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# Overconfidence and Bailouts

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Daniel Gietl (LMU Munich)

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Daniel Gietl<sup>†</sup>

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## Abstract

Empirical evidence suggests that managerial overconfidence and government guarantees contribute substantially to excessive risk-taking in the banking industry. This paper incorporates managerial overconfidence and limited bank liability into a principal-agent model, where the bank manager unobservably chooses effort and risk. An overconfident manager overestimates the returns to effort and risk. We find that managerial overconfidence necessitates an intervention into banker pay. This is due to the bank's exploitation of the manager's overvaluation of bonuses, which causes excessive risk-taking in equilibrium. Moreover, we show that the optimal bonus tax rises in overconfidence, if risk-shifting incentives are sufficiently large. Finally, the model indicates that overconfident managers are more likely to be found in banks with large government guarantees, low bonus taxes, and lax capital requirements.

**Keywords:** Overconfidence; Bailouts; Banking Regulation; Bonus Taxes

**JEL classification:** H20, H30, G28, G41

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<sup>†</sup>Seminar for Economic Policy, University of Munich, Akademiestr. 1/II, D-80799 Munich, Germany. Phone +49-89-2180-3303, fax: +49-89-2180-6296, e-mail: Daniel.Gietl@econ.lmu.de

# 1 Introduction

Excessive risk-taking in the banking sector played a crucial role in the financial crisis of 2007-2009. Banks worldwide invested in large stocks of subprime mortgage-backed securities, which resulted in the bursting of the US housing bubble in the fall of 2007 (see e.g. Diamond and Rajan, 2009). Two of the main reasons for excessive risk-taking in the banking sector - which have so far only been considered independently - are government guarantees and managerial overconfidence.

In the part of the finance literature assuming perfectly rational agents, government guarantees are seen as a major cause for excessive risk-taking, as they weaken the incentive for bank creditors to price in banks' risk-taking. This lack of market discipline makes it attractive for shareholders to shift losses to the government. The empirical relevance of this risk-shifting incentive has been shown repeatedly. In the United States, for example, financial institutions that had previously received government assistance under the Troubled Asset Relief Program subsequently shifted to riskier assets (Duchin and Sosyura, 2014). In Germany, savings banks that had their government guarantees removed cut their credit risk substantially afterwards (Gropp et al., 2014).

In the behavioral finance literature, overconfident managers are seen as a core reason for excessive risk-taking.<sup>1</sup> Overconfident managers overestimate the expected return on risky investments, which causes them to take on higher risks (see e.g. Hirshleifer and Luo, 2001; Malmendier and Tate, 2008; Gervais et al., 2011). Overconfidence is particularly pronounced in complex, high-risk environments with noisy feedback, and thus under conditions that are vividly present in the banking sector.<sup>2</sup> Indeed, there is comprehensive evidence that banks with overconfident CEOs take on more risk. Banks governed by overconfident CEOs were more aggressive in lending before the financial crisis of 2007-2009. During the crisis years, these banks suffered from greater increases

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<sup>1</sup>Moore and Healy (2008) distinguish three notions of overconfidence: overestimation, overplacement, and overprecision. We focus on overconfidence as the manager's *overestimation* of the success probability of his investment. Hence we relate to the empirical literature that investigates the effects of overconfidence on firm outcomes by using personal portfolios of top managers as a proxy for overconfidence (see e.g. Malmendier and Tate, 2005; Deshmukh et al., 2013).

<sup>2</sup>While there is substantial evidence that individuals generally overestimate their own abilities and talents (e.g. Taylor and Brown (1988)), there are several reasons why bank managers are supposed to be even more overconfident than the lay population (see Section 2.1 for details). Glaser et al. (2005) find that professional traders and investment bankers are indeed more overconfident than students.

in loan defaults, larger declines of stock return performances, and a higher likelihood of failure than banks managed by non-overconfident CEOs (Ho et al., 2016).<sup>3</sup>

It is well established that managerial overconfidence and moral hazard arising from government guarantees are key reasons for excessive risk-taking in the banking industry. Up to this point, however, it has not been analyzed how overconfidence and government guarantees interact. It is thus neither clear how to regulate and tax financial markets that are simultaneously characterized by these two features nor how banks set up contracts in such an environment. We aim to fill these gaps by incorporating managerial overconfidence and limited bank liability into a principal-agent model of the banking sector. In this setting, we allow the government to optimally set a bonus tax in order to correct for the inefficiencies resulting from overconfidence and government guarantees.

Our framework is as follows. The model consists of three stages and three players. In the first stage, the government sets the welfare-maximizing bonus tax. We define welfare as the weighted sum of the bank's profit, the manager's utility, the government's bonus tax revenue and bailout costs. Stage 2 turns to the bank's maximization problem. The bank chooses the performance-related bonus and the fixed wage that maximize the bank's expected after tax profit. In the third stage, the manager decides whether to accept the bank's contract. If the manager accepts the contract, he unobservably chooses the level of effort and the risk of the bank's investment.

Based on the work of Besley and Ghatak (2013) and Hakenes and Schnabel (2014), we incorporate two principal-agent problems in our model. The first principal-agent problem arises between the government and the bank because of government guarantees. Government guarantees imply that the government will step in to partly bail out external investors if the bank defaults. External investors, knowing that they are paid even in case of a bank default, do not fully price in the bank's risk. Hence the bank has an incentive to induce excessive risk by means of high bonuses in order to draw on the government guarantees. The second principal-agent problem arises between the bank and the manager.<sup>4</sup> The banker has costs from effort- and risk-taking and thus does not provide as much effort and risk as desired by the bank. Since the bonus increases

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<sup>3</sup>In addition, banks with overconfident CEOs generally experience higher stock return volatility (Niu, 2010) and have shown higher real estate loan growth prior to the financial crisis (Ma, 2015).

<sup>4</sup>Caprio and Levine (2002) highlight two features that differentiate banks from nonfinancial firms. First, the greater safety net that accompanies banks. And second, the opaqueness of banks, which amplifies agency problems.

effort- and risk-taking, the bank can use it to influence both principal-agent problems to its own advantage.

The other key feature of our model - besides the moral hazard resulting from government guarantees - is managerial overconfidence. Seminal findings in the psychology literature show that individuals overestimate the probabilities of advantageous events, especially if the individuals believe to have control over the probabilities of those events (e.g. Langer, 1975) and if they are highly committed to the outcome (e.g. Weinstein, 1980). We incorporate these findings by modeling overconfidence as an overestimation of the returns to effort and risk-taking.<sup>5</sup> This implies that an overconfident manager exerts greater effort and risk, increases effort and risk more strongly for a marginal increase in the bonus, and overvalues the expected utility that he obtains from the bonus.

Our analysis delivers three main results. First, we derive the optimal bonus tax and find that it always increases in overconfidence, if risk-shifting incentives are strong. Government guarantees create an externality of the bank's behavior on taxpayers, which is especially attractive for the bank to exploit when the manager is overconfident. In systemically important financial institutions, it is thus optimal to curb the social implications of overconfidence with a large bonus tax. In banks that receive a low level of government guarantees, however, the optimal bonus tax can decrease in overconfidence. This is because overconfident managers react more elastically to changes in the bonus and reduce their effort more strongly than rational managers when bonuses are taxed. Second, we find that managerial overconfidence always necessitates an intervention into banker pay, even if shareholders fully internalize the externalities of their risk-taking. Overconfidence creates an incentive for the bank to increase its bonus in order to save compensation costs, because an overconfident manager overvalues the utility derived from bonuses. This incentive drives up bonuses and thus causes socially excessive risk-taking, even if shareholders have no incentive to draw on government guarantees. Unlike instruments regulating shareholders risk-taking incentives (e.g. capital requirements), a direct intervention into banker pay (e.g. via bonus taxes or bonus caps) can implement the socially desirable bonus, because these instruments additionally tackle the

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<sup>5</sup>De la Rosa (2011) gives an overview of the literature which indicates that agents overestimate their return to effort. Our assumption that overconfident managers overestimate the return to risk-taking is backed up by several finance studies that suggest overconfident CEOs have a higher tendency to undertake risky projects (e.g. Hirshleifer et al., 2012; Ho et al., 2016; Niu, 2010).

inefficiencies arising from the manager's overvaluation of the bonus.

Third, we find that overconfident bankers and banks with large government guarantees match in equilibrium. As banks with larger government guarantees benefit more from inducing excessive risk-taking by the manager, these banks also benefit more from hiring an overconfident manager. The selection of overconfident managers into banks that receive large bailout subsidies has substantial implications for taxpayers. It leads to a high default risk of these banks and causes large expected bailout costs for taxpayers. We argue that direct interventions into banker pay (e.g. a bonus tax or cap) are particularly suited to avoid the matching between overconfident managers and banks with large government guarantees. This is because banker pay interventions not only tackle risk-shifting incentives but also make it more costly for shareholders to exploit managerial overvaluation. Taken as a whole, the three main results of our paper suggest that the presence of managerial overconfidence calls for bonus taxes in systemically important financial institutions. Bonus taxation can curb the bank's risk-shifting incentives, deter the exploitation of managerial overvaluation, and avoid the selection of overconfident managers into systemically important financial institutions.

Our paper relates to the literature on the optimal taxation and regulation of banker compensation. Besley and Ghatak (2013) examine the optimal tax-scheme for banker compensation in financial markets that are characterized by government guarantees. They find that this optimal tax-scheme is progressive in the size of the government guarantee and can increase both equity and efficiency. Investigating the international competition for bank managers, Gietl and Haufler (2018) find that there can be either a 'race to the bottom' or a 'race to the top' in bonus taxation when managers are mobile across countries and banks are protected by government guarantees. Hakenes and Schnabel (2014) and Thanassoulis and Tanaka (2018) investigate non-tax regulatory measures. Hakenes and Schnabel (2014) find that bonus caps are welfare-increasing for sufficiently large bailout expectations, because they curb the ability for banks to induce excessive risk. Thanassoulis and Tanaka (2018) show that a combination of clawback rules and restrictions on the curvature of pay can induce an executive to implement socially optimal risk choices. While these papers look at the optimal taxation and regulation, respectively, of compensation in the presence of government guarantees, they do assume fully rational bankers. Our paper contributes to this strand of literature by investigating how taxation and regulation have to adapt when bankers are not fully rational but overconfident.

A second important strand of literature concerns the effects of managerial overconfidence. Following the seminal paper of Malmendier and Tate (2005), an influential literature investigating the effects of managerial overconfidence on firm outcomes has emerged.<sup>6</sup> Empirical evidence shows that firms can benefit from CEO overconfidence, for example because overconfident CEOs capitalize on innovative growth opportunities better (Hirshleifer et al., 2012) and because firms can exploit the managerial overvaluation of incentive pay to lower compensation costs (Humphery-Jenner et al., 2016).<sup>7</sup> Overconfident CEOs, however, can also reduce shareholder value by engaging in value destroying investments and mergers (Malmendier and Tate, 2008). While this literature focuses on the impact of overconfidence on firm outcomes, we show how managerial overconfidence affects government policies.

We also contribute to the literature on the matching between overconfident managers and firm characteristics. Gervais et al. (2011) analyze how compensation contracts optimally adapt to managerial overconfidence.<sup>8</sup> The authors find that, in equilibrium, overconfident managers are selected into risky, undiversified growth firms. Graham et al. (2013) show empirically that there is indeed a positive relationship between CEO overconfidence and growth firms. Beyond that, Hirshleifer et al. (2012) find that firms in innovative industries are more likely to be run by overconfident CEOs. Our paper shows that overconfident managers may also match according to the regulatory environment faced by banks, and are more likely to be found in banks with large government guarantees, low bonus taxes, and lax capital requirements.

This paper is structured as follows. Section 2 introduces the basic setup of our three-stage model. Section 3 analyzes the effort- and risk-taking decisions of rational and overconfident managers. Section 4 investigates the maximization problem of the bank as well as the bank's optimal contract for the manager. Section 5 sets up our welfare function and derives the optimal bonus tax. Section 6 shows why overconfidence necessitates an intervention into banker pay. Section 7 investigates the competition for overconfident managers. Section 8 discusses several policy implications before Section 9 concludes.

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<sup>6</sup>See Malmendier and Tate (2015) for an overview.

<sup>7</sup>De la Rosa (2011) and Gervais et al. (2011) show theoretically that firms have an incentive to exploit the managerial overvaluation of incentive pay.

