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Bankers' pay and excessive risk

John Thanassoulis and Misa Tanaka

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Abstract

This paper studies the agency problem between bank management, shareholders, and the taxpayer. Executive bonuses increase in the probability the bank is too big to fail. Bank management recognise it is very likely optimal to select risky projects which exploit the taxpayer, implying project selection effort (eg due diligence) is more expensive to incentivise. This agency problem leads to too much risk for society, not for shareholders. Compensation rules aimed at solving management-shareholder agency problems — equity pay, deferred, including debt — do not correct the excessive risk taking. By contrast, malus and clawbacks can incentivise the bank management to make better risk choices.

Key words: Executive compensation, bankers' bonuses, risk-taking, financial regulation, return on equity, clawback, deferral.

JEL classification: G21, G28, G32, G38.

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1 Introduction

In the recent global financial crisis, a number of banks accumulated large losses while their most senior employees were paid extraordinary bonuses up to that point. The fact that these losses in some cases led to bank failures requiring support from taxpayers prompted many to call for a review of bank executives' pay structure in order to reduce incentives for excessive risk-taking. Partly in response, the Financial Stability Board (2009a,b) published the *Principles* and *Implementation Standards for Sound Compensation Practices* with the aim of aligning compensation with prudent risk-taking. Since then, a number of jurisdictions have introduced compensation regulations:[1] for example, the United States has instituted say-on-pay rules and is actively considering mandating clawback provisions; the European Union has imposed bonus caps of no more than 100% of base pay (200% with shareholder approval); the United Kingdom has mandated that at least 40% of the variable remuneration is deferred for material risk takers for a period of three to seven years, and that their variable remuneration can be clawed back for a period of seven to ten years.[2]

In designing compensation regulations, it is important to be clear what frictions they are addressing. There are arguably three major types of agency problem (AP) in banking. The existing research has thus far focused on the first two of these, while the third, the subject of this study, has received much less attention. Determining the right way to solve all three agency problems can define the right toolbox necessary to manage excessive risk taking.

AP1 – Between management and shareholders

The agency problem arising from the separation of ownership and control is perhaps the defining feature of modern finance: suggested by Berle and Means (1932), formalised by Jensen and Meckling (1976) and leading to a revolution in pay practice (Jensen and Murphy (1990)). To incentivise management to exert costly and private effort, pay must be made sensitive to performance. This can be done by, for example, equity-linked pay, bonuses, and stock options. More recently research has also studied the need to deter myopia and the pushing of risks into the future. Deferred equity-linked pay is required to achieve this.[3]

[1] For the US, see Dodd-Frank Act Section 951, and in addition see "U.S. Regulators Revive Work on Incentive-Pay Rules," Wall Street Journal, Feb 16, 2015. For the UK, see the Policy Statement PRA12/15 FCA PS15/16. For the EU bonus cap rules, see DIRECTIVE 2013/36/EU.

[2] For further details on the deferral and clawback periods in the UK, see the Policy Statement PRA12/15 FCA PS15/16. The final provisions on clawback and deeferral will apply to variable remuneration awarded for performance periods beginning on or after 1 January 2016.

[3] See, for example, Thanassoulis (2013) and Edmans, Gabaix, Sadzik and Sannikov (2012).

AP2 – Between management & shareholders & debt holders

Debt markets may not be able to monitor the risks taken by bank executives and price them accurately. In this case, the executive acting in the interests of the shareholders may take excessive risks at the expense of the debt holders, ultimately lowering the shareholders' value as costs of borrowing rise (Jensen and Meckling (1976)). The appropriate way to address this problem has only recently been studied. To incentivise management to not exploit debt holders after issuing debt, management should be exposed to the price of that debt, either by including debt in their pay directly, or by basing pay on default probabilities extracted from credit default swaps (CDS).[4] In the absence of regulation, empirical evidence suggests that firms in general manage this agency problem by linking pension pay to the health of the firm (known as inside debt): see Sundaram and Yermack (2007), Anantharaman, Fang and Gong (2014).

AP3 – Between management & shareholders & financial regulators/society

Aligning the interests of management with shareholders and debt holders may not be sufficient to achieve the socially optimal risk choice. The presence of explicit deposit insurance and the implicit possibility of government bailouts (which we call the *too-big-to-fail (TBTF)* effect as a short hand) can induce management to take excessive risks at the expense of taxpayers (or the deposit insurance fund), even if the debt market accurately prices the risks that are borne by the debt holders. Bebchuk and Spamann (2010) make the case that this is a key agency problem to correct. They propose that pay regulation is required but leave defining its structure to future work. Our work tackles this agency problem. We demonstrate that the tools needed for AP1 and AP2 (pay linked to performance, deferred in time, and the inclusion of debt) will often not solve this problem; clawbacks and the rebasing of the risk-takers' scorecard can help solve this problem, if structured properly.

