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ORIGINAL ARTICLE

Bonuses, options, and bank strategies

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Abstract

This study focuses on the management financial incentives that banking institutions adopt, with the purpose of best serving their corporate strategies. Specifically, a comparative study is carried out between medium- and long-term incentives, under the form of option-based pay, and short-term incentives, which take the form of bonus-based pay. Banking institutions should seek for the best balance between the two types of compensation, weighing their pros and cons under the specific market conditions they face. The paper advocates in favor of including the options modality in incentive packages, given that it stimulates the alignment of interests between owners and managers, allowing these last ones to act in an independent but responsible manner. Bonuses, in turn, require additional shareholders' supervision, which might be advantageous when the need to reverse harmful effects of poor performance arises. The developed theoretical model is complemented with two numerical exercises (one with simulated data and the other with real data) that corroborate the model's conjectures.

Keywords Management incentives · Managerial compensation · Banking sector · Bonus-based pay · Stock options

JEL Classification D82 · G20 · L10 · M20

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Introduction

This study examines the relationship between risk-taking and the compensation of managers in a specific sector where risk plays a fundamental role: the banking sector. Two types of incentives are compared: bonuses and options. Bonuses are a short-term form of incentive, whose application requires a close supervision by the shareholders to mitigate risk; options are a less conventional form of compensation, which is supposed to promote a long-term alignment of interests between shareholders and managers, but that can also pose risks, namely when agency conflicts are exacerbated.

The weight and influence of each type of incentive on bank risks is compared by reassessing the theoretical model of Cerasi and Oliviero (2015). This model was designed to assess and debate the role of bonuses in management incentives in the banking sector. In this paper, the framework is adapted to undertake a similar analysis in the case of options-based pay. The theoretical analysis is complemented with a couple of numerical examples (the first one using simulated data, and the second one resorting to real data) which confirm the arguments underlying the theoretical analysis, namely that banking institutions should seek the best combination between the two forms of compensation, giving special attention to how the use of options-based pay might potentiate a more effective outcome.

The starting point of our analysis is the observation that in modern corporations, in the banking sector as in other sectors, it is common to separate ownership and management. Where this is the case, the board of directors is the most common representative for the ownership of the corporation. The board of directors is responsible for developing the business strategy, approving an acceptable risk profile, and retaining management commensurate with the size, complexity, business plan, and risk profile of the institution. In this setting, payment regulation is an important tool of the shareholders' actions (Cvitanic and Zhang 2007; Cvitanic et al. 2014; Sung 2015; Loyola and Portilla 2023).

If the board of directors delegates the choice of the institution's strategy to the managers, agency problems can be mitigated through payment regulation. In fact, payment regulation is sufficient to avoid both types of risk shifting that may emerge, namely overinvestment in risk-enhancing strategies and underinvestment in strategies that reduce risk (Kolm et al. 2016). Therefore, the solution for the agency problem might be found in the setting of managerial incentives, but, in any case, monitoring measures on the principals' side must be adopted.

Management compensation tied to firm performance in its various forms, such as bonuses related to firm value, stock options, and equity plans, has become a standard instrument of managerial pay in all sectors, especially in banking. Indeed, much research has focused on how managerial pay schemes can help alleviate the agency problem in publicly traded companies (Bebchuk and Fried 2003). Despite the extensive debate and work on this subject, further understanding of the agency problem is required due to the complex and evolving business environment that firms face. In fact, there is still no consensus among experts in human resources, corporate governance, and academics on the issue of managers'

Table 1 Contributions of the option-based proposed model with respect to the Cerasi–Oliviero framework

Cerasi and Oliviero (2015) model	Contribution of the proposed model
Incentive type: **bonus**	Incentive type: **options**
+	+
Monitoring effort	Monitoring effort
+	⇓
Inspection effort	
⇓	
Results	Same or better results

This table shows the effectiveness of the options when compared to bonuses, as they save shareholders' supervision effort

pay, as remarked by Murphy (1998), Bebchuk and Fried (2003), John and Qian (2003), Wang and Singh (2014), and Jing and Zhang (2023). Thus, there is still room for further exploration of the topic at hand.

This study contributes to the literature that establishes a bridge between managers' incentives and their performance with respect to monitoring efforts (the role of managers is, in the case of the banking industry, essentially to monitor loans). Our main argument is that if the manager's incentive is options-based, this can trigger the same or a more beneficial effect than that provided by bonuses. Table 1 summarizes this improvement over the Cerasi–Oliviero framework.

The following findings are helpful when designing payment contracts for managers, and they will guide us throughout this study: (*i*) there is a positive and significant relationship between total manager pay and company performance measured by return on equity (ROE), and the payment policy for managers is a significant variable for understanding the banks' level of leverage (Jucá et al. 2012)[1]; (*ii*) the bonus has a very significant and positive pay-for-performance relationship in financial firms, which is potential evidence to support a correctly incentivized bonus scheme (Park 2010)[2]; (*iii*) payment programs for managers based on stocks and stock options assumed great importance even before the systemic crisis, from 2003 to 2006 (Jucá et al. 2012)[3]; and (*iv*) stock options are almost always part of the optimal contract; the optimal contract typically has option-like features over the most probable range of business outcomes (Armstrong et al. 2007).

The second finding above typically culminates in financial firms placing more emphasis on bonuses to reward better performance, as they benefit from high liquidity despite suffering from high volatility. This benefit is the main feature of the financial industry that allows it to use bonuses. In fact, when examining managerial

[1] For more details on this issue see Barton and Laux (2010), Sigler (2011), Bhagat and Bolton (2011), and Liu and Sickles (2021).

[2] Banks have significantly more leverage than other types of firms and this is an important distinguishing feature. In addition to conventional agency problems, these highly leveraged institutions are susceptible to risk-shifting agency issues.

[3] For more details on this finding see Doucouliagos et al. (2007), Barton and Laux (2010), and Bhagat and Bolton (2011).

pay, it is standard to either exclude the financial industry or to look at it separately due to the unique differences in asset types and industry characteristics. Thus, in complement to the Cerasi and Oliviero (2015) model, this study contributes to the discussion by taking an approach in which an alternative incentive pay is suggested based on the use of stock options. Given that the role of managers is essentially to monitor loans (Duarte et al., 2020), this exercise calls for long-term incentives for the manager. This aligns with the fourth finding above. The suggested incentive pay establishes the extent to which stock options could be used to maximize the manager's performance without harmful consequences to the firm.

Empirically, the revival of options incentives in detriment of bonuses was partially triggered by the aftermath of the 2007–2008 global financial crisis. A perception has been created that the bonus culture stimulated excessive risk-taking, and that this was the main reason behind the meltdown of financial markets worldwide and, consequently, also the ultimate cause of the government bailouts that followed. Notwithstanding, scholars do not agree on the extent in which bank compensation policies have constituted a fundamental seed of dystopia that precipitated the crisis (Conyon et al. 2013).

The remainder of this study is organized as follows. Sect. "Literature review" proceeds with a brief literature review. Sect. "The model" addresses the model. Sect. "Equilibrium bank risk and stock options" approaches the equilibrium bank risk when resorting to the stock options modality, and Sect. "Bonuses and options" compares the effects of bonuses and options. In Sects. "Application example" and "Empirical application", numerical examples are pursued to illustrate the mechanics of the model (the first example employs simulated data, and the second example uses real-world data from concrete financial institutions). Sect. "Conclusion" concludes.

Literature review

In every organization, principal–agent conflicts emerge whenever there is a need to recruit and retain skilled staff. The objectives of the company and the particular interests of the managers might not be coincidental, and often they are not, what suggests the need for a harmonization effort. The issue is particularly acute in scenarios in which the separation between ownership (personified in the board of directors) and management is explicit. Without sufficient financial and internal controls, moral hazard becomes a significant obstacle that can hamper the operation and evolution of the underlying business. An inadequate intervention by the board of directors may even intensify the agency problems and the associated information asymmetries (Handorf 2015; Podolski and Jiang 2022).

One potentially effective way of mitigating agency problems in the mentioned context is through incentive payment schemes. Well-designed incentive schemes might stimulate intra-entrepreneurship and refrain managers from overinvesting in excessively risky enterprises. Such packages may also assist in preventing underinvestment in strategies that reduce risk, although, in this case, they appear to be less efficacious (Kolm et al. 2016). Nevertheless, payment incentives are not a panacea

for every agency obstacle; monitoring measures are, in any case, required and must be implemented by the principal (i.e., the shareholder).

In managerial pay schemes, two variables play the main roles: on the one hand, the salary component is typically adjusted to meet the reservation utility and information rent, being positively correlated, over time, with formal skills and competencies. On the other hand, bonuses and other non-fixed incentives are employed to address information asymmetry issues, both moral hazard and adverse selection. Payment schemes assembled by shareholders should adequately balance fixed payments and performance stimuli, to bring closer together the interests of managers and shareholders (Bebchuk and Fried 2003; Banker et al. 2013; Eisdorfer et al. 2013; Lovett et al. 2022).