<sup>8</sup>There is indeed evidence that firms adjust their contracts to managerial overconfidence. For instance, Humphery-Jenner et al. (2016) find that overconfident executives and non-executives receive incentive-heavier compensation contracts.

## 2 Setup

The bank in our model is a financial intermediary, which is financed through equity and deposits.<sup>9</sup> We assume that the share of deposit financing is exogenously determined, for example by binding capital requirements. The depositors demand a fixed expected return for their deposits. In case of a bank default they are partly insured by the government (see below).

*Assets:* The bank's assets are normalized to 1 and consist of a risky portfolio. This portfolio can realize a high, a medium, or a low return ( $Y^h > Y^m > Y^l = 0$ ). These investment returns are exogenous and publicly observable. The corresponding probabilities of the returns ( $p^h > 0$ ,  $p^m > 0$ , and  $p^l = 1 - p^h - p^m > 0$ ), however, are endogenously determined by the unobservable decisions of the manager on effort  $e$  and risk-taking  $b$ .

Following Hakenes and Schnabel (2014), we assume that the probabilities of the exogenous returns are linear functions of the manager's effort and risk-taking choices:

$$\begin{aligned} p^h &= \alpha e + \beta b, \\ p^m &= p_0^m - b, \\ p^l &= p_0^l - \alpha e + (1 - \beta)b. \end{aligned} \tag{1}$$

Effort  $e$  increases the mean return of the portfolio as it shifts probability mass from  $p^l$  to  $p^h$ . Risk-taking  $b$  is modelled as a mean-preserving spread. It shifts probability mass from  $p^m$  to both  $p^l$  and  $p^h$ . Taking effort and risk involves private, non-monetary costs for the manager.<sup>10</sup> For simplicity, we assume that these cost functions are quadratic. The private effort and risk-taking costs of a manager are given by

$$c^e(e) = \frac{\eta e^2}{2} \quad \text{and} \quad c^b(b) = \frac{\mu b^2}{2}. \tag{2}$$

These private costs, along with non-observable effort and risk-taking choices by the manager, cause moral hazard problems between the manager and the bank. Specifically,

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<sup>9</sup>For brevity, we call these units banks. However, our model generally also applies to non-bank financial intermediaries which are characterized by government guarantees and strong agency problems.

<sup>10</sup>As in Hakenes and Schnabel (2014),  $b = 0$  can be interpreted as the natural risk-level. Raising risk beyond this natural risk-level (i.e., choosing  $b > 0$ ) causes private costs as the manager has to actively search for riskier investments or to move into new asset classes. Hence the parameter  $b$  can be seen as the effort to increase the risk level beyond its natural level, whereas the parameter  $e$  can be interpreted as the productive effort that increases the mean-return of the portfolio.



the manager exerts less effort and risk-taking than desired by the bank. The bank can mitigate this principal-agent problem by paying a bonus  $z$  if the high return  $Y^h$  is realized, which incentivizes the manager to increase effort and risk. In addition to the bonus payment  $z$ , the bank can pay a fixed wage  $F$  that is independent of the realized return.

*Government guarantees:* As deposits are partly insured, a second principal agent problem arises between the government and the bank. In the case of bank default,  $Y^l$ , the government partly bails out depositors. This assumption is motivated by the presence of deposit insurance in essentially all developed countries.<sup>11</sup> The partially insured investors do not fully price in the default probability of the bank, which enables the bank to shift losses to the government. Hence, the bank has an incentive to use the bonus  $z$  to incentivize the manager to take on excessive risk at the expense of the government.<sup>12</sup>

The government is aware of this risk-shifting problem and uses bonus taxation to correct the bank's distorted incentives. Our baseline model focuses on this policy instrument, as the bonus tax not only acts as a Pigovian tax, but also redistributes from the financial sector to taxpayers. This redistributive aspect reflects the goal of many governments to get the financial sector to "make a fair and substantial contribution toward paying for any burden associated with government interventions to repair the banking system" (International Monetary Fund, 2010). A bonus cap, as an alternative measure to intervene in banker pay, will be discussed in Section 6.1.

## 2.1 Overconfidence

As managerial overconfidence is an integral part of our analysis, this subsection motivates and explains our modelling of overconfidence. In our model, an overconfident manager overestimates his skills and thus overestimates the returns to effort and risk-

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<sup>11</sup>Barth et al. (2006) provide an overview of deposit insurance schemes and discuss their welfare effects. A more complex model would motivate the existence of deposit insurance as a means to avoid bank runs when banks engage in maturity transformation (cf. Diamond and Dybvig (1983)). We, however, focus on the principal agent problems that characterize the banking industry and thus follow the dominant approach in the literature (e.g. Besley and Ghatak, 2013; Hakenes and Schnabel, 2014) and assume government guarantees to be exogenously given.

<sup>12</sup>This argument illustrates why the bank does not pay a bonus in the medium state,  $Y_m$ . A bonus in the medium state would reduce the manager's risk-taking incentives and thus lower the bank's profits derived from the government guarantee.

taking. The psychology literature shows that individuals generally overestimate their own abilities and talents (see Taylor and Brown (1988) for a review) and the probabilities of advantageous events (e.g. Langer (1975)). As Taylor and Brown (1988) conclude: "A great deal of research in social, personality, clinical, and developmental psychology documents that normal individuals possess unrealistically positive views of themselves [and] an exaggerated belief in their ability to control the environment".

There are several reasons why top bank managers are likely to be more overconfident than the lay population. First, successful bankers are likely to become overconfident due to the self-attribution bias. Top bankers have experienced success in their careers. As individuals generally overestimate the extent to which they have contributed to their own success (Langer, 1975), successful bankers and traders are especially prone to becoming overconfident (see e.g. Daniel et al., 1998; Gervais and Odean, 2001).<sup>13</sup> Second, selection effects may imply that overconfident individuals are more likely to become top bankers than non-overconfident people. For example, overconfident individuals overestimate the expected value of performance pay and thus self select into jobs with high performance pay such as banking. Finally, Goel and Thakor (2008) show that if firms promote based on the best performances, then overconfident managers are more likely to be promoted as they take on larger risks.<sup>14</sup>

Due to the manager overestimating the returns to effort and risk-taking, the probabilities as perceived by an overconfident manager differ from the actual probabilities. We denote parameters as perceived by an overconfident manager with a hat. The probabilities as considered by the manager are given by

$$\begin{aligned}\hat{p}^h &= (1 + \theta)(\alpha e + \beta b), \\ \hat{p}^m &= p_0^m - b, \\ \hat{p}^l &= p_0^l - (1 + \theta)\alpha e + b[1 - \beta(1 + \theta)],\end{aligned}\tag{3}$$

The parameter  $\theta$  in eq. (3) measures the level of overconfidence. For  $\theta = 0$  the manager is rational and evaluates the probabilities correctly as in eq. (1). For  $\theta > 0$ , however, the

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<sup>13</sup>If agents receive *negative* (but unbiased) noisy feedback on their own performance, however, then they attribute the negative feedback to being unlucky (i.e., they think their feedback underrepresents their individual performance), as shown by Grossman and Owens (2012).

<sup>14</sup>First evidence confirms that top bankers are indeed more overconfident than the general population. Using questionnaires and experiments, Glaser et al. (2005) find that professional traders and investment bankers are more overconfident than students. Graham et al. (2013) examine psychometric tests and conclude that CEOs are more optimistic than the general population.

manager overestimates the probability of the high state ( $\hat{p}^h > p^h$ ) and underestimates the default probability ( $\hat{p}^l < p^l$ ). Our analysis will show that overconfidence affects the bank's optimal bonus and fixed wage, and thus critically influences the principal agent problems both between the bank and the manager, and between the government and the bank.

In the following sections we analyze our sequential three-stage model. In Stage 1, the government sets its welfare-maximizing bonus tax  $t$ . In Stage 2, the bank chooses the profit-maximizing bonus  $z$  and fixed wage  $F$ . Stage 3 analyzes the decisions of the manager. The manager chooses whether to accept the bank's contract based on his *perceived* expected utility. If the manager accepts the contract, he decides on the levels of effort and risk. We proceed to solve our model by backward induction.

### 3 Stage 3: Manager's choices and perceived utility

In Stage 3, the government has set its bonus tax  $t$  and the bank has chosen the manager's contract ( $z$  and  $F$ ). Given his contract, the manager maximizes his *perceived* expected utility. For an overconfident manager the perceived expected utility deviates from his actual expected utility as he misjudges the probabilities of the exogenous returns.

The risk-neutral manager receives the bonus  $z$  if and only if state  $h$  occurs.<sup>15</sup> On top of that, he obtains the fixed wage  $F$  in any state. The perceived expected utility is given by

$$\hat{u} = (1 + \theta)(\alpha e + \beta b)z + F - \frac{\mu b^2}{2} - \frac{\eta e^2}{2}. \quad (4)$$

Eq. (4) shows that the perceived expected utility depends positively on the manager's estimate of the success probability [ $\hat{p}^h = (\alpha e + \beta b)(1 + \theta)$ ], the bonus  $z$ , and the fixed wage  $F$ . The perceived expected utility decreases in the risk-taking costs,  $\frac{\mu b^2}{2}$ , and the effort-taking costs,  $\frac{\eta e^2}{2}$ .

Maximizing (4) with respect to  $e$  and  $b$ , we obtain

$$e^* = \frac{(1 + \theta)\alpha z}{\eta}, \quad (5)$$

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<sup>15</sup>Thanassoulis (2012) reviews the literature on risk preferences of bankers and finds that bankers are risk neutral or very mildly risk averse.

$$b^* = \frac{(1 + \theta)\beta z}{\mu}. \quad (6)$$

Hence both the manager's effort level  $e$  and the risk level  $b$  increase in the level of overconfidence  $\theta$  and the bonus payment  $z$ . Note that the manager's optimal effort and risk level do not depend on the fixed wage  $F$ .

Using (5) and (6) in (1), we can derive the equilibrium probabilities of the different returns:

$$\begin{aligned} p^{h*} &= \left[ \frac{\alpha^2}{\eta} + \frac{\beta^2}{\mu} \right] z(1 + \theta) \equiv \gamma z(1 + \theta), \\ p^{m*} &= p_0^m - \frac{\beta}{\mu} z(1 + \theta), \\ p^{l*} &= p_0^l + \left[ (1 - \beta)\frac{\beta}{\mu} - \frac{\alpha^2}{\eta} \right] z(1 + \theta) \equiv p_0^l + \delta z(1 + \theta). \end{aligned} \quad (7)$$

A higher bonus leads to more effort and risk-taking, which both unambiguously increase  $p^h$ . The sign of  $\delta$  in eq. (7) determines whether the marginal effect of the bonus on the low return probability  $p^l$  is positive or negative. On the one hand, a higher bonus induces more risk-taking, which increases  $\delta$  and thus also  $p^l$ . On the other hand, a higher bonus leads to more effort, which reduces  $\delta$  and therefore  $p^l$ . In what follows, we assume that  $\delta > 0$ , implying that the risk effect of the bonus dominates the effort effect and a higher bonus increases the bank's default probability  $p^l$ .<sup>16</sup> The effect of the bonus on the medium return is unambiguously negative, as the bonus shifts probability mass away from the medium state to incentivize risk-taking. Note that an increase in overconfidence amplifies the marginal effects of the bonus on the equilibrium probabilities as overconfidence increases the marginal effect of the bonus on effort- and risk-taking. The equilibrium probabilities are independent of the fixed wage.

Finally, substituting (5) and (6) in (4) gives us the maximized perceived expected utility

$$\hat{u}^* = \frac{\gamma}{2}(1 + \theta)^2 z^2 + F. \quad (8)$$

This shows that both a higher bonus and a higher fixed wage increase the perceived utility. An overconfident manager ( $\theta > 0$ ) overvalues the influence of the bonus on his utility as he overestimates the likelihood of receiving the bonus ( $\hat{p}^h > p^h$ ).

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<sup>16</sup>This is in line with Efung et al. (2015), who find that pre-crisis incentive pay was positively correlated with the volatility of bank-trading income and too high to maximize the banks' Sharpe ratio.

## 4 Stage 2: Bank's bonus and fixed wage decisions

In Stage 2, we turn to the bank and its behavior. In Section 4.1 we look at the bank's financing constraint and how it is influenced by government guarantees and overconfidence. Section 4.2 derives and discusses the bank's optimal contract ( $z$  and  $F$ ).