Of these agency problems, AP2 and AP3 are most concerned with management selecting projects that are excessively risky. Even though AP2 has been the focus of recent research, it is not the only, or even the primary, driver of excessive risk-taking by the executives of large systemic banks. We have noted the use of inside debt to alleviate AP2 already. In the case of banks, further protection from risk-shifting to debt holders is created by banks borrowing

[4] Edmans and Liu (2011) advocate the use of debt in pay, while Bolton, Mehran and Shapiro (forthcoming) suggest using CDS may be more reliable.

short-term and so frequently returning to capital markets to roll-over debt. Over the last fifteen years, global systemically important banks (G-SIBs) accessed debt markets more frequently than twice a quarter and sought to borrow over \$2.7 billion each time on average (Figure 1). Such repeated visits to the capital markets reduce the scope for risk-shifting (Brunnermeier and Oehmke (2013)). Further, major banks' debt is covered by CDS contracts which explicitly estimate the default probability, and bond yields reflect this default probability.[5] Nonetheless, AP2 will remain an important problem in banks, particularly as banks do issue some long-term bonds which cannot be re-priced after issuance.

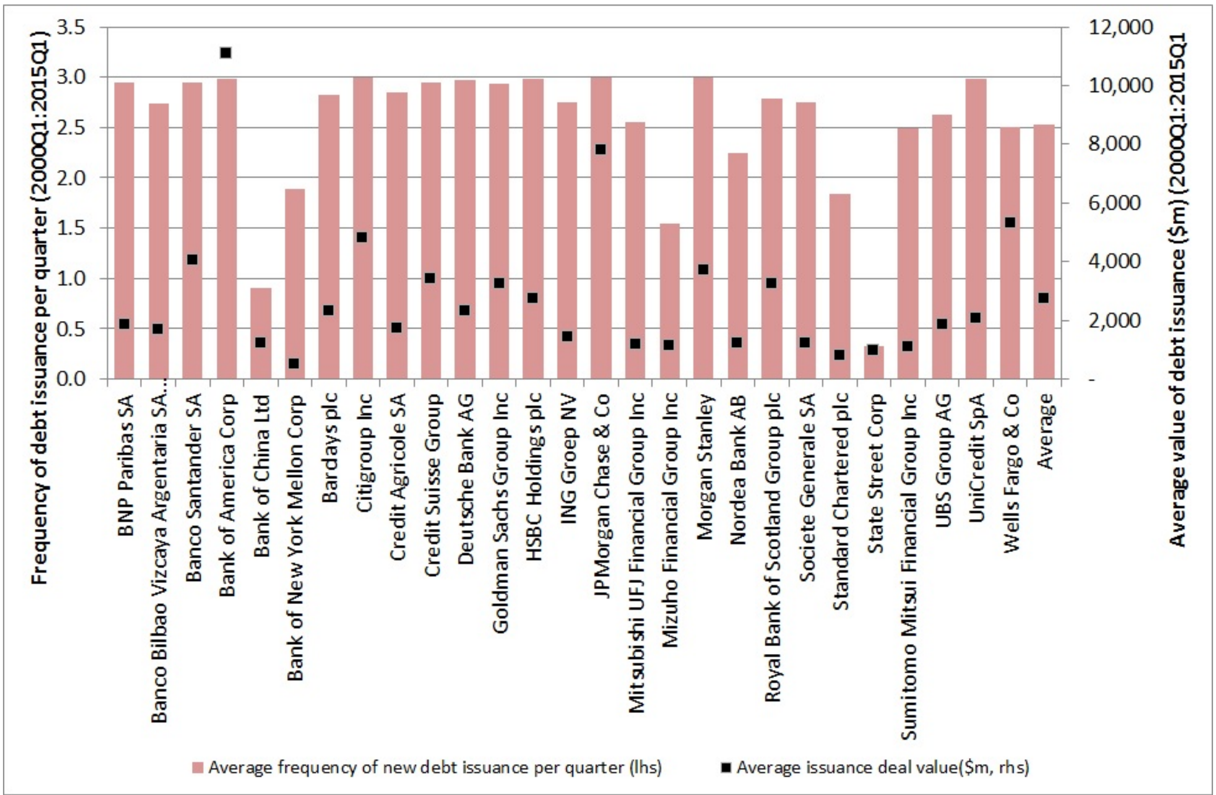


Figure 1: Frequency and Size of New Debt Issuance For G-SIBs

Notes: The graph presents the frequency and average size of new debt issuance by the G-SIBs for which data were available. The bars represent the frequency of deal issuance and demonstrate an average return to the debt markets more frequently than twice a quarter. The points on the graph represent the average issuance size and are measured on the right hand axis. The average issuance was over \$2.7 billion. These data demonstrate that bank executives are repeatedly exposed to the judgment of the market, and so interest rates payable will adjust to reflect the decisions banks take. This offers justification for our focus on an informed debt market which evaluates firm risk after project decisions are taken. Data from Dealogic Primary Issue data for 2000Q1 through to 2015Q1.

