b. Again, $-\tau\Delta m$ is only indirectly affected by b via $v_{a,e}^{\dagger}$, which increases with b. Thus, with a low level of b, $-\tau\Delta m$ is low. At the same time, for a low value of b, the agency's value diminishes, causing the tax revenue related to (15) to become higher. As a result, when b is sufficiently low, the after-tax measure generates higher tax revenue because the direct and indirect effects on (15) are stronger than the direct effect on (16).

Finally, Proposition 7 implies that for sufficiently low tax rates t and τ, the after-tax measure generates the higher tax revenue. This effect occurs because lower t and τ directly reduce tax revenue from expected output and compensation, which outweighs all other direct and indirect effects.

7 Concluding discussion

We considered a single-period agency model with taxation, in which both the principal and the agent face tax base risks. As the outcome of the agency-relationship, an uncertain cash flow will be realized at the end of the period. To motivate the agent to exert effort, his compensation contract will be based on a performance measure. We distinguish two performance measures in our analysis: an after-tax measure that consists of the firm's cash flow after corporate taxes, and a pre-tax measure that is calculated before corporate taxes. In agency theory, both pre-tax and after-tax measures are commonly used. Generally, it doesn't matter which one is chosen because, in a single-instance agency without tax base risks, the effective incentive rates of the optimal contract are the same. The difference in the actual incentive rates only reflects the different tax effects under each measure.

We show that in the presence of tax base risks, both measures are no longer equivalent in terms of effective incentive rates, firm surplus, and tax revenue. Regarding the principal's preferred performance measure, only the principal's tax base risk matters. In contrast, while the agent's tax base risk influences the effective incentive rates, it does not affect the choice of the optimal performance measure.

If the principal faces tax base risks, transitioning from a pre-tax to an after-tax measure induces a risk effect. This risk effect consists of a variance effect that increases the agent's compensation risk under the after-tax measure as the principal's tax base risk now enters his compensation. In addition, the risk effect comprises a covariance effect that stems from the (potential) correlation of the principal's tax base risk with the firm's cash flow. If and only if the covariance effect is negative and its magnitude exceeds the variance effect, the after-tax measure is the principal's optimal choice.

As an additional point of investigation, we consider the principal's possibility of evading taxes. We assume that the principal can take a costly action to reduce her tax base by a certain amount. In this setting, besides the risk effect, a tax evasion effect determines the choice of the optimal performance measure. The tax evasion effect captures an additional cost under the after-tax measure because its use distorts the principal's optimal level of tax evasion. The reason is that, under the after-tax measure, more tax evasion increases the agent's compensation, leading the principal to reduce the optimal level of tax evasion ex post. From the ex ante viewpoint, the reduction in tax evasion is inefficient from the principal's perspective, so she aims to counteract her sequentially optimal choice by reducing the agent's incentive rate. As a consequence, both agent effort and tax evasion will be distorted, leading to an additional cost. Therefore, if the principal can evade taxes, the after-tax measure is the optimal performance measure if and only if the (negative) covariance effect outweighs both the variance effect and the tax evasion effect.

We furthermore show that the firm surplus-maximizing performance measure does not always maximize tax revenue. If there are no tax evasion opportunities, and if the agent's tax base risk and the firm's cash flows are strongly positively correlated, the preferred performance measure generates lower tax revenue when the agent's tax rate sufficiently exceeds the firm's tax rate. The high tax revenue from the agent's compensation under the non-preferred measure drives this result. If the principal can evade taxes, tax revenue is also affected by the lower level of tax evasion under the after-tax measure, making this measure more effective from the government's perspective.

Our study has implications for performance measurement, tax policy, and contract design. Regarding performance measurement, our paper shows that the agent's tax base risk can be ignored when choosing the optimal performance measure, it only matters the principal's tax base risk and its correlation with the firm's cash flow. Our study demonstrates that the after-tax measure can only be the optimal choice if the cash flow and the principal's tax base risk are positively correlated. Such a correlation can be induced by a counter-cyclical tax policy implemented by the government at the firm level. In this context, the stronger the tax evasion opportunities, the stronger the counter-cyclical tax policy must be. Conversely, under a pro-cyclical tax policy, the pre-tax measure is always the optimal choice.