The agency problem, and the design of effective managerial payment packages to approach it, is particularly challenging in the banking sector. In this industry, one can identify a four-step agency chain, involving depositors, managers, the board of directors, and the shareholders. This chain originates a complex environment, involving multiple variables and the need for a variety of mechanisms of control and incentive schemes. Notwithstanding, as in any other business, the most relevant connection in the banking activity is, also, the one between shareholders and managers.

The banking sector has its own idiosyncrasies that make it difficult to examine managerial pay in the exact same terms as in other sectors. For instance, the asset types and the characteristics of the business have unique features. Specifically, regarding banks, one should note the following typical traits: (*i*) there is, pervasively, a split between ownership and control, which brings about specific agency problems provoked by the separation of the functions of risk-bearing and decision (Fama and Jensen 1983); (*ii*) managerial success and firm performance are closely linked (Guadalupe and Cuñat, 2004; Eisdorfer et al. 2013; Ahamed 2022); (*iii*) there is a need for discipline, in an area of business where profit maximization is often confronted with the need to serve the public interest and to run a safe business (Mehran and Molineaux 2012; Belasri et al. 2020); (*iv*) there are high cost attached to employee turnover (Ramlall 2003; Kurniawaty et al. 2019); and (*v*) the specificity of the reasons explaining the leveraging levels of banks, when compared with other kinds of organizations (Jucá et al. 2012; Acosta-Smith et al. 2023).

Despite its singularities, in the banking sector, payment packages associated with employment contracts are typically composed, as in any other firm, by the two earlier-mentioned components. Besides the fixed salary, there is a list of possible variable incentive payments, which include stock, options, and bonuses (Ilic and Lepojevic 2022). Stock and options may be grouped in what can be designated as equity-based pay (defined by Jucá et al. 2012, as any payment made to a manager, employer, or any other individual, based on the value of specific stock). Equity-based pay is, logically, an effective instrument in alleviating agency problems; it is straightforward to recognize that this type of incentive assists in stimulating the managers' intrapreneurship and corporatism (Chen et al. 2023).

Options are a viable form of equity-based pay. There is evidence pointing to a positive correlation between its use and firm performance, although some reservations emerged after the financial scandals that, one way or the other, have involved the exercise of options (Long and Musibau 2013; Collin et al. 2014; Swanepoel

2018). Such scandals have led to a decline in the use of options in payment packages, although its use remains noteworthy. Resorting to options in the mentioned context is attractive because it balances the behavior of the manager in favor of the best interest of the company. On the one hand, options are a good instrument to stimulate risk; on the other hand, they are capable of aligning the level of risk aversion of the manager with the interests of the capital owners (Ju et al. 2014).

Overall, including options in the payment scheme is beneficial because they offer the manager the incentive to formulate and implement plans that are in the best interest of the business (Berger et al. 1997; Carter and Lynch 2004; Muurling and Lehnert 2004; Bolton et al. 2010). Option-based compensation is also a relevant tool in fostering corporate innovation, given the stimuli it provides to managers to seek new sources of value (Mao and Zhang 2018; Biggerstaff et al. 2019; Canil and Karpavicius 2021; Cheng et al. 2023).

When empirically comparing the effectiveness of stock and options, Feltham and Wu (2001) highlight that stock is preferable in incentive plans in which the actions of managers do not have a significant effect on the firm's operating risk, whereas options are likely to generate better results in the opposite circumstance. Notwithstanding, one should bear in mind that when choosing the options modality, the managers will not have to support the potential downside risk. Furthermore, options pay tends to be not as transparent as pay through stock (Benz et al. 2001). In a competitive environment, without significant constraints on preferences and technology, Choe and Yin (2006) have demonstrated that option-based contracts are at least as effective as stock-based contracts. Further discussion on the options–stock debate can be found in Razul (2021).

One central element of the current study is yet another form of variable pay, namely bonuses. In Park (2010), it is emphasized that there is a meaningful and equal-sign relationship between bonus payments and performance. Such a relationship is observed in many sectors, including the banking sector. In fact, in the banking sector bonuses are often perceived as the most direct and easiest-to-implement type of managerial incentive. The potential drawback is that it is not always straightforward to establish a correct association between the reward via bonus and the true increment in performance and results. This association is much more direct and perceivable when the reward comes in the form of equity-based pay.

For the activity of banks, risk is a fundamental variable. Risk is also a central element in the choice of incentive payments for managers. Stock-based pay may divert the effort of managers toward low-risk suboptimal investment policies (Benmelech et al. 2010; Bolton et al. 2010; Cerasi and Oliviero 2015). Hence, to guarantee a sensible level of risk taken by managers, bonus policies might be, in some circumstances, more adequate than equity-based pay. There is an extensive research effort being pursued on the relationship between incentive pay and financial sector risk, which includes the studies by Barton and Laux (2010), Chan et al. (2013), Ju et al. (2014), Firestone and Wang (2014), Kohler (2015), Cerasi et al. (2020), Chu et al. (2020), and Carline et al. (2023). According to John et al. (2000), the sensitivity of the managerial performance in banks to the payment modality might be useful to assist the Federal Deposit Insurance Corporation (FDIC) in pricing insurance premiums and in designing regulations for financial institutions.

The next sections develop a model of banks' incentive pay that compares the effectiveness of the use of stock options against the use of bonuses in addressing the issue of the managers' payment portfolio.

The model

This study builds upon the Cerasi and Oliviero (2015) model and uses stock options instead of bonuses to assess how they change the implications of the model.

Begin by considering a bank holding a portfolio of size L of risky loans with perfectly correlated returns. Each loan has a return $z_i > 1$, such that $\Sigma z_i = z > 1$, although loan losses, l, occur with probability q. Thus, the portfolio returns $(z - l)L$ with probability q, and zL otherwise. The returns are fully observable by third parties. The bank collects funds from wealthy and varied investors whose alternative return on their capital is 1. Assume that all agents are risk neutral.

At date $t = 0$, bank shareholders, owning capital e, collect deposits d and extend loans L. Depositors are fully insured. Hence, each unit of deposit bears zero risk premium. Given the presence of the deposit insurance, the income of the loan portfolio is divided as follows: when the portfolio is successful, it returns zL, and what remains, after depositors are repaid the promised amount d, goes to bank shareholders. When loan losses are realized and the portfolio returns $z - l < d$, all the income goes to the deposit insurance fund that repays depositors d, leaving bank shareholders without any income.

Assume that the deposit insurance premium is fully funded through taxpayers' money and that bank shareholders cannot foresee it. The number of insured deposits that the bank will be able to collect is given by the bank's balance sheet at time $t = 0$,

$$L = e + d. \tag{1}$$

In what follows, assume that there is a capital ratio ρ imposed by the regulator requiring a minimum of capital for each unit of loans, so that $L \leq \frac{e}{\rho}$. Loans can be directly monitored by exerting a level of effort $m \in [0, 1]$ at a private cost $\frac{c}{2}m^2$, with $c \geq 0$. Monitoring serves the purpose of reducing the probability of losses from q_H to q_L, with $0 \leq q_L < q_H < 1$. Assume that $z - q_H l < 1 < z - q_L l - \frac{c}{2}$.

The above conditions imply that only monitored loans are worth financing. When loans are monitored, they have a positive net present value; hence, the size of the bank is limited by its minimum capital ratio. Assume that shareholders delegate the task of monitoring loans to a bank manager. Monitoring cannot be observed but has the (private) cost $\frac{c}{2}m^2$. Despite this, the bank manager cannot shirk this duty because his / her incentive package is reflected in the shareholders' earnings.

In the case of bonuses, shareholders can inspect the activity of the bank manager with intensity $s \in [0, 1]$ at a specific (private) cost. As a result of this scrutiny, shareholders could decide to dismiss the manager and replace him/her with another manager. However, the alignment provided by the options will force the manager to exert an independent monitoring effort to raise the value of stocks to a level at which

(s)he can exercise the options favorably, before the date of their expiration. Thus, the shareholders' inspection effort is offset by the effect of the option-based incentive package.

The internal effort of the activity of monitoring the loan portfolio cannot be observed by outsiders of the bank but it is privately costly for the party in charge, causing a moral hazard problem. However, the impact of monitoring the loans affects the probability of losses q. The specific value of this probability must be derived from the optimum choice of effort of the bank manager.

Summarize the timing of events on three dates, $t = 0, 1, 2$, as follows:

- At $t = 0$, bank shareholders with capital e collect insured deposits d and lend L, and they also hire a manager to monitor loans.
- At $t = 1$, the bank manager must exert a monitoring effort with intensity m to reduce expected loan losses, aligning his / her interests with those of shareholders. Due to the nature of the incentive pay, shareholders do not need to inspect the manager.
- At $t = 2$, the loans return a revenue, and the income is shared among the parties.