### 4.1 The financing constraint

The bank is financed by a share  $1 - s$  of equity and a share  $s$  of deposits ( $s \in [0; 1]$ ). The share of deposits is determined by an exogenous minimum capital requirement. As the bank prefers deposits over equity due to the deposit insurance, the capital requirement is always binding. The risk-neutral depositors demand an expected return of  $d$  per unit of deposits. As the bank's asset volume is normalized to 1, depositors thus demand a total return of  $sd$ . We assume that, if the returns  $Y^h$  or  $Y^m$  are realized, the bank is able to repay the depositors an agreed return  $s(d + X)$ , where  $X$  is the additional unit return the depositors require in order to be compensated for their potential loss in state  $l$ . If the bank defaults ( $Y^l = 0$ ), then the bank cannot repay the depositors. Instead the government pays an exogenous share  $v_i \in [0; 1]$  of  $sd$  to the depositors of bank  $i$ . This share  $v_i$  can be interpreted as the level of government guarantees that bank  $i$  receives. The financing constraint is then given by

$$(1 - p^l)s(d + X) + p^l v_i s d = s d. \quad (9)$$

Solving for  $X$ , we obtain

$$X = \frac{d p^l (1 - v_i)}{1 - p^l}. \quad (10)$$

Eq. (10) shows that the higher is the government guarantee  $v_i$ , the smaller is the extent as to which the default probability of the bank,  $p^l$ , is priced in by depositors. If depositors are completely insured by the government (i.e.,  $v_i = 1$ ), they do not price in the default risk at all ( $X = 0$ ), because the depositors receive their full repayment even in the case of bank default.

Note that the default probability  $p^l$  depends positively on the level of overconfidence  $\theta$  (see eq.(7)). An overconfident manager takes on more risk, which increases the likelihood that the bank does not pay back depositors. The lower the government guarantee, the more strongly depositors price in the overconfidence of the manager.

## 4.2 The contract

The expected bank profit is given by

$$\Pi = p^{h*}[Y^h - z(1+t) - s(d+X)] + p^{m*}[Y^m - s(d+X)] - F - (1-s)d. \quad (11)$$

Eq. (11) shows that the expected bank profit consists of the state-specific profit of the bank in the high and the medium state (weighted by the respective equilibrium probabilities), minus the fixed wage and the opportunity costs of shareholders. If the bank realizes  $Y^h$ , it pays  $s(d+X)$  to its depositors, the net bonus  $z$  to its manager, and bonus taxes  $tz$  to the government. In state  $m$ , the bank receives a portfolio return of  $Y^m$  and pays back  $s(d+X)$  to depositors.

If the bank obtains the low return  $Y^l = 0$ , then it does not pay back depositors. In this case the payments to depositors are partially covered by the deposit insurance, which does not enter the bank's profit expression. As the fixed wage  $F$  is paid by the bank in all states, bank's shareholders realize a loss in the case of default.<sup>17</sup> Finally, the term  $(1-s)d$  gives the opportunity costs of shareholders. This is the product of the share of equity financing  $(1-s)$  and the rate of return, which we assume to equal the expected unit return of depositors,  $d$ .

The bank sets the bonus  $z$  and the fixed wage  $F$  to maximize its expected after-tax profits. We assume that the bank needs the manager to run the bank and that it is thus always in the bank's best interest to hire the manager.

Substituting the financing constraint in (10) into (11), the bank's maximization problem is given by

$$\begin{aligned} \max_{z,F} \Pi &= p^{h*}[Y^h - z(1+t)] + p^{m*}Y^m - F - (1-s)d + p^{l*}v_i s d - s d \\ \text{s.t. } p^{h*} &= \gamma z(1+\theta) \\ p^{m*} &= p_0^m - \frac{\beta}{\mu} z(1+\theta) \\ p^{l*} &= p_0^l + \delta z(1+\theta) \\ \hat{u}^* &= \frac{\gamma}{2}(1+\theta)^2 z^2 + F \geq \bar{u}. \end{aligned} \quad (12)$$

The bank's maximization problem in eq. (12) effectively has three constraints: the *financing constraint*, the *incentive constraint*, and the *participation constraint*. First, the

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<sup>17</sup>We thus assume that the bank's equity can cover the fixed wage,  $F < (1-s)d$ .

*financing constraint* implies that the bank has to ensure that depositors invest in the bank. As the depositors are partly insured by the government and do not accurately price in the bank's default risk, the bank derives a subsidy  $p^{l*}v_i s d$  from the government guarantee. Second, the *incentive constraint* implies that the bank has to take into account that the equilibrium probabilities are affected by the bonus  $z$ . A higher bonus increases effort and risk-taking of the manager, which increases  $p^{h*}$  and  $p^{l*}$  and decreases  $p^{m*}$ . And third, the *participation constraint* implies that the manager's perceived expected utility of the bank's contract must be at least as large as the manager's fixed outside utility ( $\bar{u}$ ). Otherwise the manager will not accept the contract.

We restrict our analysis to the case where both the bonus  $z$  and the fixed wage  $F$  are used in equilibrium, which is the case generally observed for senior managers.<sup>18</sup> The fixed wage is only used to satisfy the banker's participation constraint (cf. eq. (12)). We assume that for all possible levels of bonus taxes (i.e.,  $t \geq 0$ ), the condition for the fixed wage to be used holds. This condition is derived in Appendix A and given by

$$(1 + \theta) < \frac{2\sqrt{2\bar{u}\gamma}}{\frac{\alpha^2}{\eta}Y^h + \delta v_i s d + \sqrt{2\bar{u}\gamma}}. \quad (13)$$

First, (13) rules out the case where the manager is so overconfident that the bonus is too attractive for the bank to pay a positive fixed wage. And second, the condition also ensures that the utility of the manager's outside option,  $\bar{u}$ , is sufficiently large for the fixed wage to be used.

The first order condition of the bonus  $z$  is given by<sup>19</sup>

$$\frac{\partial \Pi}{\partial z} = \frac{\alpha^2}{\eta}Y^h(1 + \theta) - 2(1 + t)\gamma z(1 + \theta) + \delta v_i s d(1 + \theta) + \gamma z(1 + \theta)^2 = 0. \quad (14)$$

An increase in the bonus has four effects on the bank's profit. First, the bonus increases effort-taking of the manager, which increases the mean return of the bank's portfolio. Second, the monetary bonus costs of the bank rise. Third, the bonus increases risk-taking of the manager, which shifts the costs of repaying depositors to the government. And fourth, the bonus reduces the fixed wage that is necessary for the bank to fulfill the participation constraint of the manager. Importantly, this effect is especially strong for an overconfident manager. Intuitively, as the overconfident manager overestimates the

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<sup>18</sup>For bankers earning more than 1 million euros in EU banks, for example, the average ratio between variable and fixed pay was 104% in 2016 (European Banking Authority, 2018).

<sup>19</sup>See Appendix A for the detailed solution of the bank's maximization problem in eq. (12).

probability of obtaining the bonus ( $\hat{p}^h > p^h$ ), he also overvalues the expected utility he derives from the bonus. This overvaluation creates the possibility for the bank to lower its expected compensation costs at the expense of the biased manager by increasing the bonus and lowering the fixed wage.<sup>20</sup>

The bank's profit-maximizing bonus  $z_B$  increases in the marginal profit of a costless bonus,  $(1 + \theta)\Omega$ , and decreases in the marginal net costs of the bonus,  $(1 + \theta)\Psi$ , as shown by

$$z_B = \frac{(1 + \theta)\Omega}{(1 + \theta)\Psi} = \frac{\Omega}{\Psi}, \text{ where } \Omega \equiv \frac{\alpha^2}{\eta} Y^h + \delta v_{isd} > 0 \text{ and } \Psi \equiv \gamma[2(1 + t) - (1 + \theta)] > 0. \quad (15)$$

A costless bonus increases the banker's effort and risk-taking, which raises the probability of realizing the high return, and the probability to draw on the government guarantee. The higher are the bank's risk-shifting incentives ( $\delta v_{isd}$ ), the higher is the bank's bonus. The marginal net costs of the bonus,  $(1 + \theta)\Psi$ , are the marginal bonus costs of the bank (which rise in the bonus tax  $t$ ) minus the bank's marginal savings on the fixed wage.<sup>21</sup> These marginal savings stem from the fact that a higher bonus reduces the fixed wage that is necessary to fulfill the manager's participation constraint. Note that the savings are larger for an overconfident manager, as he overvalues the utility that he derives from the bonus and is therefore willing to accept a lower fixed wage. The assumption in (13) ensure that  $2 - (1 + \theta) > 0$  and thus that the net costs are positive ( $\Psi > 0$ ).

The bank's profit-maximizing fixed wage  $F_B$  is given by

$$F_B = \bar{u} - \frac{\gamma}{2}(1 + \theta)^2 z_B^2 = \bar{u} - \frac{\gamma(1 + \theta)^2 \Omega^2}{2\Psi^2}. \quad (16)$$

The fixed wage  $F_B$  rises in the utility of the manager's outside option and falls in the manager's level of overconfidence. The latter is due to overconfidence making the bonus relatively more attractive (substitution effect) and lowering the overall compensation

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<sup>20</sup>Humphery-Jenner et al. (2016) provide empirical evidence that firms exploit overconfident CEO's overvaluation of incentive pay in order to lower compensation costs. The incentive to exploit managerial overvaluation has also been derived theoretically by De la Rosa (2011) and Gervais et al. (2011).

<sup>21</sup>The bonus tax thus always reduces the bonus in our model. Dietl et al. (2013) show that it can be optimal for a principal to increase bonuses as a response to a bonus tax, if an agent is highly risk-averse. The literature on banker's risk preferences, however, shows that banker's are very mildly risk averse or even risk neutral (see Thanassoulis (2012)).



needed for satisfying the manager's participation constraint (income effect). A bonus tax increases the fixed wage as it reduces the bonus  $z_B$ .

To sum up, the more overconfident the manager, the higher is the bonus that he receives and the lower is his fixed wage. First, this is due to the overconfident manager increasing his effort- and risk-taking more for a given increase in the bonus than a rational manager. And second, an overconfident manager overvalues the bonus. Hence bonuses become more attractive for the bank as they can be used to exploit the manager and lower compensation costs. We also find that the bonus increases in the level of the government guarantee. This is because the government guarantee makes risk-taking more attractive, which can be induced with bonuses.

## 5 Stage 1: The government

In this section we look at the role of the government. In Section 5.1 we define and discuss the welfare function. Section 5.2 derives the optimal bonus tax and discusses its properties.

### 5.1 The welfare function

The government maximizes welfare with respect to the bonus tax  $t$ . Bonus taxation can be used to redistribute from the financial sector to taxpayers. Moreover, the bonus tax affects the manager's effort and risk-taking choices in equilibrium. As the government guarantee leads to diverging interests between the bank and the government, the risk-reducing effect of the bonus tax is a valuable Pigouvian tool to decrease the likelihood of bailouts.

Our social welfare function takes into account the bank's profit  $\Pi^*$  in eq. (12) and the manager's *actual* expected utility  $u = p^{h*} z_B + F_B - \frac{\eta e^{*2}}{2} - \frac{\mu b^{*2}}{2}$ .<sup>22</sup> Additionally, the social welfare function entails the government's bailout costs,  $B$ , and its bonus tax income

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<sup>22</sup>For the *actual* expected utility, the utility derived from the bonus is weighted by the actual probability of the bonus  $p^h$  in eq. (7) and not by the perceived probability  $\hat{p}^h$  as in the perceived utility in eq. (4). This is because the actual outcome of the manager is determined by  $p^h$  and not by his biased beliefs  $\hat{p}^h$ .

$T$ .<sup>23</sup>

The bailout costs are given by

$$B = p^{l*} v_i s d = [p_0^l + \delta z_B (1 + \theta)] v_i s d. \quad (17)$$

Note that eq. (17) implies that overconfidence increases the likelihood of bailouts,  $p^{l*}$ , for two reasons. First, for a given contract, overconfident managers take on more risk as they overestimate the success probability of risky investments. And secondly, the bank creates higher powered compensation contracts for overconfident managers, which amplifies the behavioral effects of overconfidence and increases risk-taking further. As overconfidence raises the likelihood of bailouts, it increases the transfer of taxpayer money to the bank.