Our study also shows that a high variance in the principal's tax base risk always favors the pre-tax performance measure. This implies that significant tax ambiguity at the firm level makes the after-tax measure a suboptimal choice, as it imposes excessive risk on the agent's compensation. When tax evasion opportunities are limited, except for the tax rate/covariance setting mentioned above, the optimal performance measure from the firm's perspective also maximizes tax revenue and thus overall welfare. However, under strong tax evasion, the pre-tax measure, as the firm's optimal choice, may induce lower tax revenue than the after-tax measure. In this scenario stronger tax auditing could improve tax revenue and overall welfare. However, if more auditing is sufficiently costly overall tax revenue might not raise. Therefore, from the revenue agency's or government's perspective, it might be better to make the use of the pre-tax measure less attractive for the firm. For example, the government might provide a lump sum subsidy for the use of the after-tax measure. This subsidy, if sufficiently high, could induce a shift from the pre-tax measure to the after-tax measure, potentially leading to higher tax revenue and overall welfare.

With regard to contract design, our study indicates that the optimal incentive contract under the pre-tax measure can be determined without considering tax evasion. In contrast, if the after-tax measure is employed, the optimal contract and the optimal level of tax evasion must be jointly determined.

Our study has several empirical implications. First, as our paper shows that after-tax measures are less likely to be used when tax evasion opportunities increase, we expect the use of after-tax measures to be less widespread in countries with weaker tax audit regimes. Second, one could test whether pay-performance sensitivities for managers vary with cross-country differences in the strictness of tax auditing. Our results suggest that while there should be no significant variation for firms that use pre-tax measures, pay-performance sensitivities for managers compensated based on after-tax measures should be significantly lower in countries with weaker tax auditing. Third, our findings on tax evasion indicate that the level of tax evasion should be higher for firms using pre-tax measures compared to those using after-tax measures. Finally, with regard to tax revenue, our results suggest that higher tax evasion can coincide with higher tax revenue if pre-tax measures are used.

Appendix

Proof of Lemma 1

The first-order condition for the optimal v in maximizing objective function (3) is given by

$$\frac{\partial \Pi_p}{\partial v} = (1-\tau)\left(b^2(1-t) - \frac{v\,b^2(1-t)^2 + \frac{r\left(2(1-t)^2 v\sigma_x^2 - 2(1-t)t\mu\sigma_x\sigma_A\right)}{2}}{1-t}\right) = 0.$$

Solving for v yields $v_p^\dagger = \frac{b^2(1-t)+r\mu\sigma_x\sigma_A t}{(b^2+r\sigma_x^2)(1-t)}$. Inserting $v_p^\dagger$ into (3) yields the equilibrium surplus $\Pi_p^\dagger$ in Lemma 1.

Proof of Lemma 2

Maximizing (4) with respect to v, the following first-order condition must be fulfilled

$$\frac{\partial \Pi_a}{\partial v} =$$

$$(1-\tau)\left(b^2(1-t)(1-\tau) - \frac{vb^2(1-t)^2(1-\tau)^2 + \frac{r\left(\begin{array}{c} 2(1-t)^2 v\sigma_x^2(1-\tau)^2 \\ +2v(1-t)^2\sigma_P^2\tau^2 \\ -4\tau(1-\tau)(1-t)^2 v\rho\sigma_x\sigma_P \\ -2(1-t)(1-\tau)t\mu\sigma_x\sigma_A \end{array}\right)}{2}}{(1-t)}\right) = 0.$$

Solving for v yields $v_a^\dagger = \frac{\left(b^2(1-t)+r\mu\sigma_x\sigma_A t\right)(1-\tau)}{(1-t)\left(b^2(1-\tau)^2+r\left(\sigma_x^2(1-\tau)^2-2\sigma_x\sigma_P\rho(1-\tau)\tau+\sigma_P^2\tau^2\right)\right)}$. Inserting $v_a^\dagger$ into the objective function (4) yields the equilibrium surplus $\Pi_a^\dagger$ in Lemma 2.