At date $t = 0$, the managerial pay is disclosed to all third parties. Depositors are insured and minimum capital requirements are in place. Effort choices are not observable, while returns from projects are observable to outsiders. This timing of events implies that outsiders can observe the managerial pay but cannot infer the insiders' actual effort-level choices. The model is solved in reverse: equilibrium efforts and returns are computed for a given managerial payment.

Equilibrium bank risk and stock options

Unlike Cerasi and Oliviero (2015), who focus on bonuses as the source of managerial compensation, this section concentrates attention on stock options. The bank manager, whose choice of effort responds to monetary incentives, is offered monetary pay, namely the sum of a fixed salary, b, and β stock call options on the rising equity resulting from successful portfolios. For convenience, assume that the fixed salary component is paid out in the bank's operating cash flow such that the terminal cash flow is residual to the fixed payment, b, to the manager. This means that the fixed salary is set equal to zero for the sake of simplicity. Hence, the bank manager is granted $\beta \in (0, 1)$ stock options with an exercise price x.

Since options are equity-based and part of a long-term incentive package, they produce post-exercise effects within the exercise period only. However, the bank manager knows that (s)he needs to exert a monitoring effort to make the portfolio successful so that it can be beneficial to him/her, and that effort produces results normally evaluable at $t = 2$. Thus, there is an alignment of shareholders' and manager's interests. This fact relaxes the need for internal supervision by shareholders and guarantees that the manager is not dismissed, unless (s)he has no ambition to grow his/her own earnings. This goes against human nature and so it can be ignored, as

it can be ignored, as well, the doubt about the manager's abilities; hence, the moral hazard is much reduced.

The stock options represent the variable component of the managerial pay and, given that they are tied to a good performance of the loan portfolio, they can be interpreted as a "pay-for-performance" scheme. The shareholders use the average level of income to measure the performance, in line with their expectations. Thus, shareholders will not fire the incumbent manager unless the portfolio losses are visible and (s)he fails to reach that average level of expected income. In this case, the new bank manager is offered the same incentive package and shareholders will benefit from firing the incumbent bank manager only in the next investment cycle.

As a result of the exemption from inspection by shareholders, the inspection-related parameters taken in Cerasi and Oliviero (2015) model are set to null, what simplifies the following equation, which solves for the monitoring effort as a fixed point of the best reply functions,

$$q(m) = mq_L + (1-m)q_H = q_L + (1-m)\Delta = q_H - m\Delta, \tag{2}$$

with $\Delta = q_H - q_L$. The probability of losses is q_L, when the bank manager exerts effort.

Bank managerial pay

Given the bank shareholders' limited liability, in the event that the loan portfolio falls short due to losses, the deposit insurance repays insured depositors the entire face value d. Hence, the expected profit of the bank can be deduced as follows:

$$tcf = \big[1 - q(m)\big](zL - d), q(m) \in \big[q_L, q_H\big], \tag{3}$$

with $q(m)$ as defined in Eq. (2). This produces the following income,

$$y_0 = tcf - e = \big[1 - q(m)\big](zL - d) - e. \tag{4}$$

Because of the minimum capital requirements, the income to distribute can be expressed as

$$y_1 = (1-\rho)\big\{\big[1 - q(m)\big](zL - d) - e\big\}. \tag{5}$$

Hence, for a given managerial incentive pay β, the expected utility of the incumbent bank manager becomes

$$y_m = \beta(1-\rho)\big\{\big[1 - q(m)\big](zL - d) - e\big\} - \frac{c}{2}m^2L, \tag{6}$$

while the shareholders income is:

$$s_h = (1-\beta)(1-\rho)\big\{\big[1 - q(m)\big](zL - d) - e\big\} + \frac{c}{2}m^2L. \tag{7}$$

The relationship of the probabilities for Eqs. (4), (5), and (7) can be visualized in Fig. 1.

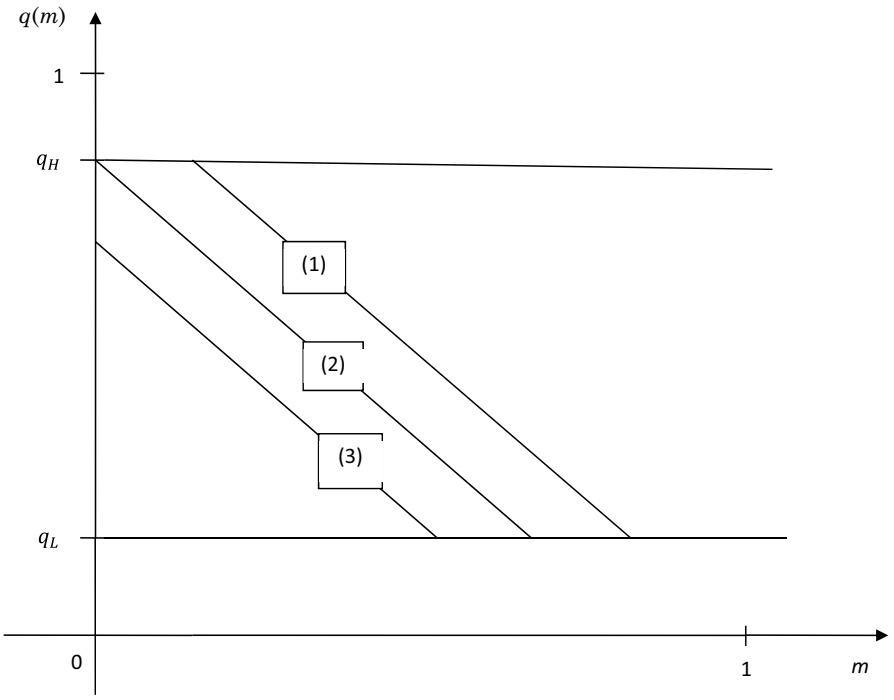

Fig. 1 Relationship between q and m. This figure depicts, from top to bottom, the parallel probability lines (1) of the expected profit of bank, $1 - q(m)$; (2) of the income to be shared, with the minimum capital requirements in place, $(1 - \rho)[1 - q(m)]$; and (3) of the shareholders' income, $(1 - \beta)(1 - \rho)[1 - q(m)]$

Because of the linearity of Eq. (3), $q(m)$ has a direct decreasing effect on $y_{0,}$ y_1, and s_h. Hence, because m has a decreasing effect on $q(m)$, then m has an increasing impact over variables $y_{0,}$ y_1, and s_h. Concerning y_m, through the first derivative of Eq. (6) one verifies that the best reply function of the bank manager utility in terms of monitoring, m, is the solution to $\frac{dy_m}{dm} = \beta\Delta(1 - \rho)(zL - d) - cmL = 0$, i.e.,

$$m = \frac{\beta\Delta(1 - \rho)(zL - d)}{cL}. \tag{8}$$

If c, Δ, ρ, z, d, and L are known, the m variation in its interval makes it possible to establish the corresponding relationship with β that helps to extract the best corresponding volume of options as

$$\beta = \frac{cmL}{\Delta(1 - \rho)(zL - d)}. \tag{9}$$

Equation (8) indicates that the monitoring effort m of the bank manager increases with β granted stock options, and Eq. (9) indicates that the granted stock options β increase with the monitoring effort m of the bank manager, in order to minimize losses. The suitable interval for both m and β is [0,1]. However, setting

Table 2 m explained by β (Eq. 7)

L	d	e	Δ	ρ	c	β	m
1000	800	200	0.6	0.1	0.1	**0**	**0**
1000	800	200	0.6	0.1	0.1	**0.1**	**0.324**
1000	800	200	0.6	0.1	0.1	**0.2**	**0.648**
1000	800	200	0.6	0.1	0.1	**0.3**	**0.972**
1000	800	200	0.6	0.1	0.1	0.4	1.296
1000	800	200	0.6	0.1	0.1	0.5	1.62
1000	800	200	0.6	0.1	0.1	0.6	1.944
1000	800	200	0.6	0.1	0.1	0.7	2.268
1000	800	200	0.6	0.1	0.1	0.8	2.592
1000	800	200	0.6	0.1	0.1	0.9	2.916
1000	800	200	0.6	0.1	0.1	1	3.24

This table simulates the monitoring effort m limits according to the granted options portion β, under certain conditions (known values for L, d, e, Δ, ρ and c). In this example, the monitoring effort, m, requires the options portion, β, not to be much higher than 0.3

Table 3 β explained by m (Eq. 8)