By focusing on the third of the above agency problems, AP3, this paper complements the existing literature on remuneration contract design that has thus far been focused primarily

[5]On the link between the price of debt and CDS-implied default probabilities see Blanco, Brennan, Marsh (2005), and Hull, Predescu and White (2004).

on AP2. We explore project selection when the executive's remuneration is set optimally from the viewpoint of shareholders, and when debt markets are informed of the project risk so that debt holders cannot be exploited. In our analysis, bank debt holders benefit from an implicit government guarantee, but the bank's shareholders do not have to bear the cost of this guarantee in the form of a fairly priced insurance premium. The principal (shareholders) contracts with the agent (bank management) to incentivise costly project selection effort so as to maximise equity value. The bank management then chooses the investment project from a range of alternatives which are only privately observable after costly effort is exerted. The management then publicly announces the project choice and issues debt, such that the debt market is fully informed of the risk of the chosen project and debt prices fully reflect the default risk borne by the debt holders. We establish the optimal compensation contract in this framework, explore how it depends on the probability of government bailout and other parameters, and examine how pay regulation can correct AP3.

Our analysis demonstrates that leverage alone is not sufficient to create an AP3 problem and induce excessive risk-taking. When bank debt is not subject to any government guarantee, and the debt market can observe and price risks taken by bank management, as assumed in Modigliani and Miller (1958), then the equity-remunerated executive makes efficient project selection decisions. However, in the presence of an implicit or explicit government guarantee on bank debt, the equity-remunerated executive selects projects which maximise shareholder value but are too risky from society's point of view. The optimal compensation contract in this setting has yet to be studied. We demonstrate that increasing the probability of a government bailout increases the equilibrium bonus rate. When the probability of a bailout is high, the executive anticipates that, after exerting project selection effort, the likely most profitable course will be to select risky projects which maximise the expected value of the government guarantee. Hence, project selection effort (e.g. intensive due diligence or risk assessment) is unlikely to alter the project choice; so to maintain incentives for the executive to exert costly project selection effort, higher bonus pay is required. Similarly, if the business climate is such that the expected returns from the high risk business strategy are high, then equilibrium bonuses will rise to induce project selection effort *ex ante*.

Our framework provides a theoretical laboratory in which the impact of different compensation regulations on bank managers' incentives can be studied. Our first results here are negative: as noted previously, the tools needed to tackle AP1 and AP2 (pay linked to performance, deferred in time, and the inclusion of debt in remuneration) do not solve AP3. Both the use of equity-based bonuses and their deferral align the executive's interests with those of the shareholders. But in the presence of AP3, shareholders can gain at taxpayers' expense, and the executive remunerated in equity chooses projects of excessive risk from the perspective of taxpayers, even if the equity-linked bonus is subject to deferral. Likewise, paying the executive partly in (standard) debt cannot solve AP3: even if the price of debt reflects the default risk borne by the creditors, if the bank is subject to an implicit or explicit government guarantee then this creditor risk is below the total social risk. Hence the executive remains incentivised to choose projects whose risk is beyond the social optimal but which benefit shareholders and so raise the equity-linked part of his/her bonus. This result assumes that the debt held by the executive ranks *pari passu* with other debt: it is not singled out for special treatment in the case of insolvency – whether the debt is bailed in, or bailed out.

We demonstrate that there are two main ways of correcting for AP3. The first is to ensure that the bank managers suffer financial penalties *ex post* when the bank fails, regardless of whether its creditors are bailed out or not. The second is to ensure that, *ex ante*, their performance metrics incorporate the distortion in return on equity caused by the implicit government guarantee. Specifically, we consider the following policies in our analysis:

Clawback and malus are both forms of *ex-post* risk adjustment, whereby past awards of variable remuneration may be adjusted to reflect subsequent information about the underlying risks, including any evidence of poor risk management. Whereas application of malus prevents the unvested proportion of variable remuneration from being paid out, clawback can be used to recover variable remuneration that has already been paid out. We show that clawback and malus can help to correct AP3 and induce optimal risk taking if they can be conditioned fully on risks taken *ex ante*. If, however, the bank managers expect such financial penalties to be conditioned on *ex post* performance of the bank, then these tools improve social welfare relative to non-intervention but can achieve only a second best outcome. In this case a clawback regime generates some projects over which they will be excessively risk averse from society's point of view, while they will remain insufficiently risk averse over others. In an illustrative calibration, we show that bank executives' risk-taking incentives could be brought closest to the social optimum if they expect to lose around 20% of their bonus in the event of the bank's failure – for example, losing all of their bonus with 20% probability.