The tax revenue  $T$  is given by

$$T = t p^{h*} z_B = t(1 + \theta) \gamma z_B^2. \quad (18)$$

Hence overconfident managers create larger tax revenues, as they generate higher expected bonus payments,  $p^{h*} z_B$ . First, overconfident managers receive a higher bonus. And secondly, they take on more effort and risk, which lead to a higher probability of the bonus being paid,  $p^{h*}$ . Hence with respect to the tax revenue, the government can benefit from overconfident managers as they generate more bonus tax income.

We normalize the welfare weights of the banker and the shareholders to 1 and weigh the bailout costs  $B$  and the tax revenue  $T$  by  $\lambda$ . We argue that a monetary unit in the pocket of the government is worth more than a monetary unit for the bank or the banker (i.e.,  $\lambda > 1$ ). This is due to the marginal costs of public funds, which are the loss of society that the government causes when it raises additional revenues to finance its spending (see e.g. Browning (1976)).<sup>24</sup>

Substituting the bank profit from eq. (12), our welfare function is thus given by

$$\begin{aligned} W &= \Pi^* + u + \lambda(T - B) \\ &= p^{h*}(Y^h - t z_B) + p^{m*} Y^m + p^{l*} v_i s d - (1 - s)d - s d - \frac{\eta e^{*2}}{2} - \frac{\mu b^{*2}}{2} \\ &\quad + \lambda(t p^{h*} z_B - p^{l*} v_i s d). \end{aligned} \quad (19)$$

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<sup>23</sup>The risk-neutral depositors always receive an expected return of  $sd$  independent of the bonus tax. Their payoffs are thus not included explicitly in our welfare function.

<sup>24</sup>The higher weight of tax income and bailout costs in our welfare function can also be explained by a preference for redistribution from banker income and bank profits to taxpayers.

The welfare function can be subdivided into three parts. First, the first five terms in the second line of eq. (19) capture the bank's profit net of the bank's payments to the banker (cf. eq (12)). Note that the expected bonus payments  $p^{h*}z$  and the fixed wage  $F$  are simply transfers from the bank to the banker and therefore do not directly affect welfare in eq. (19). Second, the behavioral costs of the manager (i.e., the effort- and risk-taking costs  $\frac{\eta e^{*2}}{2}$  and  $\frac{\mu b^{*2}}{2}$ ) lower welfare, because they reduce the manager's utility.

Finally, the government's net revenue (i.e., tax revenue minus bailout costs) is shown in the third line of eq. (19). The government's net revenue is positive, if the tax revenue dominates the bailout costs. It is also possible, however, that the expected bailout costs  $B$  dominate the tax revenue  $T$ , which implies a negative net revenue for the government. This is the case when the exogenous default probability of the bank  $p_0^l$  is large and when the level of government guarantees  $v_i$  is high.

## 5.2 The optimal bonus tax

We now proceed to derive the optimal bonus tax  $t^*$ . Substituting eqs. (5), (6), (7) into eq. (19) and differentiating the welfare function with respect to  $t$  gives

$$\frac{\partial W}{\partial t} = (1 + \theta) \left\{ \frac{\alpha^2}{\eta} Y^h \frac{\partial z_B}{\partial t} - \gamma(1 + \theta) z_B \frac{\partial z_B}{\partial t} + (\lambda - 1) \left[ \gamma(2z_B \frac{\partial z_B}{\partial t} t + z_B^2) - \delta v_i s d \frac{\partial z_B}{\partial t} \right] \right\}. \quad (20)$$

On the one hand, a bonus tax lowers the mean return of the bank's investment due to the lower effort-taking incentives ( $\frac{\alpha^2}{\eta} Y^h \frac{\partial z_B}{\partial t} < 0$ ). On the other hand, the bonus tax has several positive welfare implications. First, it reduces the manager's effort and risk-taking costs ( $-\gamma(1 + \theta) z_B \frac{\partial z_B}{\partial t} > 0$ ). Second, the bonus tax redistributes from the financial sector to the government. Note that the tax revenue is especially high for overconfident managers as they receive a higher bonus  $z$  and take on more effort and risk for a given bonus. Finally, the bonus tax reduces the net bailout costs,  $(\lambda - 1)p^{l*}v_i s d$ , as it lowers risk-taking incentives. This is particularly desirable when banks receive large government guarantees and employ overconfident managers.

Whether the bonus tax is used in equilibrium is determined by the first order condition at  $t = 0$ , which is derived in Appendix B and given by

$$\frac{\partial W}{\partial t} \Big|_{t=0} = \left[ \frac{\gamma^2 \Omega (1 + \theta)}{\Psi^3} \right] \{ [2 - (1 + \theta)] [2\lambda \delta v_i s d + (\lambda - 1)\Omega] + 4\theta \Omega \} > 0. \quad (21)$$

Eq. (21) shows that the first marginal unit of bonus tax always increases welfare. The bonus tax lowers the bank's profit. At  $t = 0$  this negative welfare effect is always

dominated by the positive effects, namely the reduction of bailout costs, the increase in tax revenue, and the reduction of the manager's effort and risk costs.

We now investigate the condition for the bonus tax to be finite. In Appendix B we show that  $\frac{\partial W}{\partial t} > 0 \forall t$ , if and only if  $\delta v_i s d > \frac{(\lambda+1)\frac{\alpha^2}{\eta} Y^h}{(\lambda-1)}$ . Hence if the risk-shifting incentives,  $\delta v_i s d$ , are very large, then the government optimally sets  $t^* \rightarrow \infty$  in order to minimize the bailout costs caused by the bonus. If, however,

$$\delta v_i s d < \frac{(\lambda+1)\frac{\alpha^2}{\eta} Y^h}{\lambda-1}, \quad (22)$$

then there is an interior solution for  $t^*$  (see Appendix B).

Setting the first order condition in eq. (20) equal to zero, we get the optimal interior bonus tax

$$t^* = \frac{[2 - (1 + \theta)][(\lambda - 1)\Omega + 2\lambda\delta v_i s d] + 4\theta\Omega}{2[(\lambda + 1)\Omega - 2\lambda\delta v_i s d]}. \quad (23)$$

Note that the condition for the interior solution in eq. (22) implies that the denominator of the optimal bonus tax in eq. (23) is always positive.

We can now use comparative statics for eq. (23) to analyze the properties of the optimal bonus tax. Differentiating  $t^*$  with respect to  $v_i$  gives

$$\frac{\partial t^*}{\partial v_i} = \frac{4\delta s d \{ \lambda^2 [2 - (1 + \theta)] \frac{\alpha^2}{\eta} Y^h + (\lambda - 1)\theta\Omega \}}{2 [(\lambda + 1)\Omega - 2\lambda\delta v_i s d]^2} > 0. \quad (24)$$

Eq. (24) shows that the bonus tax increases in the level of bailout guarantees  $v_i$ . The larger the bailout guarantees, the stronger the risk-taking incentives of the bank, because depositors price in the bank's risk-taking to a smaller extent. Hence bailout guarantees make the bonus tax more attractive, as the tax curbs the bank's excessive risk-taking.

The effect of a tightening of capital requirements on the optimal bonus tax is given by

$$\frac{\partial t^*}{\partial(1-s)} = \frac{-4\delta v_i d \{ \lambda^2 [2 - (1 + \theta)] \frac{\alpha^2}{\eta} Y^h + (\lambda - 1)\theta\Omega \}}{2 [(\lambda + 1)\Omega - 2\lambda\delta v_i s d]^2} < 0. \quad (25)$$

Tighter capital requirements (i.e., larger  $1 - s$ ) reduce the leverage of the bank, which implies that the bank can shift fewer costs onto the government. This decreases the marginal benefit of the tax that arises from reducing the bailout costs. Hence capital requirements and bonus taxes are strategic substitutes.

The effect of the weight of the government's net revenue,  $\lambda$ , on the optimal bonus tax is given by

$$\frac{\partial t^*}{\partial \lambda} = \frac{\Omega \left[ (1 + \theta) \delta v_i s d + \frac{\alpha^2}{\eta} Y^h (1 - 3\theta) \right]}{[(\lambda + 1)\Omega - 2\lambda \delta v_i s d]^2}. \quad (26)$$

For a rational manager ( $\theta = 0$ ), an increase in the weight of the government's net revenue  $\lambda$  always raises the optimal bonus tax  $t^*$ . This is because a higher tax reduces the government's bailout costs and can raise tax revenue, while it hurts the bank's profits.

If the manager is overconfident ( $\theta > 0$ ), the effect of  $\lambda$  on the optimal tax depends on the strength of the bank's risk-shifting incentives. If the bank's risk-shifting incentives are strong (i.e.,  $\delta v_i s d$  is large and  $\frac{\alpha^2}{\eta} Y^h$  is low), then the optimal tax rises in  $\lambda$ , as it becomes increasingly important for the government to reduce its bailout costs.

If the risk-shifting incentives are weak (i.e.,  $\delta v_i s d$  is small and  $\frac{\alpha^2}{\eta} Y^h$  is large), however, a net revenue maximizing government is mainly concerned with the bonus tax revenue the manager generates. In this case, the government maximizes welfare by setting a low bonus tax for an overconfident banker, as the effort of an overconfident manager reacts especially elastically to the bonus tax. This is because overconfident managers overestimate the likelihood of obtaining the bonus, and thus react more elastically to changes in the bonus (cf. the optimal effort in eq. (5)). Hence (26) shows that if the manager is sufficiently overconfident and risk-shifting incentives are low, an increase in  $\lambda$  can actually lower the optimal bonus tax, because the government does not want to distort the especially elastic effort of an overconfident manager.

Finally, we investigate how the optimal bonus tax depends on overconfidence. Differentiating  $t^*$  in eq. (23) with respect to  $\theta$ , we get

$$\frac{\partial t^*}{\partial \theta} = \frac{5\Omega - \lambda\Omega - 2\lambda \delta v_i s d}{2[(\lambda + 1)\Omega - 2\lambda \delta v_i s d]}. \quad (27)$$

If the bank's risk-shifting incentives are sufficiently strong ( $\delta v_i s d > 3\frac{\alpha^2}{\eta} Y^h$ ), then overconfidence always increases the optimal bonus tax  $t^*$ , as shown in Appendix C.<sup>25</sup> An overconfident manager overestimates the returns to risk. Hence managerial overconfidence makes it cheaper for the bank to induce risk-shifting and to draw on the bailout

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<sup>25</sup>Appendix C shows that the condition  $\delta v_i s d > 3\frac{\alpha^2}{\eta} Y^h$  does not preclude an interior equilibrium for the bonus tax.

subsidy. These risk-shifting incentives are socially undesirable and can be mitigated with a larger bonus tax.<sup>26</sup>

In other words, overconfidence mitigates the principal-agent problem between the bank and the manager as it becomes cheaper for shareholders to align the manager's behavior with the bank's objective. This is detrimental for welfare, however, if risk-shifting incentives are strong, because it becomes easier for the bank to exploit the government subsidy. Hence the principal-agent problem between government and bank becomes more severe in the presence of overconfidence, and the government optimally sets a higher bonus tax in order to align the bank's with the government's interests.

Appendix C shows that a negative effect of overconfidence on the optimal bonus tax arises if simultaneously the risk-shifting incentives are sufficiently weak ( $\delta v_i s d < \frac{\alpha^2}{\eta} Y^h$ ) and the weight of the government's net revenue is large ( $\lambda > 5$ ).<sup>27</sup> In this case the government mainly aims to maximize its bonus tax revenue  $T$ . As an overconfident manager's effort reacts more elastically to changes in the bonus, the government then optimally sets a lower bonus tax for an overconfident banker.

We summarize our main results of Section 5 in

**Proposition 1** *Optimal bonus tax*

If eq. (22) holds, then

(i) the welfare-maximizing bonus tax  $t^*$  is given in eq. (23).

(ii)  $t^*$  always increases in the level of overconfidence  $\theta$ , if the risk-shifting incentives are sufficiently strong ( $\delta v_i s d > 3 \frac{\alpha^2}{\eta} Y^h$ ).

*Proofs: Appendices B and C.*

The key finding in Proposition 1 is that the optimal bonus tax always increases in overconfidence, if risk-shifting incentives are sufficiently strong. This is particularly the case for systemically important financial institutions as they receive bailout subsidies through both explicit and implicit government guarantees. These guarantees create an externality of the bank's behavior on taxpayers, which is especially attractive to exploit

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<sup>26</sup>It is also easy to see from eq. (27) that overconfidence always increases the optimal tax for a sufficiently low weight of the government's net revenue ( $\lambda < \frac{5}{3}$ ).