L	d	e	Δ	ρ	c	m	β
1,000	800	200	0.6	0.1	0.1	**0**	**0**
1,000	800	200	0.6	0.1	0.1	**0.03**	**0.1**
1,000	800	200	0.6	0.1	0.1	**0.06**	**0.2**
1,000	800	200	0.6	0.1	0.1	**0.09**	**0.3**
1,000	800	200	0.6	0.1	0.1	**0.12**	**0.4**
1,000	800	200	0.6	0.1	0.1	**0.15**	**0.5**
1,000	800	200	0.6	0.1	0.1	**0.19**	**0.6**
1,000	800	200	0.6	0.1	0.1	**0.22**	**0.7**
1,000	800	200	0.6	0.1	0.1	**0.25**	**0.8**
1,000	800	200	0.6	0.1	0.1	**0.28**	**0.9**
1,000	800	200	0.6	0.1	0.1	**0.31**	**1**

This table simulates the β limits for the monitoring effort m, under certain conditions (known values for L, d, e, Δ, ρ and c). In this example the maximum of the options portion, $\beta = 1$, needs the toughest monitoring effort $m = 0.31$

β without criteria (eventually leading to relatively high values of β), means that m can move out of its suitable interval before reaching the optimum, thus reducing the effectiveness of the monitoring effort (see Table 2). Parameter β has a positive correlation with the monitoring effort m that makes it possible to set the highest suitable value for β. One example of this relationship can be seen in Table 3, as well as in the numerical examples further below (Sects. "Application example" and "Empirical application"). An example of the behavior of variables m, y_0, y_1,

Table 4 Simulation of results

L	d	e	q_L	q_H	z	m	$q(m)$	tcf	y_0	ρ	y_1	β	c	y_m	s_h
1,000	800	200	0.2	0.8	1.5	0	0.8	140	− 60	0.1	− 54.0	0.1	0.1	− 5.40	− 48.60
1,000	800	200	0.2	0.8	1.5	0.1	0.74	182	− 18	0.1	− 16.2	0.1	0.1	− 2.12	− 14.08
1,000	800	200	0.2	0.8	1.5	0.2	0.68	224	24	0.1	21.6	0.1	0.1	0.16	21.44
1,000	800	200	0.2	0.8	1.5	0.3	0.62	266	66	0.1	59,4	0.1	0.1	1.44	57.96
1,000	800	200	0.2	0.8	1.5	**0.4**	**0.56**	**308**	**108**	0.1	**97.2**	0.1	0.1	**1.72**	**95.48**
1,000	800	200	0.2	0.8	1.5	0.5	0.5	350	150	0.1	135.0	0.1	0.1	1.00	134.00
1,000	800	200	0.2	0.8	1.5	0.6	0.44	392	192	0.1	172.8	0.1	0.1	− 0.72	173.52
1,000	800	200	0.2	0.8	1.5	0.7	0.38	434	234	0.1	210.6	0.1	0.1	− 3.44	214.04
1,000	800	200	0.2	0.8	1.5	0.8	0.32	476	276	0.1	248.4	0.1	0.1	− 7.16	255.56
1,000	800	200	0.2	0.8	1.5	0.9	0.26	518	318	0.1	286.2	0.1	0.1	− 11.88	298.08
1,000	800	200	0.2	0.8	1.5	1	0.2	560	360	0.1	324.0	0.1	0.1	− 17.60	341.60

This table simulates results for an expectation of $z=1.5$. Under these conditions (given values for L, d, e,q_L,q_H, ρ, β and c), the table shows the results for m, $q(m)$, tcf,y_0,y_1,y_m, ands_h. Value $\beta=0.1$ optimizes y_m with a monitoring effort $m=0.4$

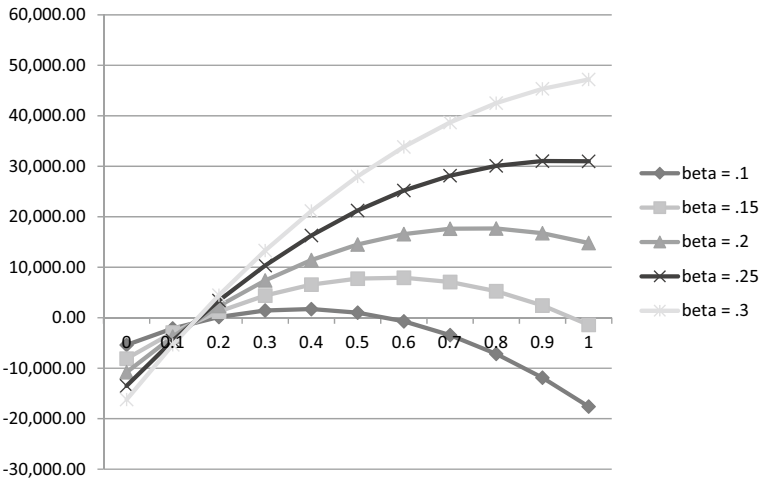

Fig. 2 Manager incentives (y_m). This graph depicts the manager incentives influenced by the β values, where the maximum is reachable for β values lower than 0.3, when m varies from 0 to 1, based on the values in Table 4

y_m, and s_h can be observed in Table 4 and in Figs.2 and 3 (the money values in the tables are supposed to represent thousands of dollars).

From the manager's perspective, examples summarized in the various panels of Table 5, 6, 7, 8 explain the behavior of the manager's incentive. Note that β has an uncertain effect on the probability of loan losses q, in that the manager might take more risks. Figures 2 and 3 illustrate how the increase in β is beneficial for the manager when moving the best m from 0 to 1. They also illustrate how

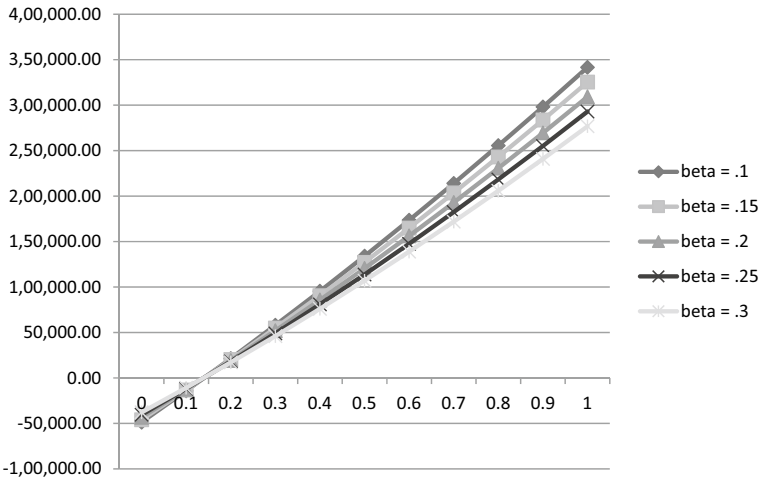

Fig. 3 Shareholders' income (s_h). This graph depicts the shareholders' income according to the corresponding β values, used in Fig. 2, when m varies from 0 to 1

Table 5 Results for $z = 1.5$

β	m	0.1	0.15	0.2	0.25	0.3
y_m	**0**	− 5.40	− 8.10	− 10.80	− 13.50	− 16.20
	0.1	− 2.12	− 2.93	− 3.74	− 4.55	− 5.36
	0.2	0.16	1.24	2.32	3.40	4.48
	0.3	1.44	4.41	7.38	10.35	13.32
	0.4	**1.72**	6.58	11.44	16.30	21.16
	0.5	1.00	7.75	14.50	21.25	28.00
	0.6	− 0.72	**7.92**	16.56	25.20	33.84
	0.7	− 3.44	7.09	17.62	28.15	38.68
	0.8	− 7.16	5.26	**17.68**	30.10	42.52
	0.9	− 11.88	2.43	16.74	**31.05**	45.36
	1	− 17.60	− 1.40	14.80	31.00	**47.20**
s_h	**0**	− 48.60	− 45.90	− 43.20	− 40.50	− 37.80
	0.1	− 14.08	− 13.27	− 12.46	− 11.65	− 10.84
	0.2	21.44	20.36	19.28	18.20	17.12
	0.3	57.96	54.99	52.02	49.05	46.08
	0.4	**95.48**	90.62	85.76	80.90	76.04
	0.5	134.00	127.25	120.50	113.75	107.00
	0.6	173.52	**164.88**	156.24	147.60	138.96
	0.7	214.04	203.51	192.98	182.45	171.92
	0.8	255.56	243.14	**230.72**	218.30	205.88
	0.9	298.08	283.77	269.46	**255.15**	240.84
	1	341.60	325.40	309.20	293.00	**276.80**