Proof of Proposition 1

Including the definition of the effective incentive rates in (1), the principal's optimization problem under the pre-tax and after-tax measure ((3) and (4)) can be written as

$$\max_{\nu_p} \Pi_p = \left(b^2\nu_p - \frac{\frac{(\nu_p b)^2}{2} + \frac{r}{2}Var\left(\overline{S}_p\right)}{1-t}\right)(1-\tau),$$

and

$$\max_{\nu_a} \Pi_a = \left(b^2 \nu_a - \frac{\frac{(\nu_a b)^2}{2} + \frac{r}{2} Var\left(\overline{S}_a\right)}{1-t} \right)(1-\tau).$$

For a given effective incentive rate $\nu_a = \nu_p = \nu_0$, the principal's objective functions (and optimization problems) under both regimes coincide except for the variance terms. The difference amounts to:

$$\begin{aligned}\Pi_a(\nu_0) - \Pi_p(\nu_0) &= -\frac{r(1-\tau)}{2(1-t)}\left(Var\left(\overline{S}_a\right) - Var\left(\overline{S}_p\right)\right) \\ &= -\frac{r}{2(1-t)}\frac{\tau\nu_0^2}{(1-\tau)}(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho) \\ &= -\omega\nu_0^2(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho), \qquad (17)\end{aligned}$$

with

$$\omega = \frac{r\tau}{2(1-t)(1-\tau)}, \qquad (18)$$

which proves the proposition.

Proof of Lemma 3

By substituting the binding participation constraint and the incentive constraints into the objective function, optimization problem (7) can be written as

$$\max_{v} \Pi_{p,e} = (1-\tau)\left(b^2 v(1-t) - \frac{\frac{v^2 b^2 (1-t)^2}{2} + \frac{r(1-t)^2 v^2 \sigma_x^2}{2}}{1-t} \right) + \frac{\tau^2}{2\alpha}. \qquad (19)$$

From the first-order condition $\frac{d\Pi_{p,e}}{dv} = 0$, we obtain the optimal incentive rate

$$v_{p,e}^{\dagger} = \frac{b^2}{b^2 + r\sigma_x^2},$$

and by substituting $v_{p,e}^{\dagger}$ into $\Pi_{p,e}$, equilibrium surplus $\Pi_{p,e}^{\dagger} = \frac{b^2\tau^2 + \sigma_x^2 r\tau^2 + b^4(1-t)(1-\tau)\alpha}{2(b^2+\sigma_x^2 r)\alpha}$ results ($m_{p,e}^{\dagger} = \tau/\alpha$ is independent of $v_{p,e}^{\dagger}$).

Proof of Lemma 4

By substituting the binding participation constraint and the incentive constraints into the objective function, optimization problem (10) can be written as

$$\max_{v} \Pi_{a,e} = \left(b^2 v\,(1-t)\,(1-\tau) - \frac{\left(\frac{v^2 b^2 (1-t)^2 (1-\tau)^2}{2} + \frac{r(1-t)^2 v^2 (1-\tau)^2 \sigma_x^2}{2}\right)}{1-t} \right) (1-\tau) - \frac{\tau^2}{2\alpha}\left(-1 + (v\,(1-\tau))^2\right). \quad (20)$$

From the first-order condition $\frac{d\Pi_{a,e}}{dv} = 0$, we obtain the optimal incentive rate and the corresponding level of tax evasion as

$$v_{a,e}^{\dagger} = \frac{b^2(1-t)\alpha}{\tau^2 + (b^2 + \sigma_x^2 r)\,(1-t)\alpha(1-\tau)}, m_{a,e}^{\dagger} = \frac{\tau - (1-\tau)\tau v_{a,e}^{\dagger}}{\alpha}.$$