<sup>27</sup>This is a sufficient but not a necessary condition for the effect of overconfidence on the optimal bonus tax to be negative (see Appendix C).

if the manager is overconfident. In systemically important financial institutions, it is thus optimal to curb the social implications of overconfidence with a higher bonus tax. Recent evidence shows that managerial overconfidence indeed not only affects firm outcomes, but also causes substantial externalities. Banks with overconfident CEOs generally experience higher stock return volatility (Niu, 2010) and have shown higher real estate loan growth prior to the financial crisis (Ma, 2015). During the recent financial crises, banks managed by CEOs suffered from greater increases in loan defaults and a higher likelihood of failure than banks governed by non-overconfident CEOs (Ho et al., 2016). Due to the large externalities on taxpayers caused by banks' risk-taking and failures, it is necessary for the government to counteract the adverse effects arising from overconfidence in the banking industry. In the following section we discuss why the bonus tax is better suited to do so than other instruments (e.g. capital requirements).

## 6 Do we need to intervene in banker pay?

Following the financial crisis of 2007-2009 a lively discussion has emerged about whether or not the government should intervene in banker pay. We shed light on the role of managerial overconfidence in this debate in the following. To do so, Section 6.1 derives the socially optimal bonus and compares it to the bonus set by the bank. Section 6.2 then uses the example of capital requirements to illustrate why the socially optimal bonus cannot be obtained without interventions in banker pay, if bankers are overconfident.

### 6.1 The socially optimal contract

In this section we derive the socially optimal bonus when the government does not directly intervene in the banker's compensation (i.e.,  $t = 0$ ). We then compare this bonus to the one chosen by the bank.

In Appendix D we maximize the welfare function in eq. (19) with respect to the bonus, which gives us the socially optimal bonus:

$$z_{S|t=0} = \frac{\frac{\alpha^2}{\eta} Y^h - \delta v_i s d (\lambda - 1)}{\gamma(1 + \theta)} = \frac{\Omega - \lambda \delta v_i s d}{\gamma(1 + \theta)}. \quad (28)$$

We can now investigate how the bank's bonus in eq. (15) deviates from the socially

optimal bonus, if the government does not intervene into banker pay:

$$z_{B|t=0} - z_{S|t=0} = \frac{[2 - (1 + \theta)]\lambda\delta v_i s d + 2\theta\Omega}{\gamma[(1 + \theta)][2 - (1 + \theta)]} > 0. \quad (29)$$

The bonus chosen by the bank is unambiguously larger than the socially optimal bonus.<sup>28</sup> The bank does not internalize the bailout costs of the government. Hence it prefers more risk, which can be induced with a higher bonus. Moreover, the bank exploits the managerial overvaluation, which leads to the manager providing too much effort and risk relative to the actual probability of getting the bonus.

Note that an upper bound for bonuses, a bonus cap, set at  $z_{S|t=0}$  can implement the socially optimal bonus. The cap has the same qualitative behavioral effects as the bonus tax discussed in Section 5.2, because it also lowers the bonus and raises the fixed wage. A bonus cap, however, does not raise tax revenue, which is an attractive channel to redistribute from the financial sector to the government. Hence in a setting where the marginal costs of public funds exceed one ( $\lambda > 1$ ), the optimal bonus tax dominates the optimal bonus cap with respect to welfare.

## 6.2 Capital requirements

This section investigates, if capital requirements can implement the socially optimal bonus. To see if an increase in the capital requirements,  $1 - s$ , brings the bank bonus closer to the social optimum, we derive eq. (29) with respect to  $(1 - s)$ :

$$\frac{\partial(z_{B|t=0} - z_{S|t=0})}{\partial(1 - s)} = -\frac{\lambda\delta v_i d[2 - (1 + \theta)] + 2\delta v_i d\theta}{\gamma(1 + \theta)[2 - (1 + \theta)]} < 0. \quad (30)$$

Eq. (30) implies that tighter capital requirements indeed reduce the gap between the bank's bonus and the socially optimal bonus. With tighter capital requirements, the bank internalizes the downside risk of its investment to a larger extent and thus has a smaller incentive to induce risk-taking via bonuses. Whether capital requirements can actually establish the socially optimal bonus is determined by

$$\lim_{(1-s) \rightarrow 1} (z_{B|t=0} - z_{S|t=0}) = \frac{2\frac{\alpha^2}{\eta} Y^h \theta}{\gamma(1 + \theta)[2 - (1 + \theta)]} > 0. \quad (31)$$

Eq. (31) shows that capital requirements alone cannot implement the socially desirable bonus level, if the manager is overconfident ( $\theta > 0$ ). Even in the extreme case

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<sup>28</sup>The fixed wage chosen by the bank,  $F_B$ , is smaller than the socially optimal fixed wage, which is given by  $F_S = \bar{u} - \frac{\gamma}{2}(1 + \theta)^2 z_S^2$ .



with capital requirements approaching 100%, the bank's bonus is higher than socially optimal.<sup>29</sup>

Recall from Section 6.1 that there are two reasons why the bank's bonus is higher than the socially optimal bonus. First, the bank uses the bonus to maximize its value of the government subsidy. Capital requirements can tackle this problem, as they force the bank to internalize the externalities of its risk-taking. And second, the bank sets an excessively high bonus in order to exploit the manager, if he is overconfident. An overconfident manager overvalues the utility that he derives from a bonus, because he overestimates the probability to obtain the bonus ( $\hat{p}^h > p^h$ ). Hence, for an overconfident manager, the bank can save compensation costs by offering a higher bonus and a lower fixed wage. This higher bonus has the side effect that risk-taking is greater (see eq. (6)) than under the socially optimal bonus. Capital requirements cannot tackle the inefficiencies arising from the exploitation of managerial overvaluation.

For a rational manager ( $\theta = 0$ ), capital requirements can establish the socially optimal bonus (cf. eq. (31)), as there is no possibility for the bank to exploit the manager. Unlike an overconfident manager, a rational manager derives the same perceived utility from one dollar of expected bonus payments as from one dollar of fixed wage.

Moving away from capital requirements and generalizing our argument, Appendix E derives the bank's bonus  $z_{R|t=0}$  under the assumption that regulation achieves that the bank fully internalizes the bailout costs of the government ( $\lambda p^{l*} v_i sd$ ). Analogously to the capital requirements, the bank's bonus is higher than socially optimal, if the manager is overconfident. In the presence of overconfidence, curbing shareholders' risk-shifting incentives alone is not enough, as the bank has an incentive to use bonuses in order to exploit the manager's overvaluation.

We summarize Section 6.2 in

**Proposition 2** *Shareholders' risk-shifting incentives and the socially optimal bonus*

*If the manager is overconfident (i.e.,  $\theta > 0$ ),*

*(i) capital requirements alone cannot implement the socially desirable bonus. The bank's bonus,  $z_{B|t=0}$ , is then always larger than the socially desirable bonus,  $z_{S|t=0}$ .*

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<sup>29</sup>Of course, an increase in capital requirements has other potential downsides (e.g. a decrease in lending to firms) that are not dealt with in our model. See, for example, Van den Heuvel (2008) for an analysis of the welfare costs of capital requirements.

(ii) the bonus ,  $z_{R|t=0}$ , of a bank that fully internalizes the government's bailout costs is always larger than the socially desirable bonus,  $z_{S|t=0}$ .

*Proofs: Equation (31) and Appendix E.*

A direct intervention into banker pay (e.g. bonus taxes or bonus caps) can however implement the socially desirable bonus, as it addresses both motives for the excessive use of the bonus at the same time. Direct interventions into banker pay not only tackle the inefficiencies caused by incentives for excessive risk-taking, but also the adverse effects arising from the manager's overvaluation of the bonus. A bonus tax, for example, increases the bank's costs of the bonus relative to its costs of the fixed wage. Hence the higher is the bonus tax, the lower is the incentive of the bank to save fixed wage costs by offering an excessive bonus.<sup>30</sup>

Our results suggest that the EU bonus cap mitigates the socially adverse effects of managerial overconfidence. This regulation became effective across the European Union in 2014 as part of the Capital Requirements Directive IV. The EU bonus cap limits bonuses paid to senior managers and other "material risk takers" in the financial sector to 100% of their fixed salary (200 % with shareholder approval). Our analysis implies that the bonus cap curbs the exploitation of managerial overvaluation, because it limits the banks' ability to lower compensation costs via higher bonuses and lower fixed wages. Hence the EU bonus cap lowers excessive risk-taking in equilibrium.

More generally, Proposition 2 suggests that interventions into banker pay are part of the optimal regulatory package for the banking industry. The existing literature has identified competition for mobile bankers as the major reason to intervene directly into banker compensation instead of only curbing shareholders' risk-shifting incentives. For example, Bannier et al. (2013) find that the competition for bankers with heterogeneous and unobservable skill leads to excessive bonuses. This causes a level of risk-taking that is not only excessive for society but also for the banks themselves. Thanassoulis (2012) shows that the competition for bankers increases bankers' pay, which gives rise to a negative externality as rival banks have to increase banker remuneration as well. This increase in banker pay drives up the remuneration costs of banks and thus their default risk. Our finding in Proposition 2 adds to these findings by showing that bonuses in the banking industry are excessive from a social point of view, even when competition for

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<sup>30</sup>Of course Proposition 2 does not imply that interventions into banker pay should be the *only* instrument in an optimal regulatory scheme.

managerial talent in the banking sector is weak. This is because overconfidence creates an incentive for banks to exploit managerial overvaluation.

## 7 Competition for overconfident bankers

In order to shed light on the competition for overconfident managers, this section introduces heterogeneities in bank characteristics and managerial overconfidence. Specifically, we are interested in how government guarantees, bonus taxes, and capital requirements affect the matching between banks and overconfident managers. Section 7.1 derives the equilibrium contracts and allocation when banks compete for an overconfident manager. In Section 7.2 we analyze how this competitive equilibrium is affected by heterogeneities in government guarantees, capital requirements, and bonus taxes.

### 7.1 Equilibrium contracts under competition

In this section, we introduce heterogeneities in bank characteristics and managerial overconfidence. Specifically, there are two banks  $i \in (1, 2)$  that potentially differ in the level of government guarantees  $v_i$ , the bonus taxes  $t_i$ , and the capital requirements  $1 - s_i$ . There are two types of managers  $j \in (OC, N)$  that only differ in managerial overconfidence  $\theta_j$ . We assume that type  $OC$ , who we refer to as overconfident manager, is more overconfident than type  $N$  ( $\theta_{OC} > \theta_N \geq 0$ ), who we refer to as rational manager.

The two banks compete for the services of the overconfident manager via their compensation packages. We assume that the overconfident manager is scarce (i.e., there is only one overconfident manager) and that rational managers are abundant.<sup>31</sup> Hence the bank that does not hire the overconfident manager in equilibrium will hire a rational manager instead. The manager  $j$ 's outside option to working for bank  $i$  is determined by the contract that the other bank  $I$  ( $\forall i, I \in \{1, 2\}, i \neq I$ ) offers to him.

As rational managers are abundant, the two banks do not compete for their services. Hence the bonus and fixed wage of a rational manager in bank  $i$ ,  $z_{i,N}$  and  $F_{i,N}$ , are the same as in the previous sections. Substituting the bank bonus from eq. (15) and the fixed wage from eq. (16), we get bank  $i$ 's optimal profit when hiring the rational

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<sup>31</sup>Our approach is thus similar to Gervais et al. (2011), who model the competition for a scarce overconfident manager in the absence of government guarantees and government policies.

manager  $N$ :

$$\begin{aligned} \Pi_{i,N}^* &= p_0^m Y^m + p_o^l v_i s_i d - \bar{u}_N - (1 - s_i)d - s_i d + \frac{(1 + \theta_N)\Omega_i^2}{2\Psi_{i,N}}, \\ \text{where } \Omega_i &= \frac{\alpha^2}{\eta} Y^h + \delta v_i s_i d \text{ and } \Psi_{i,N} = \gamma[2(1 + t_i) - (1 + \theta_N)]. \end{aligned} \quad (32)$$

It is easy to see from eq. (32) that bank  $i$ 's profit rises in the level of overconfidence. This is because overconfidence increases effort- and risk-taking and reduces the compensation costs needed to convince the manager to work for the bank. Hence banks benefit more from hiring an overconfident manager than from hiring a rational manager, and compete for the services of the overconfident manager.