Table 6 Results for $z = 1.4$

β	m	0.1	0.15	0.2	0.25	0.3
y_m	**0**	− 7.20	− 10.80	− 14.40	− 18.00	− 21.60
	0.1	− 4.46	− 6.44	− 8.42	− 10.40	− 12.38
	0.2	− 2.72	− 3.08	− 3.44	− 3.80	− 4.16
	0.3	− 1.98	− 0.72	0.54	1.80	3.06
	0.4	− 2.24	0.64	3.52	6.40	9.28
	0.5	− 3.50	**1.00**	5.50	10.00	14.50
	0.6	− 5.76	0.36	**6.48**	12.60	18.72
	0.7	− 9.02	− 1.28	6.46	14.20	21.94
	0.8	− 13.28	− 3.92	5.44	**14.80**	24.16
	0.9	− 18.54	− 7.56	3.42	14.40	25.38
	1	− 24.80	− 12.20	0.40	13.00	**25.60**
s_h	**0**	− 64.80	− 61.20	− 57.60	− 54.00	− 50.40
	0.1	− 35.14	− 33.16	− 31.18	− 29.20	− 27.22
	0.2	− 4.48	− 4.12	− 3.76	− 3.40	− 3.04
	0.3	27.18	25.92	24.66	23.40	22.14
	0.4	59.84	56.96	54.08	51.20	48.32
	0.5	93.50	**89.00**	84.50	80.00	75.50
	0.6	128.16	122.04	**115.92**	109.80	103.680
	0.7	163.82	156.08	148.34	140.60	132.86
	0.8	200.48	191.12	181.76	**172.40**	163.04
	0.9	238.14	227.16	216.18	205.20	194.22
	1	276.80	264.20	251.60	239.00	**226.40**

β values above 0.3 in the example make m values unsuitable within the interval [0,1], i.e., the best m value falls out of the interval. This unfeasibility can be better understood by looking at Fig. 2, that depicts the manager's incentive, where β values higher than 0.3 move the optimum (maximum) m out of the interval [0,1]. In contrast, from the shareholders' perspective, the unfeasibility can be better understood by looking at Fig. 3, that depicts the shareholders' income s_h, where the higher the β, the lower the income.

In addition, β also influences the length of the interval $[q_L, q_H]$: the larger the value of β, the larger also is the length of the interval. While β only has a decreasing effect on the shareholders' income, for fixed and adequate values, its dilution effect makes the benefit for the manager initially increase with the monitoring effect m, attain a maximum at a specific level, and then decrease. This decreasing interval for the incentive pay fades away for values above the optimum β.

There is a critical point for m, in which all manager incentive trajectories cross, as do shareholders' income trajectories, regardless of β values. For this critical m value, the income y is null, the manager's incentive is negative, and the shareholders' income is positive and symmetrical to the manager's negative incentive value because it accurately reflects the minimum monitoring effort so as to avoid losses. This critical m value is provided by the following equation,

Table 7 Results for $z = 1.3$

β	m	0.1	0.15	0.2	0.25	0.3	0.35	0.4
y_m	0	− 9.00	− 13.50	− 18.00	− 22.50	− 27.00	− 31.50	− 36.00
	0.1	− 6.80	− 9.95	− 13.10	− 16.25	− 19.40	− 22.55	− 25.70
	0.2	− 5.60	− 7.40	− 9.20	− 11.00	− 12.80	− 14.60	− 16.40
	0.3	− 5.40	− 5.85	− 6.30	− 6.75	− 7.20	− 7.65	− 8.10
	0.4	− 6.20	− 5.30	− 4.40	− 3.50	− 2.60	− 1.70	− 80
	0.5	− 8.00	− 5.75	− 3.50	− 1.25	1.00	3.25	5.50
	0.6	− 10.80	− 7.20	− 3.60	0.00	3.60	7.20	10.80
	0.7	− 14.60	− 9.65	− 4.70	**0.25**	5.20	10.15	15.10
	0.8	− 19.40	− 13.10	− 6.80	− 0.50	**5.80**	12.10	18.40
	0.9	− 25.20	− 17.55	− 9.90	− 2.25	5.40	**13.05**	20.70
	1	− 32.00	− 23.00	− 14.00	− 5.00	4.00	13.00	**22.00**
s_h	0	− 81.00	− 76.50	− 72.00	− 67.50	− 63.00	− 58.50	− 54.00
	0.1	− 56.20	− 53.05	− 49.90	− 46.75	− 43.60	− 40.45	− 37.30
	0.2	− 30.40	− 28.60	− 26.80	− 25.00	− 23.20	− 21.40	− 19.60
	0.3	− 3.60	− 3.15	− 2.700	− 2.25	− 1.80	− 1.35	− 0.90
	0.4	24.20	23.30	22.40	21.50	20.60	19.70	18.80
	0.5	53.00	50.75	48.50	46.25	44.00	41.75	39.50
	0.6	82.80	79.20	75.60	72.00	68.40	64.80	61.20
	0.7	113.60	108.65	103.70	**98.75**	93.80	88.85	83.90
	0.8	145.40	139.10	132.80	126.50	**120.20**	113.90	107.60
	0.9	178.20	170.55	162.90	155.25	147.60	**139.95**	132.30
	1	212.00	203.00	194.00	185.00	176.00	167.00	**158.00**

Table 8 The approximations (m) vs the best (m^*) monitoring efforts

z	β	m	m^*
1.5	0.1	0.4	0.378
1.5	0.15	0.6	0.567
1.5	0.2	0.8	0.756
1.5	0.25	0.9	0.945
1.4	0.15	0.5	0.486
1.4	0.2	0.6	0.648
1.4	0.25	0.8	0.810
1.3	0.25	0.7	0.675
1.3	0.3	0.8	0.810
1.3	0.35	0.9	0.945

$$m = \frac{e - (1 - q_H)(zL - d)}{(q_H - q_L)(zL - d)}. \tag{10}$$

Other causal relationships that can be read from Eqs. (5) and (7) are that:

i. The probability of loan losses q decreases with a larger capital ratio ρ; and
ii. In a bank with a larger capital ratio ρ, a larger incentive β is more effective in reducing the probability of loan losses q.

Conditions (*i*) and (*ii*) were proved in the Cerasi and Oliviero (2015) model. The relationship (*ii*) is equally valid using stock options.

Risk-sensitive deposit insurance

When the deposit insurance premium is charged to the bank at date $t = 0$, there is an additional countervailing effect: the larger managerial incentive will have an expected impact on the risk through the deposit insurance premium. Assuming that the bank shareholders pay a fair premium to the deposit insurance at date $t = 0$ to refund depositors for the expected shortfalls on the face value of their deposits, one has the following premium deposit insurance:

$$\pi = q(m)[d - (z - l)L]. \tag{11}$$

Hence, the bank's balance sheet at date $t = 0$ is given by:

$$e + d = \pi + L. \tag{12}$$

Therefore, an increase in the managerial incentive can be even more beneficial than initially expected. However, when larger β options have the effect of increasing the bank risk, a risk-sensitive deposit insurance premium might exacerbate the negative effect. In fact, a risk-sensitive premium reacts to the increase in risk by reducing the stake of revenues from loans retained by shareholders. Under these conditions, Eq. (2) remains unchanged, but the following equations, (4)–(9), are subject to changes emerging from replacing L with $\pi + L$.

Bonuses and options

A quick look at the results from Eqs. (4) to (8) allows us to compare them with the results of the Cerasi and Oliviero (2015) model, and draw the following conclusions:

i. While bonuses create conflicts of interest between managers and shareholders and require shareholders to make an additional inspection of the managers' activities, options establish an alignment of interests between the parties. In this case, because of the convergence of interests, shareholders do not need to inspect the manager's effort. When this is the case, the criteria for firing the manager are also different. Whereas with bonuses the manager can be dismissed at any time, with stock options the manager is safe in that (s)he can only be fired after the loans' maturation (because the moral hazard is minimized). So, instead of firing, the options can serve as a retention strategy for the manager, especially when managers can be swayed by competitors.

ii. As a result of the exemption from inspection by shareholders, Eq. (2) from the Cerasi and Oliviero (2015) model is simplified to Eq. (2) in this model; this means that, compared to options, bonuses have a lowering effect on the income expectations by reducing $q(m)$, and they also lower the actual inspection cost.
iii. As a result of the inspection by shareholders, bonuses have an immediate effect in that they are short-term incentive pay. In contrast, as long-term incentive pay, options cause a delayed effect because of their maturity period, thus granting stability conditions.
iv. However, in the case of the manager's poor performance, bonuses may have an advantage over the stock options because they allow immediate intervention in order to reverse the harmful effects of such inadequate performance.

The next two sections provide numerical examples that allow to illustrate and support the previously presented arguments. The first example employs simulated data; the second example resorts to real-world data from banks in Australia and the United Kingdom (U.K.), to show that the reasoning associated with the model has practical relevance.