By substituting $v_{a,e}^{\dagger}$ and $m_{a,e}^{\dagger}$ into $\Pi_{a,e}$, we obtain equilibrium surplus

$$\Pi_{a,e}^{\dagger} = \frac{\tau^4 + (b^2 + \sigma_x^2 r)(1-t)(1-\tau)\tau^2\alpha + b^4(1-t)^2(1-\tau)^2\alpha^2}{2\alpha\Big(\tau^2 + (b^2 + \sigma_x^2 r)\,(1-t)\alpha(1-\tau)\Big)}.$$

Proof of Proposition 2

From Lemmas 3 and 4 we know

$$m_{p,e}^{\dagger} = \frac{\tau}{\alpha},\ m_{a,e}^{\dagger} = \frac{\tau - (1-\tau)\tau v_{a,e}^{\dagger}}{\alpha},$$

and thus

$$m_{p,e}^{\dagger} - m_{a,e}^{\dagger} = \frac{(1-\tau)\tau v_{a,e}^{\dagger}}{\alpha} > 0,$$

which proves the first part of the Proposition.

We now prove the second part. With the effective incentive rate $\nu_p = v(1-t)$, the principal's optimization problem under the pre-tax measure (19) can be stated as:

$$\max_{\nu_p} \Pi_{p,e} = (b^2\nu_p - \frac{\frac{(\nu_p b)^2}{2} + \frac{r}{2}\left(Var\left(\overline{S}_p\right)\right)}{1-t})(1-\tau) + \frac{\tau^2}{2\alpha}.$$

Similarly, with $\nu_a = (1-t)(1-\tau)v$ under the after-tax measure the principal's optimization problem (20) can be written as:

$$\max_{\nu_a} \Pi_{a,e} = \left(b^2\nu_a - \frac{\frac{(\nu_a b)^2}{2} + \frac{r}{2}\left(Var\left(\overline{S}_a\right)\right)}{1-t}\right)(1-\tau) + \frac{\tau^2}{2\alpha}\left(1 - \left(\frac{\nu_a}{1-t}\right)^2\right).$$

For a given effective incentive rate $\nu_a = \nu_p = \nu_0$, $Var\left(\overline{S}_p\right) = Var\left(\overline{S}_a\right) = \nu_0^2\sigma_x^2$ so that optimization problems under the pre-tax and after-tax measure coincide, except for the net benefit of manipulation. Thus, the pre-tax surplus $\Pi_{p,e}(\nu_0)$ exceeds the after-tax one $\Pi_{a,e}(\nu_0)$ if and only if:

$$\frac{\tau^2}{2\alpha} > \frac{\tau^2}{2\alpha}\left(1 - \left(\frac{\nu_0}{1-t}\right)^2\right).$$

or, equivalently,

$$\frac{\tau^2}{2\alpha}\frac{\nu_0^2}{(1-t)^2} > 0,$$

which is always true.

Proof of Proposition 3

The optimization problems with tax base risks are similar to those without tax base risks in (19) and (20) except the variance terms. The optimization problems are given by

$$\max_{\nu_p} \Pi_{p,e} = (b^2\nu_p - \frac{\frac{(\nu_p b)^2}{2} + \frac{r}{2}\left(Var\left(\overline{S}_p\right)\right)}{1-t})(1-\tau) + \frac{\tau^2}{2\alpha}, \tag{21}$$

with $Var\left(\overline{S}_p\right) = \nu_p^2\sigma_x^2 - 2\nu_p t\mu\sigma_x\sigma_A + t^2\sigma_A^2$ and $\nu_p = v(1-t)$ under the pre-tax measure, and