In equilibrium, the overconfident manager  $OC$  works for the bank  $i$  that is willing to offer him his highest perceived utility. The maximum willingness to pay of bank  $i$  for manager  $OC$  in terms of his perceived utility,  $\hat{u}_{i,max}$ , is determined by

$$\Pi_{i,OC}^* = p_0^m Y^m + p_o^l v_i s_i d - \hat{u}_{i,max} - (1 - s_i)d - s_i d + \frac{(1 + \theta_{OC})\Omega_i^2}{2\Psi_{i,OC}} = \Pi_{i,N}^*. \quad (33)$$

Hence  $\hat{u}_{i,max}$  is the level of  $OC$ 's perceived utility for which bank  $i$  is indifferent between hiring him and hiring the rational manager  $N$ . Substituting  $\Pi_{i,N}^*$  from eq. (32) and solving for  $\hat{u}_{i,max}$ , we get

$$\hat{u}_{i,max} = \bar{u}_N + \frac{\gamma\Omega_i^2(1 + t_i)(\theta_{OC} - \theta_N)}{\Psi_{i,OC}\Psi_{i,N}}. \quad (34)$$

Eq. (34) determines in which bank the overconfident manager works. The bank with the higher willingness to pay for the overconfident manager,  $\hat{u}_{i,max}$ , hires the overconfident manager in equilibrium. This willingness to pay rises in the exogenous outside option of the rational manager  $\bar{u}_N$ , and in the level of overconfidence of the overconfident manager.

For the bank  $i$  that hires the overconfident manager in equilibrium, it is optimal to offer this manager a contract for which he is indifferent between working for bank  $i$  and the other bank  $I$ .<sup>32</sup> This is given by

$$\hat{u}_{i,OC} = \hat{u}_{I,max}. \quad (35)$$

Recall from eq. (8) that the perceived utility  $\hat{u}_{i,OC}$  that manager  $OC$  derives from bank  $i$ , depends on the bonus,  $z_{i,OC}$ , and the fixed wage  $F_{i,OC}$ . As in previous sections, bank

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<sup>32</sup>For simplicity, we assume here that if both banks offer the overconfident manager the same perceived utility, he will decide to work for the bank with a higher maximum willingness to pay.

$i$  chooses the profit-maximizing bonus  $z_{i,OC}$  given in eq. (15). The fixed wage is used to attract the overconfident manager to work for bank  $i$  and thus adjusts to fulfill eq. (35). Hence by substituting  $\hat{u}_{I,max}$  from eq. (34) and the bonus from eq. (15), we get the equilibrium wage of the overconfident manager

$$F_{i,OC} = \bar{u}_N + \frac{\gamma\Omega_I^2(1+t_I)(\theta_{OC} - \theta_N)}{\Psi_{I,OC}\Psi_{I,N}} - \frac{\gamma\Omega_i^2(1+\theta_{OC})^2}{2\Psi_{i,OC}^2}, \quad (36)$$

The first two terms capture the willingness to pay for the overconfident manager of the bank  $I$  that loses the bidding war for the overconfident manager. The first term in eq. (36),  $\bar{u}_N$ , implies that the better the rational manager's outside option, the more expensive he will be for the bank and the more attractive is the overconfident manager in comparison. The second term shows that the higher  $OC$ 's overconfidence, the more valuable he is for the losing bank, which drives up his fixed wage in the bank that hires him. Hence, due to the competition for his services, the overconfident manager can now capture (some of) the rent that his overconfidence creates.<sup>33</sup> Effectively, the manager's overconfidence commits him to exert more effort and risk, which generates bank profits that he can (partly) capture under competition.<sup>34</sup> The third term is the perceived utility that the overconfident manager derives from the bonus in the bank he works for. The higher this perceived utility from the bonus, the smaller the fixed wage has to be in order to attract the overconfident manager.

To summarize, Section 7.1 shows that, in equilibrium, the banks' contracts and the managers' allocation are given by

**Lemma 1** *Competitive equilibrium*

*In equilibrium, the bank  $i$  with the higher maximum willingness to pay,*

$$\hat{u}_{i,max} = \bar{u}_N + \frac{\gamma\Omega_i^2(1+t_i)(\theta_{OC} - \theta_N)}{\Psi_{i,OC}\Psi_{i,N}},$$

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<sup>33</sup>If the two banks are identical, then the overconfident manager captures the whole rent,  $\Pi_{i,OC}^* - \Pi_{i,N}^*$ , of his excess overconfidence,  $\theta_{OC} - \theta_N$ . As under Bertrand Competition, the two banks will in this case overbid each other until the banks' profits for  $OC$  are just as low as the banks' profits for the rational manager. If the two banks differ (e.g in the level of the government guarantee  $v_i$ ), then the overconfident manager will typically not be able to obtain the whole rent, because the losing bank  $I$  is not willing to bid up his fixed wage until  $\Pi_{i,OC}^* = \Pi_{i,N}^*$  holds.

<sup>34</sup>Gervais et al. (2011) show, in a theoretical model, that a manager can actually benefit from his overconfidence when firms compete for his services.

employs the overconfident manager with the bonus  $z_{i,OC}$  in eq. (15) and the fixed wage  $F_{i,OC}$  in eq. (36). The other bank  $I$  employs the rational manager with the bonus  $z_{I,N}$  in eq. (15) and the fixed wage  $F_{I,N}$  in eq. (16).

In Section 7.2, we use Lemma 1 to see how the matching between overconfident managers and banks depends on government guarantees, bonus taxes, and capital requirements. We can use the maximum willingness to pay,  $\hat{u}_{i,max}$ , to determine how changes in the exogeneous parameters affect the sorting of managers. If  $\hat{u}_{i,max}$ , in equilibrium, is an increasing function of an exogenous parameter, then the overconfident manager will ceteris paribus work for the bank with a higher value of this exogenous parameter. If  $\hat{u}_{i,max}$  decreases in an exogenous parameter, then the bank with a higher value of this parameter will ceteris paribus employ the rational manager.

## 7.2 Matching

This section analyzes the sorting of managers with respect to government guarantees, capital requirements, and bonus taxes.<sup>35</sup> The effect of the government guarantee on the willingness to pay for the overconfident manager is given by

$$\frac{\partial \hat{u}_{i,max}}{\partial v_i} = \frac{2\gamma(1+t_i)(\theta_{OC} - \theta_N)\Omega_i \delta s_i d}{\Psi_{i,OC}\Psi_{i,N}} > 0. \quad (37)$$

Eq. (37) shows that the maximum willingness to pay for the overconfident manager,  $\hat{u}_{i,max}$ , unambiguously increases in the level of government guarantees,  $v_i$ . A bank with higher government guarantees benefits more from excessive risk-taking as it can shift more of the repayment costs to depositors,  $sd$ , onto the government. An overconfident manager takes on more risk than a rational manager as he overestimates the success probability of risky investments, and is thus especially attractive for banks that receive large government guarantees. Hence the higher is the government guarantee of a bank, the larger is the positive effect of overconfidence on the bank's profit, which drives up the willingness to pay for the overconfident manager,  $\hat{u}_{i,max}$ .

From eq. (37) and Lemma 1, it follows that the overconfident manager ceteris paribus works for the bank with a higher level of government guarantees in equilibrium. Lemma 1 also implies that the overconfident manager earns a higher bonus than the rational manager. First, overconfidence makes the bonus more attractive for the bank. And

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<sup>35</sup>Throughout this section we assume that the bonus tax is exogenously given.

second, the overconfident manager works for the bank with a higher government guarantee, which has a higher risk appetite and accordingly sets a higher bonus.

The effect of the capital requirement on the sorting of the overconfident manager is determined by

$$\frac{\partial \hat{u}_{i,max}}{\partial (1 - s_i)} = -\frac{2\gamma(1 + t_i)(\theta_{OC} - \theta_N)\Omega_i \delta v_i d}{\Psi_{i,OC}\Psi_{i,N}} < 0. \quad (38)$$

Eq. (38) implies that bank  $i$ 's willingness to pay for the overconfident manager is the lower, the tighter are the capital requirements (i.e., the higher  $(1 - s_i)$ ). From the bank's perspective, overconfident managers have the advantage that they take on more risk and that their risk-taking is cheaper to incentivize. Tighter capital requirements, however, lower the shareholders' risk appetite, as they imply that shareholders internalize a larger share of the bank's risk-taking. The shareholders' lower risk appetite, induced by tighter capital requirements, entails that the bank benefits less from employing an overconfident manager. Hence, ceteris paribus, overconfident managers work for banks with lax capital requirements.

Considering an exogenous bonus tax, the effect of the bonus tax on the willingness to pay for the overconfident manager is given by

$$\frac{\partial \hat{u}_{i,max}}{\partial t_i} = \frac{\gamma^3 \Omega_i^2 (\theta_{OC} - \theta_N) [-4(1 + t_i)^2 + (1 + \theta_{OC})(1 + \theta_N)]}{\Psi_{i,OC}^2 \Psi_{i,N}^2} < 0. \quad (39)$$

Eq. (39) implies that, ceteris paribus, overconfident managers work for banks where bonus taxes are relatively low. Note that the bonus tax is especially suitable to affect the selection of overconfident managers. Like capital requirements, the bonus tax curbs the bank's incentive to shift risks, which decreases the benefit from employing an overconfident manager. In addition, and unlike capital requirements, the bonus tax makes it more costly for the bank to exploit the fact that an overconfident banker overvalues the bonus. Hence, if the government wants to avoid the selection of overconfident managers into certain institutions, the bonus tax is a particularly effective tool to do so.

We summarize our findings in

**Proposition 3** *Matching*

*The overconfident manager, OC, ceteris paribus works for the bank  $i$  with larger government guarantees  $v_i$ , lower bonus taxes  $t_i$ , and laxer capital requirements  $1 - s_i$ .*

*The rational manager,  $N$ , ceteris paribus works for the other bank  $I$  with smaller government guarantees  $v_I$ , higher bonus taxes  $t_I$ , and stricter capital requirements  $1-s_I$ .*

*Proof: Follows directly from equations (37), (38), (39), and Lemma 1.*

The finding that overconfident managers select into banks with large government guarantees has significant implications for taxpayers. It causes equity and efficiency losses. The selection of overconfident managers into institutions with large bailout guarantees increases the likelihood of bailouts,  $p^{l*}$ , for two reasons. First, for a given contract, overconfident managers take on more risk as they overestimate the success probability of risky investments. And secondly, the bank creates higher powered compensation contracts for overconfident managers, which amplifies the behavioral effects of overconfidence and increases risk-taking further. The rise in the likelihood of bailouts increases the bailout subsidy,  $B$ , and thus the transfer of taxpayer money to the bank and the banker.

Beyond the direct bailout costs,  $B$ , the financial crisis of 2007-2009 has shown that there are large externalities both within the financial market as well as from financial institutions to non-financial firms. A selection of overconfident managers, who increase the default risk, into banks that are systemically important enough to receive government guarantees is thus hazardous for the economy.

Proposition 3 suggests that a government can influence the selection of managers by changing the bonus tax,  $t_i$ , and/or changing the capital requirements,  $1-s_i$ . Hence the government can counteract the selection of overconfident managers into institutions with large government guarantees. A bonus tax is particularly well suited to do so, because it can tackle the exploitation of managerial overvaluation.

## 8 Discussion

This section briefly investigates some policy implications of our analysis. Section 8.1 discusses the international policy competition for mobile bankers. In Section 8.2 we summarize why our model supports the implementation of bonus taxes in systemically important financial institutions. Section 8.3 considers deferrals and clawbacks of variable remuneration and Section 8.4 briefly discusses the role of strong supervisory boards.



## 8.1 International policy competition

Proposition 3 suggests that governments can affect the matching of managers with banks by changing the bonus tax  $t$  and/or changing the capital requirements,  $1 - s$ . This has implications for governments that compete for internationally mobile bankers.<sup>36</sup> In a non-cooperative setting of these two instruments, the governments can set high bonus taxes or strict capital requirements in order to have a selection of rational bankers in the domestic country. Conversely, if governments set low bonus taxes or lax capital requirements, there will be a selection of overconfident bankers in the domestic country. These findings can be of interest to the literature on tax competition for mobile bank managers (see e.g. Gietl and Haufler (2018)) and to the literature on regulatory competition in capital requirements (see e.g. DellAriccia and Marquez (2006)), which do not consider overconfidence.