The banking activity of the two above-mentioned countries is regulated by the Financial Stability Board (FSB), an international institution that is committed to regulatory initiatives aiming at improving the stability of financial systems. In its report, compensation at significant financial institutions is among the many factors that contributed to the financial crisis that began in 2007, because high short-term profits led to generous bonus payments to employees without paying due attention to the long-term risks that they imposed on their companies' workers.

The Financial Stability Board Principles (FSB Principles) for Sound Compensation Practices and their Implementation Standards (Principles and Standards, P&S) were developed in 2009 to align compensation with prudent risk-taking, particularly at significant financial institutions, including U.K. and Australian banks. The aim of these standards is to enhance the stability and robustness of the financial system.

One of the P&S is related to the implementation of a bonus ceiling, which was generally set at 100% of the base salary, and could rise up to 200% in particular and specific cases, mainly in European countries (E.U.), although with adaptations in each country according to its specificities. However, the effect of a bonus cap on risk transfer is mixed if the labor market adjusts, while its impact on efficiency is ambiguous as it leads to underinvestment and consequently has an inversely proportional effect on base salary level (Asai 2016). Probably as a result, it is in the process of being abandoned by U.K. banks in the context of BREXIT, to increase their competitiveness.

However, this is a subject that is not exhausted and is still being discussed in Australia, where, under the pressure of the banking industry, the Australian Prudential Regulatory Authority (APRA) abandoned its previous position that the proportion of banker bonuses that can come from financial performance should be capped at 50%. The same discussion is ongoing in the U.K., on the basis of which the Prudential Regulation Authority (PRA) plans to eliminate poorly

designed E.U. rules that limit variable pay for senior bankers, undermine growth, and hinder financial stability, while pay in bonuses aligns the incentives of individuals with those of the bank, in turn supporting growth in the UK economy.

Application example

The example in this section uses simulated data in a very simplified context (again, values are in thousands of dollars). Imagine that at $t = 0$ a bank engages in a loan $L = 1000$ (equity: $e = 200$; liabilities: $d = 800$) with a capital ratio $\rho = 10$ percent. Suppose that at $t = 1$ the manager exerts a monitoring effort m that must be at least $q_L = 0.2$ and at most $q_H = 0.8$. Where the optimal m is not defined, set the average $m = 0.5(q_L + q_H)$. Additionally, set $c = 0.1$, and $\beta = 0.2$. Because of the risk neutrality of shareholders that sets the discount rate to zero, in this case it holds true that $f = d = 800$.

Within this framework, the following results are obtained:

- Probability of loan losses:
$$q(m) = q_H - m\Delta = 0.8 - 0.5 \times (0.8 - 0.2) = 0.5.$$

- Terminal cash flow:
$$tcf = \big[1 - q(m)\big](zL - d) = 0.5 \times 600 = 300.$$

- Increment in equity:
$$y_0 = \Delta e = tcf - e = 300 - 200 = 100.$$

- Income after deducting the minimum capital requirements:
$$y_1 = (1 - \rho)\Delta e = 0.9 \times 100 = 90.$$

- Management incentive pay:
$$y_m = \beta y_1 - \frac{c}{2}m^2 L = 0.2 \times 90 - 12.5 = 5.5.$$

- Shareholders' profit after dividends:
$$s_h = (1 - \beta)y_1 + \frac{c}{2}m^2 L = 0.8 \times 90 + 12.5 = 84.5.$$

However, seeking the manager's optimum incentive pay for this volume of granted options, $\beta = 0.2$, and following the same procedure, the most suitable monitoring effort amounts to,

$$m^* = \frac{\beta\Delta(1-\rho)(zL-d)}{cL} = \frac{0.2\times 0.6\times 0.9\times 600}{0.1\times 1000} = 0.648.$$

With this value of m^*, the following results are obtained:

- Probability of loan losses:

$$q(m^*) = q_H - m^*\Delta = 0.8 - 0.648\times(0.8-0.2) \approx 0.4112.$$

- Terminal cash flow:

$$tcf = \left[1 - q(m^*)\right](zL-d) = 0.5888\times 600 = 353.28.$$

- Increment in equity:

$$y_0 = \Delta e = tcf - e = 353.28 - 200 = 153.28.$$

- Income after deducting the minimum capital requirements:

$$y_1 = (1-\rho)\Delta e = 0.9\times 153.28 = 137.952.$$

- Management incentive pay:

$$y_m = \beta y_1 - \frac{c}{2}(m^*)^2 L = 0.2\times 137.952 - 20.9952 = 6.5952.$$

- Shareholders' profit after dividends:

$$s_h = (1-\beta)y_1 + \frac{c}{2}(m^*)^2 L = 0.8\times 137.952 + 20.9552 = 131.3568.$$

Obviously, this last procedure generates better results, and it will be the manager's preference.

Empirical application

The application example in the previous section resorted to simulated data to illustrate the arguments that were set forth throughout the study. To get further insights, this additional section applies the model directly to empirical data. This application confirms, once more, the thesis underlying the developed theoretical framework.

The collected data relates to fiscal years 2005 and 2015, that span the global financial crisis, a period that is considered a natural experiment for the study of banking institutions (Abreu et al. 2019), and was extracted from the analysis of the managerial reports of the one hundred largest banks in the world in the year 2017. From the mentioned reports, information on the use of managerial financial incentives has been gathered. Only a fraction of the financial institutions has reported the use of incentives (bonuses, options, or both), as indicated in Table 9.

Table 9 Number of banks reporting the use of managerial incentives

Fiscal year	# Banks	Bonuses	Options
2005	26	14	12
%	100	53.85	46.15
2015	23	15	8
%	100	65.22	34.78

Figure in the table correspond to the number of banks, within the largest 100 banks in the world, that report some kind of managerial incentive (bonuses or options)

From 2005 to 2015, the number of institutions resorting to bonuses increased slightly, from 14 to 15, while the number of banks opting for options fell from 12 to 8, suggesting a greater sensibility of options to the market instability.

In Table 10, relevant financial data are presented for seven of the banks composing the sample of large financial institutions that have disclosed the use of managerial paying incentives. This data is presented for three Australian banks and for four banks from the United Kingdom.

According to the data in Table 10, in 2015 four of the seven banks selected for the analysis granted bonuses, four of them granted options, and one granted both incentives. Although in 2015 there was a notable drop in the use of incentives in general, in both years, the predisposition to grant bonuses is similar to that of granting options, which prevents highlighting any preference of these banks for either of these two modalities of incentives. According to the respective managerial reports, at least the most standardized banks use these long- and short-term incentives indiscriminately, and this study aims at demonstrating that they are not necessarily making management errors.

Let us now proceed to the application of the above data to the developed model. The example uses data from the Commonwealth Bank of Australia report in year 2005, with a capital ratio $\rho = 7\%$, and from the Lloyds Banking Group report in year 2015, with a capital ratio $\rho = 9\%$, in a very simplified context. These banks were randomly chosen from the above group of seven banks. The capital ratios were fixed to meet the requirement of a minimum of capital for each unit of loan, to satisfy $L \leq \frac{e}{\rho}$. In everything else we use the same assumptions, specifically supposing that at $t = 1$, the manager exerts a monitoring effort m that must be at least $q_L = 0.2$ and at most $q_H = 0.8$, setting the average $m = 0.5(q_L + q_H)$, where the optimal m is not defined. Additionally, set $c = 0.1$, and $\beta = 0.2$. These two parameters have an opposite effect. While an increase in β is directly proportional to the management incentive pay, the increase in the cost of monitoring c decreases proportionally to the management incentive pay.

For the case of the Commonwealth Bank of Australia (fiscal year 2005), the bank engages in a loan $L = 145,735.72$ (equity: $e = 11,532.04$; liabilities: $d = 134,205.68$). Because of the risk neutrality of shareholders that sets the discount rate to zero, in this case it holds true that $f = d = 134,203.68$. Within this framework, the expected profit of the bank can be deduced as follows:

Table 10 Financial data for seven major Australian and UK banks

Bank	Country	Loans (million euros)	Total equity (million euros)	Bonuses (euros)	Options (euros)
Australia & New Zealand Banking Group	AU	2005:154,737.84 2015: 376,655.91	2005: 13,056.96 2015: 38,426.51	2005: – 2015: –	2005: 530,004 2015: 290,419
Commonwealth Bank of Australia	AU	2005: 145,735.72 2015: 428,305.54	2005: 11,532.04 2015: 36,123.05	2005: 95,475 2015: 16,750	2005: 250,000 2015: –
National Australia Bank	AU	2005: 174,235.51 2015: 356,965.28	2005: 17,460.20 2015: 35,505.31	2005: 1,879,350 2015: –	2005: 900,000 2015: 208,432
Barclay PLC	UK	2005: 295,785.60 2015: 439,138.70	2005: 26,873.00 2015: 72,450.40	2005: 1,526,800 2015: 555,500	2005: 2,060,000 2015: –
Lloyds Banking Group	UK	2005: 227,258.90 2015: 532,931.30	2005: 11,693.00 2015: 51,678.00	2005: 1,002,000 2015: 935,000	2005: 521,876 2015: 37,151
Royal Bank of Scotland Group	UK	2005: 536,594.30 2015: 400,991.80	2005: 41,298.40 2015: 59,561.70	2005: 1,813,900 2015: –	2005: 1,037,603 2015: 417,486
Standard Chartered Plc	UK	2005: 117,161.92 2015: 225,567.33	2005: 13,566.30 2015: 53,363.20	2005: 2,998,600 2015: 1,289,200	2005: 154,479 2015: –