$$\max_{\nu_a} \Pi_{a,e} = \left(b^2\nu_a - \frac{\frac{(\nu_a b)^2}{2} + \frac{r}{2}\left(Var\left(\overline{S}_a\right)\right)}{1-t}\right)(1-\tau) + \frac{\tau^2}{2\alpha}\left(1 - \left(\frac{\nu_a}{1-t}\right)^2\right),$$

with $Var\left(\overline{S}_a\right) = \nu_a^2\sigma_x^2 + \frac{\nu_a^2\tau}{(1-\tau)^2}\left(\tau\sigma_p^2 - 2\rho\sigma_P\sigma_x(1-\tau)\right) - 2\nu_a t\mu\sigma_x\sigma_A + t^2\sigma_A^2$ and $\nu_a = (1-t)(1-\tau)v$ under the after-tax measure.

For a given effective incentive rate $\nu_a = \nu_p = \nu_0$, the after-tax surplus exceeds the pre-tax one ($\Pi_{a,e}(\nu_0) > \Pi_{p,e}(\nu_0)$) if and only if:

$$\begin{aligned} -\frac{r}{2}\frac{1-\tau}{1-t}\left(Var\left(\overline{S}_p\right) - Var\left(\overline{S}_a\right)\right) &< -\frac{\tau^2}{\alpha}\frac{1}{2}\left(\frac{-\nu_0}{1-t}\right)^2 \\ \Leftrightarrow \frac{r\tau}{2(1-\tau)(1-t)}\nu_0^2\left(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho\right) &< -\frac{\tau^2}{2\alpha}\frac{\nu_0^2}{(1-t)^2} \\ \Leftrightarrow \frac{r\tau}{2(1-\tau)(1-t)}\left(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho\right) &< -\frac{\tau^2}{2\alpha(1-t)^2}, \end{aligned} \tag{22}$$

which for $\omega \equiv \frac{r\tau}{2(1-\tau)(1-t)}$ can be rewritten as

$$\frac{\tau^2}{2\alpha(1-t)^2} < -\omega\left(\tau\sigma_P^2 - 2(1-\tau)\sigma_x\sigma_P\rho\right).$$

If and only if this relation is true, the principal's surplus is higher under the after-tax measure for any effective incentive rate. This implies that if and only if this relation is true, the optimal surplus under the after-tax measure is higher than under the pre-tax measure.

Proof of Proposition 4

We can derive the optimal incentive rates under the pre-tax and after-tax measure from the optimization programs in (21) and (22). From the first-order conditions $\frac{d\Pi_{p,e}}{d\nu_p} = 0$ and $\frac{d\Pi_{a,e}}{d\nu_a} = 0$, in the first step we obtain the following optimal effective incentive rates:

$$\nu_{a,e}^{\dagger} = -\frac{(1-\tau)^2(1-t)(B+U)\alpha}{N}, \quad \nu_{p,e}^{\dagger} = \frac{B+U}{(b^2 + r\sigma_x^2)}, \tag{23}$$

with

$$B = b^2(1-t),$$
$$U = \mu r t \sigma_x \sigma_A,$$
$$N = -\left((1-\tau)\tau^2 + (1-t)\left(b^2(1-\tau)^2 + r\left(\sigma_x^2(1-\tau)^2 - 2\sigma_x\sigma_P\rho(1-\tau)\tau + \sigma_P^2\tau^2\right)\right)\alpha\right).$$

N is negative since $r(\sigma_x^2(1-\tau)^2 - 2\sigma_x\sigma_P\rho(1-\tau)\tau + \sigma_P^2\tau^2) = Var(\epsilon_x(1-\tau) - \tau\theta_p) > 0$, and $B + U > 0$ applies because we consider positive incentive rates.