Recall from Section 5.1 that overconfident managers create larger bailout costs,  $B$ , but also generate greater tax revenue,  $T$ . Hence it is an interesting avenue for future research to investigate under which conditions there is a 'race to the bottom' or a 'race to the top' in bonus taxes when (some) bankers are overconfident. For example, it could be rational for governments to attract overconfident bankers, if there is a joint liability of bailout costs between the countries (i.e., a country partly comes up for the bailout costs of another country and vice versa). In this case, governments can benefit from the greater tax revenue that overconfident managers create, and only partly come up for the larger domestic bailout costs that overconfident managers cause.

## 8.2 Bonus taxes and systemically important financial institutions

Our model supports the implementation of bonus taxes in systemically important financial institutions (SIFIs). In SIFIs, risk-shifting incentives,  $\delta v_i s d$ , are strong due to explicit (e.g. due to deposit insurance) and implicit (e.g. because the SIFI is too big to fail) government guarantees. The bonus tax can counteract these socially adverse incentives. Hence the optimal bonus tax rises in the bank's risk-shifting incentives (see eq. (24)). As managerial overconfidence exacerbates the risk-shifting problem, the optimal

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<sup>36</sup>There is ample evidence that bankers are mobile across countries (see e.g. Greve et al., 2009, 2015). For example, Staples (2008) shows that almost 70% of the 48 largest commercial banks have one or more non-national board members.

bonus tax further increases in overconfidence, if risk-shifting incentives are sufficiently large (see Proposition 1). In banks with weak risk-shifting incentives, however, the optimal bonus tax should be lower in order not to deter the manager's effort-taking. This is especially the case if the manager is overconfident, because an overconfident banker's effort reacts more elastically to changes in the bonus tax.

Proposition 2 shows that direct interventions into banker pay are best suited to establish the socially optimal bonus if bankers are overconfident. Overconfidence creates an incentive for the bank to exploit the managerial overvaluation of bonus payments. This leads to socially excessive bonuses and excessive risk-taking. Unlike capital requirements, bonus taxes can counteract the bank's incentive to exploit managerial overvaluation and are thus able to deter excessive risk-taking. This is especially important in systemically important financial institutions where the social costs from defaults are large.

Proposition 3 shows that overconfident managers select into banks with large government guarantees. This matching implies large bailout costs for taxpayers. Bonus taxes are particularly well suited to counteract this selection. Like capital requirements, they reduce the bank's risk appetite and thus the benefit of employing an overconfident banker. Unlike capital requirements, bonus taxes additionally tackle the exploitation of managerial overvaluation, which further reduces the benefit of hiring an overconfident manager. Hence Proposition 3, like Proposition 1, suggests that bonus taxes should be larger in systemically important financial institutions than in institutions that carry less systemic risk, albeit for different reasons. Bonus taxes should be higher in SIFIs to mitigate excessive risk-taking (Proposition 1) and to deter the matching of overconfident bankers and SIFIs (Proposition 3).

### 8.3 Deferred pay and clawbacks

Following the financial crisis of 2007-2009, several countries have considered and implemented deferrals and clawbacks of variable remuneration. In the United Kingdom, for example, the variable pay of bankers is partly subject to deferral and clawbacks for up to seven and ten years, respectively, from the date of a variable remuneration award.<sup>37</sup> This regulation aims to reduce excessive risk-taking in the banking industry

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<sup>37</sup>See FCA PS 15/16 for details on the rules regarding bonus deferrals and clawbacks for bankers in the United Kingdom.

by forcing bankers to internalize the costs of potential future losses. Thanassoulis and Tanaka (2018) find that, in the presence of government guarantees, clawback rules can establish socially optimal risk choices of a rational bank CEO.<sup>38</sup> In their model, clawbacks can discourage socially excessive risk-taking as they penalize the banker in case of the bank’s default.<sup>39</sup>

Our analysis implies, however, that the effectiveness of deferred pay and clawbacks is limited if the banker is overconfident ( $\theta > 0$ ). An overconfident banker underestimates the probability of bank default ( $\hat{p}^l < p^l$ ). He thus underestimates any expected penalty that he might incur in the case of default. Hence overconfidence deters the intended effect of clawbacks and deferred pay to make the banker internalize downside risks.

## 8.4 Strong Boards

In recent years several papers have shown that better board supervision and monitoring can attenuate the adverse effects of overconfidence on firm outcomes. Kolasinski and Li (2013) show that strong boards help overconfident CEOs make better acquisition decisions. Banerjee et al. (2015) use the passage of the Sarbanes-Oxley act as an exogenous shock in governance and find that it has improved operating performance and market value for overconfident-CEO firms.

Our results show that the adverse social effects of managerial overconfidence cannot be attenuated by strengthening boards, if risk-shifting incentives are strong (i.e.,  $\delta v_i s d$  is large). In systemically important financial institutions, a strong board has the incentive to set excessively high bonuses for overconfident managers in order to exploit their overvaluation and to induce them to take on excessive risks. Hence strong supervisory boards can indeed benefit firm value in the presence of managerial overconfidence, but they potentially create substantial welfare losses for taxpayers when risk-shifting incentives are strong. Unlike strong boards, a bonus tax can curb the banks’ incentives to exploit managerial overvaluation and it can deter socially excessive risk-taking.

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<sup>38</sup>Thanassoulis and Tanaka (2018) emphasize that the clawback rules need to be assisted by rules on the convexity of CEO pay. Otherwise the bank can adjust the CEOs remuneration to circumvent the risk-reducing role of clawbacks.

<sup>39</sup>In a similar vein, Chaigneau (2013) suggests that a credible threat of sanctions for CEOs of failed banks can curb risk-shifting incentives.

## 9 Conclusion

In this paper we have incorporated managerial overconfidence and limited bank liability into a principal-agent model of the banking industry. Overconfident managers overestimate the returns to effort and risk-taking, which implies that they exert more effort and risk than rational managers. We find that the optimal bonus tax increases as a response to managerial overconfidence, if risk-shifting incentives are strong. This is because government guarantees create an externality of the bank's behavior on taxpayers, which is especially attractive to exploit, if the manager is overconfident. These socially adverse incentives can be counteracted with a bonus tax.

Our model shows that overconfidence necessitates an intervention into bankers' pay. Curbing the risk-shifting incentives of shareholders (e.g. via capital requirements) alone is not sufficient, as overconfidence leads to excessive bonuses even if shareholders fully internalize the externalities of their risk-taking. This is because shareholders exploit the fact that overconfident managers overestimate the probability of obtaining the bonus. Hence shareholders have an incentive to increase their usage of bonuses to lower their total compensation costs at the expense of the overconfident banker. The bonus tax makes it more expensive for the bank to exploit managerial overvaluation and thus reduces excessive risk-taking in equilibrium.

Finally, our model suggests that overconfident managers work for banks with large government guarantees. These banks have a larger risk appetite and thus benefit more from employing overconfident managers than banks with smaller government guarantees. Hence overconfident managers select into banks where they are particularly detrimental for taxpayers. Bonus taxes are particularly well suited to counteract this selection, as they not only curb the bank's risk-taking incentive, but also make it more costly for the bank to exploit an overconfident manager's overvaluation of the bonus. All in all, our model suggests that the presence of managerial overconfidence makes bonus taxes in systemically important financial institutions necessary.

Our paper raises several questions for future research. For example, our prediction that overconfident managers sort into banks (and, more generally, firms) according to the regulatory environment could be empirically tested by using personal portfolios of CEOs to determine overconfidence (as in Malmendier and Tate, 2005). Another promising research avenue is the international policy competition for mobile, overconfident bankers. Our model shows that policy parameters such as bonus taxes and capital

requirements affect the selection of overconfident and rational managers in a country. Endogenizing such a policy parameter could shed light on whether it is optimal for all countries to set strict regulation/taxation and drive out overconfident managers, or if it's actually optimal for some countries to have a high-risk banking sector run by overconfident agents. We plan to cover this issue in future research.

## Appendix

### Appendix A. Bank's maximization problem

From eq. (12), the bank's maximization problem is given by

$$\begin{aligned} \max_{z,F} \Pi &= p^{h*} [Y^h - z(1+t)] + p^{m*} Y^m + p^{l*} v_i s d - F - d \\ \text{s.t. } \hat{u}^* &= \frac{\gamma}{2} (1+\theta)^2 z^2 + F \geq \bar{u}. \end{aligned} \quad (\text{A.1})$$

Using the equilibrium probabilities from eq. (7), we get the following Lagrangian:

$$\begin{aligned} \max_{z,F} \mathcal{L} &= [\gamma z(1+\theta)] [Y^h - z(1+t)] + [p_0^m - \frac{\beta}{\mu} z(1+\theta)] Y^m + [p_0^l + \delta z(1+\theta)] v_i s d \\ &\quad - F - d + \kappa \left[ \frac{\gamma}{2} (1+\theta)^2 z^2 + F - \bar{u} \right]. \end{aligned} \quad (\text{A.2})$$

As risk-taking is a mean-preserving spread,  $\beta Y^h = Y^m$  holds. The three first order conditions are then given by

$$\frac{\partial \mathcal{L}}{\partial z} = \frac{\alpha^2}{\eta} Y^h (1+\theta) - 2(1+t)\gamma z(1+\theta) + \delta v_i s d (1+\theta) + \kappa \gamma z(1+\theta)^2 = 0, \quad (\text{A.3})$$

$$\frac{\partial \mathcal{L}}{\partial F} = -1 + \kappa \leq 0, \quad (\text{A.4})$$

$$\frac{\partial \mathcal{L}}{\partial \kappa} = \frac{\gamma}{2} (1+\theta)^2 z^2 + F - \bar{u} \geq 0. \quad (\text{A.5})$$

The bonus will always be used in equilibrium ( $z > 0$ ) as the marginal costs of the bonus at  $z=0$  are zero, while the marginal benefits are positive due to the positive effect of the bonus on effort- and risk-taking.

We focus on the case where the bonus and the fixed wage are used in equilibrium (**Case 1**:  $z > 0$  and  $F > 0$ ). From the complementary slackness condition it follows

that a positive fixed wage ( $F > 0$ ) implies  $\kappa = 1$  in eq. (A.4). Note also that for the fixed wage to be used ( $F > 0$ ), the participation constraint must be binding (i.e., eq. (A.5) holds with equality). Otherwise profits could be increased by lowering the fixed wage.

Solving eq. (A.3) for  $z$  and using  $\kappa = 1$ , we get the bank bonus  $z_B$  in eq. (15). Using the participation constraint in (A.5) gives the bank's fixed wage  $F_B$  in eq. (16). The second order condition with respect to  $z_B$  is given by

$$\frac{\partial^2 \mathcal{L}}{\partial z^2} = -\gamma(1 + \theta)[2(1 + t) - (1 + \theta)]. \quad (\text{A.6})$$

In the two other possible cases, the fixed wage is not used. In **Case 2** ( $z > 0$ ,  $F = 0$  and  $0 < \kappa < 1$ ) only the bonus is used and the participation constraint is binding. In **Case 3** ( $z > 0$ ,  $F = 0$  and  $\kappa = 0$ ) only the bonus is used and the participation constraint is not binding.

Analyzing the conditions under which  $\kappa = 0$  and  $\kappa = 1$ , we can derive the conditions for the three cases. Case 1 holds if overconfidence is sufficiently low:

$$(1 + \theta) < \frac{2\sqrt{2\bar{u}\gamma}(1 + t)}{\Omega + \sqrt{2\bar{u}\gamma}}, \text{ where } \Omega \equiv \frac{\alpha^2}{\eta}Y^h + \delta v_i s d. \quad (\text{A.7})$$

Note that (A.7) implies that  $(1 + \theta) < 2(1 + t)$ , which ensures that there is an interior solution for the bonus (cf. eq. (A.6)). We assume that the fixed wage is used for any possible bonus tax (i.e.,  $t \geq 0$ ). This assumption can be derived by setting  $t = 0$  in eq. (A.7), and is given in eq. (13).

Case 2 holds for  $\frac{2\sqrt{2\bar{u}\gamma}(1+t)}{\Omega + \sqrt{2\bar{u}\gamma}} < (1 + \theta) < \frac{2\sqrt{2\bar{u}\gamma}(1+t)}{\Omega}$ . If overconfidence is very high,  $(1 + \theta) > \frac{2\sqrt{2\bar{u}\gamma}(1+t)}{\Omega}$ , the participation constraint does not bind and Case 3 holds.