The absence of values in some of the cells in the bonuses and options columns signifies that in the corresponding years no managerial incentive of the respective type has been attributed

- Probability of loan losses:

$$q(m) = q_H - m\Delta = 0.8 - 0.5 \times (0.8 - 0.2) = 0.5.$$

- Terminal cash flow:

$$tcf = \big[1 - q(m)\big](zL - d) = 0.5 \times 69,824.33 = 34,913.16.$$

- Increment in equity:

$$y_0 = \Delta e = tcf - e = 34,913.16 - 11,532.04 = 23,381.12.$$

- Income after deducting the minimum capital requirements:

$$y_1 = (1 - \rho)\Delta e = 0.93 \times 23,381.12 = 21,744.44$$

- Management incentive pay:

$$y_m = \beta y_1 - \frac{c}{2}m^2 L = 0.2 \times 21,744.44 - 1,821.70 = 2,527.19.$$

- Shareholders' profit after dividends:

$$s_h = (1 - \beta)y_1 + \frac{c}{2}m^2 L = 0.8 \times 21,744.44 + 1,821.70 = 19,217.25.$$

However, seeking the manager's optimum incentive pay for this volume of granted options, $\beta = 0.2$, and following the same procedure, the most suitable monitoring effort amounts to,

$$m^* = \frac{\beta\Delta(1 - \rho)(zL - d)}{cL} = \frac{0.2 \times 0.6 \times 0.93 \times 69,824.33}{0.1 \times 145,735.72} \approx 0.535.$$

With this value of m^*, the following results are obtained:

- Probability of loan losses:

$$q(m^*) = q_H - m^*\Delta \approx 0.8 - 0.535 \times (0.8 - 0.2) = 0.479.$$

- Terminal cash flow:

$$tcf = \big[1 - q(m^*)\big](zL - d) \approx 0.521 \times 69,824.33 = 36,379.52.$$

- Increment in equity:

$$y_0 = \Delta e = tcf - e \approx 36,379.52 - 11,532.04 = 24,847.48.$$

- Income after deducting the minimum capital requirements:

$$y_1 = (1 - \rho)\Delta e \approx 0.93 \times 24,846.43 = 23,108.15.$$

- Management incentive pay:

$$y_m = \beta y_1 - \frac{c}{2}(m^*)^2 L \approx 0.2 \times 23,108.15 - 2,085.66 = 2,535.97.$$

- Shareholders' profit after dividends:

$$s_h = (1-\beta)y_1 + \frac{c}{2}(m^*)^2 L \approx 0.8 \times 23,108.15 + 2,085.66 = 20,718.18.$$

For the case of the Lloyds Banking Group (fiscal year 2015), the bank engages in a loan $L = 532,931.30$ (equity: $e = 51,678.00$; liabilities: $d = 481,253.30$). Because of the risk neutrality of shareholders that sets the discount rate to zero, in this case it holds true that $f = d = 481,253.30$. Within this framework, the expected profit of the bank can be deduced as follows:

- Probability of loan losses:

$$q(m) = q_H - m\Delta = 0.8 - 0.5 \times (0.8 - 0.2) = 0.5.$$

- Terminal cash flow:

$$tcf = \big[1 - q(m)\big](zL - d) = 0.5 \times 264,850.52 = 132,425.26.$$

- Increment in equity:

$$y_0 = \Delta e = tcf - e = 132,425.26 - 51,678.00 = 80,747.26.$$

- Income after deducting the minimum capital requirements:

$$y_1 = (1-\rho)\Delta e = 0.91 \times 80,747.26 = 73,480.01.$$

- Management incentive pay:

$$y_m = \beta y_1 - \frac{c}{2} m^2 L = 0.2 \times 73,480.01 - 6,661.64 = 8,034.36.$$

- Shareholders' profit after dividends:

$$s_h = (1-\beta)y_1 + \frac{c}{2} m^2 L = 0.8 \times 73,480.01 + 6,661.64 = 65,445.65.$$

However, seeking the manager's optimum incentive pay for this volume of granted options, $\beta = 0.2$, and following the same procedure, the most suitable monitoring effort amounts to,

$$m^* = \frac{\beta\Delta(1-\rho)(zL-d)}{cL} = \frac{0.2 \times 0.6 \times 0.91 \times 264,850.52}{0.1 \times 532,931.30} \approx 0.543.$$

With this value of m^*, the following results are obtained:

- Probability of loan losses:

$$q(m^*) = q_H - m^*\Delta \approx 0.8 - 0.543 \times (0.8 - 0.2) = 0.4742.$$

- Terminal cash flow:

$$tcf = \left[1 - q(m^*)\right](zL - d) \approx 0.5258 \times 264,850.52 = 139,258.40.$$

- Increment in equity:

$$y_0 = \Delta e = tcf - e \approx 139,258.40 - 51,678.00 = 87,580.40.$$

- Income after deducting the minimum capital requirements:

$$y_1 = (1 - \rho)\Delta e \approx 0.91 \times 87,580.40 = 79,698.17.$$

- Management incentive pay:

$$y_m = \beta y_1 - \frac{c}{2}(m^*)^2 L \approx 0.2 \times 79,698.17 - 7,856.71 = 8,082.92.$$

- Shareholders' profit after dividends:

$$s_h = (1 - \beta)y_1 + \frac{c}{2}(m^*)^2 L \approx 0.8 \times 79,698.17 + 7,856.71 = 72,290.92.$$

Again, as in the simulation exercise of the precedent section, the options-based pay alternative emerges in this case as the one leading to higher shareholders' profit after dividends.

Conclusion

This study sophisticates the Cerasi and Oliviero (2015) model of managerial compensation in banks by replacing bonuses with options, and by comparing how effective the two types of managerial incentives are under the model's assumptions. The theoretical framework confirms the intuition and the empirical evidence discussed in the first two sections of the study: bonuses apparently have an advantage over options when the performance of the manager is poor, because, in this case, prompt corrective action can be taken to reverse the situation. However, by establishing a long-term alignment of interests between the parties, the options modality is better equipped to avoid conflicts of interests and costly inspective and monitoring activities. The option-based incentive creates safe conditions for the manager to act in a relaxed, independent but responsible manner because his / her interests and those of the shareholders are aligned.

The undertaken analysis strengthens the position of those who defend the benefits of stock options, despite the fact that they have been severely criticized, notably since the financial crises that triggered the great recession of the beginning of this century. It showed that, at least for equity-based pay, options emerge as a strong and safe alternative for the payment of incentives, although they can encourage managers to run unnecessary risks. The implications drawn above confirm the expectations

about the influence of bonuses vis-à-vis options in the strategies that the manager uses as well as with his own entrepreneurial initiatives. Bonuses proved to influence the choice of riskier strategies, while options proved to align with the most conservative strategies and with the objectives of shareholders.

The most obvious potential avenue for future work consists in conducting a study similar to the one in this paper, in which option-based incentives are compared with direct equity-based compensation rather than bonuses (this is the path already pursued in Razul et al. 2023). In a more integrated way, one may conceive a model that takes into account every possible compensation possibility (fixed pay, bonuses, equity, and options) with the goal of seeking for the formula that best serves the financial institution goals both in the short and in the long run. Notwithstanding, one should keep in mind that a general formula most likely does not exist: banks in different markets face different challenges, and challenges change fast. We live today in a world of risks of many types (economic, environmental, political, societal, and technological); assessing which of those are most important in one or another context is the first step in trying to establish the best alignment possible between the interests of shareholders and managers in banking institutions.

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Data availability The data used in this study are related to the 100 largest banks in early 2017, based on their assets on 31/12/2016. It was gathered from the FY2005 and FY2015 reports, downloaded through link http://www.google.pt/largest100banksintheworld

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the authors. The study complies with all relevant ethical standards.