From (23), with $\nu_{a,e}^{\dagger} = v_{a,e}^{\dagger}(1-t)(1-\tau)$ and $\nu_{p,e}^{\dagger} = v_{p,e}^{\dagger}(1-t)$, the optimal incentive rates under the after-tax and pre-tax measures are obtained as:

$$v_{a,e}^{\dagger} = -\frac{(1-\tau)(B+U)\alpha}{N}, v_{p,e}^{\dagger} = -\frac{B+U}{(b^2 + r\sigma_x^2)(t-1)}. \tag{24}$$

From (24), we then derive

$$\frac{\partial v_{p,e}^{\dagger}}{\partial \alpha} = 0, \ \frac{\partial v_{a,e}^{\dagger}}{\partial \alpha} = \frac{(B+U)(-1+\tau)^2\tau^2}{N^2} > 0.$$

Proof of Proposition 5

Recall the following definitions

$$B = b^2(1-t),$$
$$U = \mu r t \sigma_x \sigma_A,$$

with $U + B > 0$ by assumption, which is equivalent to saying that $v_p^{\dagger}$ and $v_a^{\dagger}$, as given in Lemmas 1 and 2, are positive. Furthermore, let $R = 2\rho\tau\sigma_x - 2\rho\sigma_x + \tau\sigma_P$ denote an equivalent to the risk effect, i.e., risk effect $= R\sigma_P$. Recall furthermore the definition of ΔTR

$$\Delta TR = TR_a - TR_p = \tau\Delta E(x) + (t-\tau)\Delta E(S) \tag{25}$$

with $\Delta E(x) = E(x_a) - E(x_p)$ and $\Delta E(S) = E(S_a) - E(S_p)$. With the equilibrium solutions for the pre-tax and after-tax measure provided in Lemmas 1 and 2, we can calculate

$$\tau \Delta E(x) = -\frac{R\sigma_P r(B+U)b^2\tau^2}{(\sigma_x^2 r + b^2)\left(2\rho r\tau\sigma_P\sigma_x(\tau-1) + r\tau^2\sigma_P^2 + (b^2 + r\sigma_x^2)(1-\tau)^2\right)} \tag{26}$$

and

$$(t-\tau)\Delta E(S) = -\frac{(t-\tau)\, r\tau\sigma_P\,(B+U)\,(U-B)\,R}{2\left(2\rho r\tau\sigma_P\sigma_x(\tau-1) + r\tau^2\sigma_P^2 + (b^2 + r\sigma_x^2)(1-\tau)^2\right)(-1+t)\,(\sigma_x^2 r + b^2)}, \tag{27}$$

so that

$$\Delta TR = -\frac{R\sigma_P\tau r\,(B+U)\,(U(t-\tau) - B(\tau+t))}{2\left(2\rho r\tau\sigma_P\sigma_x(\tau-1) + r\tau^2\sigma_P^2 + (b^2 + r\sigma_x^2)(1-\tau)^2\right)(-1+t)\,(\sigma_x^2 r + b^2)}. \tag{28}$$

According to the definition of $R =$ risk effect$/\sigma_P$, for $R < (>)\, 0$ the use of the after-tax measure (the pre-tax measure) is optimal. For $R = 0$ both measures are equivalent in terms of the principal's surplus. The denominator of (28) is negative as $2\rho r\tau\sigma_P\sigma_x(\tau - 1) + r\tau^2\sigma_P^2 + r\sigma_x^2(1-\tau)^2 = rVar(\epsilon_x(1-\tau) - \tau\theta_P) > 0$. As $B + U > 0$, from (28) we can then derive that $\Delta TR \gtreqless 0$ iff $R \cdot V \gtreqless 0$, with $V = U(t-\tau) - B(\tau + t)$. Thus, the principal's preferred performance measure does not generate higher tax revenue if and only if $V > 0$.

1. Assume $\tau \geq t$. a) For $U > 0$, V is clearly negative. b) For $U < 0$ the term $U(t-\tau)$ in V becomes (weakly) positive. However, as $-B < U$ and $t + \tau > |t - \tau|$, $V < 0$ holds true as well.