## Appendix B. Optimal bonus tax

Substituting the bank's bonus  $z_B$  from eq. (15) and  $\frac{\partial z_B}{\partial t}$  into eq. (20), we get

$$\begin{aligned} \frac{\partial W}{\partial t} = & -\frac{2\gamma(1 + \theta)\Omega \frac{\alpha^2}{\eta}Y^h}{\Psi^2} + \frac{2\gamma^2(1 + \theta)^2\Omega^2}{\Psi^3} \\ & + (\lambda - 1) \left\{ \frac{(1 + \theta)\gamma^2\Omega^2[2 - (1 + \theta) - 2t]}{\Psi^3} + \frac{2\gamma(1 + \theta)\Omega\delta v_i s d}{\Psi^2} \right\}. \end{aligned} \quad (\text{B.1})$$

Collecting terms in eq. (B.1) gives

$$\begin{aligned} \frac{\partial W}{\partial t} = & \left[ \frac{(1 + \theta)\gamma^2\Omega}{\Psi^3} \right]^* \\ & \{-2[\Omega - \lambda\delta v_i s d][2(1 + t) - (1 + \theta)] + 2\Omega(1 + \theta) + (\lambda - 1)\Omega[2 - (1 + \theta) - 2t]\}. \end{aligned} \quad (\text{B.2})$$

Setting  $t = 0$  and summarizing terms in eq. (B.2), we get the first order condition at  $t = 0$ , as given in eq. (21).

Using the fact that  $\left[\frac{(1+\theta)\gamma^2\Omega}{\Psi^3}\right] > 0$  always holds, and collecting terms in (B.2), we find that

$$\text{sgn}\left\{\frac{\partial W}{\partial t}\right\} = \text{sgn}\{[2 - (1 + \theta)][2\lambda\delta v_i sd + (\lambda - 1)\Omega] + 4\Omega\theta + t[-2(1 + \lambda)\Omega + 4\lambda\delta v_i sd]\}. \quad (\text{B.3})$$

Eq. (B.3) shows that there is a corner solution (i.e.,  $\frac{\partial W}{\partial t} > 0 \forall t \geq 0$ ), if

$$\delta v_i sd > \frac{(\lambda + 1)\frac{\alpha^2}{\eta}Y^h}{(\lambda - 1)}. \quad (\text{B.4})$$

This condition implies that the last term in squared brackets in eq. (B.3) is positive. As all other terms in eq. (B.3) are positive as well, eq. (B.4) is thus a sufficient condition for a corner solution. Intuitively, this condition shows that if the risk-shifting incentives,  $\delta v_i sd$ , are very large, the government optimally chooses  $t^* \rightarrow \infty$  in order to minimize its bailout costs.

If eq. (22) holds, however, then there is an interior solution for the optimal bonus tax. Setting  $\frac{\partial W}{\partial t}$  in eq. (B.2) equal to zero, dividing both sides by  $\frac{(1+\theta)\gamma^2\Omega}{\Psi^3}$ , and solving for  $t$ , we get the optimal bonus tax in eq. (23). It's easy to show that eq. (22) implies that  $\frac{\partial W}{\partial t} > 0$  for  $0 \leq t < t^*$ , and that  $\frac{\partial W}{\partial t} < 0$  for  $t > t^*$ . Hence  $t^*$  in eq. (23) is a global maximum, if eq. (22) holds.

## Appendix C. Effect of overconfidence on the optimal bonus tax

The effect of overconfidence on the optimal tax is negative, if and only if simultaneously (i) the condition for an interior tax (cf. eq. (22)) holds, and (ii) the effect of  $\theta$  on  $t^*$  in (27) is negative. Solving (22) for  $\lambda$ , we get two cases:

$$\lambda < \frac{\frac{\alpha^2}{\eta}Y^h + \delta v_i sd}{\delta v_i sd - \frac{\alpha^2}{\eta}Y^h} \quad \text{if} \quad \delta v_i sd > \frac{\alpha^2}{\eta}Y^h, \quad (\text{C.1})$$

$$\lambda > \frac{\frac{\alpha^2}{\eta}Y^h + \delta v_i sd}{\delta v_i sd - \frac{\alpha^2}{\eta}Y^h} \quad \text{if} \quad \delta v_i sd < \frac{\alpha^2}{\eta}Y^h. \quad (\text{C.2})$$

## Case 1

For the effect of  $\theta$  on  $t^*$  to be negative in **Case 1** (i.e.,  $\delta v_i sd > \frac{\alpha^2}{\eta} Y^h$ ), (27) has to be negative and simultaneously (C.1) has to hold. These two conditions hold simultaneously if and only if

$$\frac{5(\frac{\alpha^2}{\eta} Y^h + \delta v_i sd)}{\frac{\alpha^2}{\eta} Y^h + 3\delta v_i sd} < \lambda < \frac{\frac{\alpha^2}{\eta} Y^h + \delta v_i sd}{\delta v_i sd - \frac{\alpha^2}{\eta} Y^h}. \quad (\text{C.3})$$

A necessary condition for (C.3) to hold is thus

$$\frac{5(\frac{\alpha^2}{\eta} Y^h + \delta v_i sd)}{\frac{\alpha^2}{\eta} Y^h + 3\delta v_i sd} < \frac{\frac{\alpha^2}{\eta} Y^h + \delta v_i sd}{\delta v_i sd - \frac{\alpha^2}{\eta} Y^h}.$$

This condition is satisfied for  $\delta v_i sd > \frac{\alpha^2}{\eta} Y^h$ , if and only if  $\delta v_i sd < 3\frac{\alpha^2}{\eta} Y^h$ . We have thus proven that the effect of overconfidence on the optimal bonus tax can never be negative, if the risk-shifting incentives are sufficiently strong as given by

$$\delta v_i sd > 3\frac{\alpha^2}{\eta} Y^h. \quad (\text{C.4})$$

Hence the effect of overconfidence on the optimal bonus tax is positive for any interior solution of  $t^*$ , if (C.4) holds. Eq. (C.4) does hold for an interior solution of the optimal bonus tax, if (C.4) and (C.1) hold simultaneously. This is the case, if

$$3\frac{\alpha^2}{\eta} Y^h < \delta v_i sd < \frac{\lambda + 1}{\lambda - 1} \frac{\alpha^2}{\eta} Y^h, \quad (\text{C.5})$$

which holds for a wide range of combinations of exogenous parameter values (e.g. it is always fulfilled for (C.4), if  $\lambda$  is sufficiently close to 1).

To summarize, **Case 1** proves that the effect of overconfidence on the optimal bonus tax is positive for any interior optimal bonus tax, if risk-shifting incentives are sufficiently strong (i.e., if eq. (C.4) holds). The strong risk-shifting incentives in (C.4) do not rule out an interior optimal bonus tax as shown by (C.5).

## Case 2

For the effect of  $\theta$  on  $t^*$  to be negative in **Case 2** (i.e.,  $\delta v_i sd < \frac{\alpha^2}{\eta} Y^h$ ), (27) has to be negative and simultaneously (C.2) has to hold. For  $\delta v_i sd < \frac{\alpha^2}{\eta} Y^h$ , the bonus tax is



always finite (i.e., (C.2) always holds). Hence, the condition for a negative effect of  $\theta$  on  $t^*$  in **Case 2** is the same as the condition for (27) to be negative, and given by

$$\lambda > \frac{5(\frac{\alpha^2}{\eta}Y^h + \delta v_i sd)}{\frac{\alpha^2}{\eta}Y^h + 3\delta v_i sd}. \quad (\text{C.6})$$

For  $\delta v_i sd < \frac{\alpha^2}{\eta}Y^h$ , (C.6) never holds if  $\lambda \leq 2.5$  and always holds if  $\lambda > 5$ . Hence a sufficient condition for the effect of  $\theta$  on  $t^*$  to be negative is given by

$$\delta v_i sd < \frac{\alpha^2}{\eta}Y^h \quad \wedge \quad \lambda > 5. \quad (\text{C.7})$$

## Appendix D. Socially optimal bonus

In the absence of bonus taxes, social welfare is the (weighted) sum of bank profit  $\Pi^* = p^{h^*}(Y^h - z) + p^{m^*}Y^m + p^{l^*}v_i sd - F - sd - (1 - s)d$ , actual manager utility  $u = p^{h^*}z + F - \frac{\eta e^{*2}}{2} - \frac{\mu b^{*2}}{2}$ , and the weighted bailout costs  $\lambda B = \lambda p^{l^*}v_i sd$ .

The social planner's maximization problem is then given by

$$\begin{aligned} \max_z W &= \Pi^* - \lambda B + u \\ &= p^{h^*}Y^h + p^{m^*}Y^m - p^{l^*}v_i sd(\lambda - 1) - \frac{\eta e^{*2}}{2} - \frac{\mu b^{*2}}{2} - (1 - s)d - sd. \end{aligned} \quad (\text{D.1})$$

Substituting eqs. (5), (6), and (7) into eq. (D.1), we get

$$\begin{aligned} W &= \gamma z(1 + \theta)Y^h + \left[ p_0^m - \frac{\beta}{\mu}z(1 + \theta) \right] Y^m - [p_0^l + \delta z(1 + \theta)] v_i sd(\lambda - 1) \\ &\quad - \frac{1}{2}\gamma z^2(1 + \theta)^2 - (1 - s)d - sd. \end{aligned} \quad (\text{D.2})$$

Deriving eq. (D.2) with respect to  $z$  gives

$$\frac{\partial W}{\partial z} = \gamma(1 + \theta)Y^h - \frac{\beta}{\mu}(1 + \theta)Y^m - \delta(1 + \theta)v_i sd(\lambda - 1) - \gamma z(1 + \theta)^2. \quad (\text{D.3})$$

As risk-taking is a mean-preserving spread, we can use  $\beta Y^h = Y^m$ . Setting (D.3) equal to zero, and solving for  $z$ , we get the socially optimal bonus in eq. (28).

The second order condition is given by

$$\frac{\partial^2 W}{\partial z^2} = -\gamma(1 + \theta)^2 < 0. \quad (\text{D.4})$$

## Appendix E. Internalized risk-shifting incentives

We can derive the bonus of a bank that fully internalizes the government's bailout costs by adding the term  $-\lambda p^{l*}v_i sd$  to the bank profit in eq. (12). Setting  $t = 0$ , the bank's maximization problem is then given by

$$\begin{aligned}
 \max_{z, F} \Pi^R &= p^{h*}(Y^h - z) + p^{m*}Y^m - F - (1 - s)d + p^{l*}v_i sd - sd - \lambda p^{l*}v_i sd \\
 s.t. \quad p^{h*} &= \gamma z(1 + \theta) \\
 p^{m*} &= p_0^m - \frac{\beta}{\mu} z(1 + \theta) \\
 p^{l*} &= p_0^l + \delta z(1 + \theta) \\
 \hat{u}^* &= \frac{\gamma}{2}(1 + \theta)^2 z^2 + F \geq \bar{u}.
 \end{aligned} \tag{E.1}$$

Solving the maximization problem in (E.1), we get the bonus of a bank that fully internalizes the government's bailout costs

$$z_{R|t=0} = \frac{\Omega - \lambda \delta v_i sd}{\gamma[2 - (1 + \theta)]}. \tag{E.2}$$

Eq. (E.2) shows that the internalisation of bailout costs indeed reduces the bank's bonus,  $z_{R|t=0}$ . Comparing this bonus to the socially optimal bonus, we get

$$z_{R|t=0} - z_{S|t=0} = \frac{\Omega - \lambda \delta v_i sd}{\gamma[2 - (1 + \theta)]} - \frac{\Omega - \lambda \delta v_i sd}{\gamma(1 + \theta)} = \frac{2\theta(\Omega - \lambda \delta v_i sd)}{\gamma[2 - (1 + \theta)](1 + \theta)}. \tag{E.3}$$

It follows from eq. (E.3) that the bank's bonus,  $z_{R|t=0}$ , equals the socially optimal bonus,  $z_{S|t=0}$ , only if the manager is rational ( $\theta = 0$ ). If the manager is overconfident  $\theta > 0$ , the bank's bonus will be higher than the socially optimal bonus. The reason is analogous to the argument why capital requirements alone cannot achieve the socially optimal bonus. If a bank internalizes the externalities of its risk-taking, then the bank chooses a lower bonus in order to reduce bailout costs. If the manager is overconfident, however, the participation constraint of a manager (cf. eq. (E.1)) provides an additional incentive for the bank to choose an excessive bonus in order to save compensation costs.

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