References

Abreu JF, Alves MG (2019) State interventions to rescue banks during the global financial crisis. Int Rev Econ Financ 62(July):213–229

Acosta-Smith J, Grill M, Lang JH (2023) The Leverage Ratio, Risk-taking and Bank Stability. J Financ Stability forthcoming

Ahamed F (2022) CEO compensation and performance of banks. Eur J Bus Manag Res 7(1):100–103

Armstrong CS, Larcker DF, Su CL (2007) Stock Options and Chief Executive Officer Compensation. Center for Mathematical Studies in Economics and Management Science working paper nº 1447

Asai K (2016) Is capping executive bonuses useful? International Monetary Fund Working Paper (WP 16/196)

Banker RD, Darrough MN, Huang R, Plehn-Dujowich JM (2013) The relation between manager compensation and past performance. Account Rev 88(1):1–30

Barton H, Laux JA (2010) Executive pay inefficiencies in the financial sector. J Appl Bus Res 26(4):65–71

Bebchuk LA, Fried JM (2003) Executive compensation as an agency problem. J Econ Perspect 17(3):71–92

Belasri S, Gomes M, Pijourlet G (2020) Corporate social responsibility and bank efficiency. J Multinational Financ Manag 54:1–10

Benmelech E, Kandel E, Veronesi P (2010) Stock-based compensation and manager (Dis)incentives. Quart J Econ 125(4):1769–1820

Benz M, Kucher M, Stutzer A (2001) Are stock options the managers' blessing? Stock option compensation and industrial controls. IEW working papers 061, Institute for Empirical Research in Economics, University of Zurich

Berger PG, Ofek E, Yermack DL (1997) Managerial entrenchment and capital structure decisions. J Finance 52(4):1511–1538

Bhagat S, Bolton BJ (2011) Bank executive Compensation and Capital Requirements Reform. SSRN working paper nº 1781318

Biggerstaff L, Blank B, Goldie B (2019) Do incentives work? Option-based compensation and corporate innovation. J Corp Finan 58:415–430

Bolton P, Mehran H, Shapiro J (2010) Executive compensation and risk taking. Federal Reserve Bank of New York Staff Reports No. 456

Canil J, Karpavicius S (2021) The relation between non-executive employee stock options and corporate innovation: evidence from FAS 123R. SSRN working paper nº 3909511

Carline NF, Pryshchepa OO, Wang B (2023) CEO compensation incentives and playing it safe: evidence from FAS 123R. J Financ Quant Anal pp.1–34

Carter ME, Lynch LJ (2004) The effect of stock option repricing on employee turnover. J Account Econ 37(1):91–112

Cerasi V, Oliviero T (2015) Manager compensation, regulation, and risk in banks: theory and evidence from the financial crisis. Int J Cent Bank 11(3):241–297

Cerasi V, Deininger SM, Gambacorta L, Oliviero T (2020) How post-crisis regulation has affected bank CEO compensation. J Int Money Finance 104:1–19

Chan SG, Karim MZA, Burton B, Atkan B (2013) Efficiency and risk in commercial banking: empirical evidence from east Asian countries. Eur J Financ 20(12):1114–1132

Chen Y, Zhang Z, Zhou J, Liu C, Zhang X, Yu T (2023) A cognitive evaluation and equity-based perspective of pay for performance on job performance: a meta-analysis and path model. Front Psychol 13:1–26

Cheng R, Frijns B, Kim H, Ryu D (2023) The effects of option incentive compensation on corporate innovation: the case of China. SSRN working paper nº 4491761

Choe C, Yin X (2006) Should executive stock options be abandoned? Aust J Manag 31(2):163–179

Chu Y, Liu M, Ma T, Li X (2020) Executive compensation and corporate risk-taking: evidence from private loan contracts. J Corporate Finance 64:1–17
Collin SOY, Gustafsson L, Petersson E, Smith E (2014) Options are a manager's best friend: executive compensation in Swedish listed corporations. IUP J Corporate Governance 13(3):40–71
Conyon MJ, Fernandes N, Ferreira MA, Pedro M, Murphy KJ (2013) Banking bonuses and the financial crisis. In: Boeri T, Lucifora C, Murphy KJ (eds) Executive remuneration and employee performance—related pay: a transatlantic perspective. Oxford University Press, Oxford, pp 65–99
Cvitanic J, Zhang J (2007) Optimal compensation with adverse selection and dynamic actions. Math Financ Econ 1:21–55
Cvitanic J, Henderson V, Lazrak A (2014) On managerial risk-taking incentives when compensation may be hedged against. Math Financ Econ 8:453–471
Doucouliagos H, Haman J, Askary S (2007) Directors' payment and performance in Australian banking. Corporate Governance Int Rev 15(6):1363–1383
Duarte FD, Gama APM (2020) Credit risk, owner liability and bank loan maturities during the global financial crisis. Eur Financ Manag 26(3):628–683
Eisdorfer A, Giaccotto C, White R (2013) Capital structure, executive compensation, and investment efficiency. J Bank Finance 37(2):549–562
Fama EF, Jensen MC (1983) Separation of ownership and control. J Law Econ 26(2):301–325
Feltham G, Wu M (2001) Incentive efficiency of stock versus options. Rev Account Stud 6(1):7–28
Firestone S, Wang K (2014) Bank risk management and portfolio diversification. Federal Reserve Board of Governors, Washington
Guadapule M, Cuñat V (2004) Executive compensation and competition in the banking and financial sectors. IZA Discussion Paper Series, nº 1123
Handorf WC (2015) Bank risk management, regulation and manager compensation after the panic of 2008. J Bank Regul 16(1):39–50
Ilic M, Lepojevic V (2022) Rewarding top managers in the banking sector during the COVID 19 pandemic. Eur J Appl Econ 19(2):1–13
Jing L, Zhang H (2023) Venture capital, compensation incentive, and corporate sustainable development. Sustainability 15(7):1–19
John K, Qian Y (2003) Incentive features in manager compensation in the banking industry. FRBNY Econ Policy Rev 9(1):109–121
John K, Saunders A, Senbet LW (2000) A theory of bank regulation and management compensation. Rev Financ Stud 13(1):95–125
Ju N, Leland H, Senbet LW (2014) Options, option reprising in managerial compensation: their effects on corporate investment risk. J Corporate Finance 29(C):628–643
Jucá MN, de Sousa AF, Fishlow A (2012) Capital structure determinant's of north American banks and the compensation executive program—an empiric study on actual systemic crisis. Int J Bus Manag 7(17):13–26
Köhler M (2015) Which banks are more risky? The impact of business models on bank stability. J Financ Stab 16:195–212
Kolm J, Laux C, Loranth G (2016) Bank regulation, manager compensation, and boards. Rev Finance 21(5):1901–1932
Kurniawaty K, Ramly M, Ramlawati R (2019) The effect of work environment, stress, and job satisfaction on employee turnover intention. Manag Sci Lett 9(6):877–886
Long CS, Musibau AA (2013) Can employee share option scheme improve firm's performance? A Malaysian case study. Inf Manag Bus Rev 5(3):119–128
Liu S, Sickles R (2021) The agency problem revisited: a structural analysis of managerial productivity and CEO compensation in large US commercial banks. Empir Econ 60(1):391–418
Lovett S, Rasheed AA, Hou W (2022) Stock options, restricted stock, salary, or bonus? Managing CEO compensation to maximize organizational performance. Bus Horiz 65(2):115–123
Loyola G, Portilla Y (2023) Optimal incentives for managerial innovation. North Am J Econ Finance 68:1–25
Mao CX, Zhang C (2018) Managerial risk-taking incentive and firm innovation: evidence from FAS 123R. J Financ Quant Anal 53(2):867–898
Mehran H, Mollineaux L (2012) Corporate Governance of Financial Institutions. Federal Reserve Bank of New York Staff Reports nº 539
Murphy KJ (1998) Executive Pay. Manager Publication G 98–9 (397)
Muurling R, Lehnert T (2004) Option-based compensation: a survey. Int J Account 39(4):21–37

Park JS (2010) Are wall street manager compensations a complete nonsense?. University of Pennsylvania working paper
Podolski E, Jiang C (2022) Managerial equity incentive schemes and corporate innovation outcomes: evidence from China. SSRN Working Paper 4018951
Ramlall S (2003) Managing employee retention as a strategy for increasing organizational competitiveness. Appl H.r.m. Res 8(2):63–72
Razul A (2021) Management incentives and corporate strategies of banks. PhD thesis in Management (supervisor: M.A. Gulamhussen), ISCTE University Institute of Lisbon
Razul A, Gomes O, Gulamhussen MA (2023) Equity, options, and bank strategies. Lisbon University Institute working paper
Sigler KJ (2011) Manager compensation and company performance. Bus Econ J BEJ-311:1–8
Sung J (2015) Pay for performance under hierarchical contracting. Math Financ Econ 9:195–213
Swanepoel MJ (2018) Investigating Steinhoff international holdings' results: application of integrated financial decision-making model and lean accounting principles. Int J Econ Finance Stud 10(1):167–183
Wang G, Singh P (2014) The evolution of manager compensation over the organizational life cycle: a contingency explanation. Hum Resour Manag Rev 24(2):144–159