2. Assume $t > \tau$. a) For $U < 0$, V is clearly negative. b) For $U > 0$ the term $U(t - \tau)$ becomes positive. Since $t + \tau > t - \tau$, $|U|$ must be greater than $|-B|$ for $V > 0$ to be true, or, alternatively, $U - B > 0$ must hold true. Given this condition applies, $V > 0$ holds if and only if $t > \frac{\tau(U+B)}{U-B}$.

Thus, we have demonstrated that $V > 0$ holds if and only if $t > \frac{\tau(U+B)}{U-B}$, with $t > \tau$ and

$U - B > 0$. Consequently, the principal's preferred performance measure results in lower tax revenue if and only if these conditions are met.

Notice furthermore, that the difference in expected compensation, which according to (27) can be written as $\Delta E(S) = -\frac{r\tau\sigma_P(B+U)(U-B)R}{2\left(2\rho r\tau\sigma_P\sigma_x(\tau-1)+r\tau^2\sigma_P^2+(b^2+r\sigma_x^2)(1-\tau)^2\right)(-1+t)(\sigma_x^2 r+b^2)}$, is higher for the principal's preferred performance measure if and only if $U - B < 0$ because $\Delta E(S) \gtreqless 0 \Leftrightarrow R(U - B) \gtreqless 0$.

Proof of Proposition 6

Assume $t = \tau$. Then $\Delta TR_e = \tau(\Delta E(x) - \Delta m)$.

From (23) and (24) we derive

$$\Delta m = -\frac{(1-\tau)\tau v_{a,e}^{\dagger}}{\alpha} = \frac{\tau(1-\tau)^2(B+U)}{N}, \tag{29}$$

$$\Delta E(x) = b(a_{a,e}^{\dagger} - a_{p,e}^{\dagger}) = b^2(\nu_{a,e}^{\dagger} - \nu_{p,e}^{\dagger}) = -\frac{\tau b^2(B+U)C}{(r\sigma_x^2 + b^2)N}, \tag{30}$$

such that the difference in tax revenues is given by

$$\Delta TR_e = \tau(\Delta E(x) - \Delta m) = -\tau\frac{(B+U)[\tau b^2 C + \tau(1-\tau)^2(r\sigma_x^2 + b^2)]}{(r\sigma_x^2 + b^2)N}, \tag{31}$$

where $N < 0$ is defined in the proof of Proposition 4.

From (31) we derive that $\Delta TR_e > 0$ if and only if $\frac{\tau b^2 C}{b^2 + r\sigma_x^2} + \tau(1-\tau)^2 > 0$.

Proof of Proposition 7

The difference in tax revenues is given by adding (15) and (16):

$$\begin{aligned} \Delta TR_e &= \tau\Delta E(x) + (t-\tau)E\left(\Delta S\right) - \tau\left(\Delta m\right) \\ &= \frac{\left[\begin{array}{l} \tau^2\left(t-1\right)b^2\Bigg(\Big[\left(1-t\right)\left(1-\tau\right)\left(b^2+r\sigma_x^2\right)\left(b^2\left(t+\tau-1\right)\right. \\ \left.+r\sigma_x^2\left(\tau-1\right)\right)\Big]\alpha + \frac{\tau^2}{2}\Big[b^2\left(t+3\tau-2\right)+2r\sigma_x^2\left(\tau-1\right)\Big]\Bigg) \end{array}\right]}{\left(r\sigma_x^2+b^2\right)\left(\alpha\left(\tau-1\right)\left(t-1\right)\left(r\sigma_x^2+b^2\right)+\tau^2\right)^2}. \end{aligned} \tag{32}$$

The after-tax measure is the optimal measure if and only if (32) is positive, or, alternatively, if and only if

$$\left[(1-t)(1-\tau)\left(b^2+r\sigma_x^2\right)\left(b^2(t+\tau-1)+r\sigma_x^2(\tau-1)\right)\right]\alpha$$
$$+\frac{\tau^2}{2}\left[b^2(t+3\tau-2)+2r\sigma_x^2(\tau-1)\right]<0.$$

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