We also note that, as clawback and malus induce bank executives to be excessively risk averse from shareholders' point of view, shareholders are likely to seek ways to re-incentivise the executives to select projects which are profitable for them, that is to recreate AP3. We demonstrate that introducing a sufficiently convex bonus function can achieve this: by allowing the bonus to rise disproportionately with the final equity returns, the executives can be incentivised to choose high-risk projects that maximise shareholder returns at the expense of taxpayers.

Rebasing the CEO scorecard can tackle AP3 directly by adjusting the performance metric which is used for determining the bonus *ex ante*. The distortion in executive project choice arises from the implicit government guarantee on debt, which artificially inflates the equity value. If the value of this implicit guarantee is subtracted from the equity value before bonuses are calculated, the executive can be induced to internalise the full costs of their project choice and hence the distortions caused by AP3 can be eliminated. The current literature has not settled on how large the value of implicit government guarantee might be, and so how substantial this rebasing would need to be. Estimates available range from the order of 10% of equity value to multiples of this figure.

Bonus caps have become a reality in the European Union. We demonstrate that bonus caps alone are unlikely to be effective in improving project selection.

We conclude this introduction by reviewing the existing literature to which this study contributes. We have noted above that the formal principal-agent analysis of pay builds in large measure off the insights of Jensen and Meckling (1976). Prominent among the more recent scholarly work on AP2 is Edmans and Liu (2011) and Bolton, Mehran and Shapiro (forthcoming). Hakanes and Schnabel (2014) study a combination of AP2 and AP3 in that banks receive an unpriced government guarantee (AP3) whilst debt holders must supply debt in ignorance of the manager's actions, thus creating scope for risk-shifting to debt holders (AP2). They predict, as we do, that higher bailout probability should increase the bonus rate, but their reasoning is different from ours. As we noted above, we predict this link existing as it becomes too easy for management to make money by exploiting the taxpayer and so incentives must be sharpened to preserve project selection effort. In Hakanes and Schnabel, by contrast, bonus incentives are dampened to guard against risk-shifting (AP2); as the bailout probability increases, debt holders are less exposed to risk, and so risk-shifting concerns diminish allowing the bank to sharpen incentives. Our analyses agree that clawback clauses can be helpful, though our analysis is perhaps more nuanced as the possible returns for the bank are continuous and so clawback need not be beneficial for all potential projects. Our analyses disagree that bonus caps are an effective tool to deal with AP3: Hakanes and Schnabel's (2014) result may depend on their modelling assumption that the remuneration contract pays out only one amount, and so a bonus cap is equivalent to a substantial restriction on both the shape and scale of possible compensation contracts.

There exists a related literature which studies optimal financial regulation in the presence of executive agency problems. An important early contribution here is John, Saunders and Senbet (2000) who study AP3 and argue that banks' risk taking can be mitigated by making deposit insurance premiums payable as a function of the executive compensation contract. More recently, Freixas and Rochet (2013) study optimal resolution in the presence of AP2 and AP3. They propose that bank managers at TBTF banks should be given a grace period upon being hired during which they are allowed to keep their job even in the event of bank default. However, to mitigate the manager's moral hazard, Freixas and Rochet (2013) propose that external pay restraint is required during this grace period.

Finally, our study also contributes to the wider literature on optimal financial regulation to counter excessive risk-taking by banks, without exploring the complications due to manager-shareholder agency problems. A prominent body of work has noted that mispriced deposit insurance allows banks to gain from taking excessive risks.[6] Capital adequacy regulation has been traditionally used to curb such risk-taking by ensuring that shareholders have sufficient 'skin in the game'. However, the recent financial crisis has undermined the notion that capital adequacy regulation alone is sufficient to curb banks' risk-taking incentives, not least because risk weights used to calculate the risk-weighted capital ratios were inadequately capturing the risks that banks were exposed to (Admati, DeMarzo, Hellwig and Pfleiderer (2013)).

The paper is structured as follows. Section 2 outlines our baseline model and applies it to the benchmark case of the all-equity financed firm. Section 3 examines the distortion in project choice due to the possibility of government bailouts and establishes the shareholder optimal contract. Section 4 examines alternative proposals for regulating executives' pay in order to correct excessive risk-taking and assesses banks' possible attempts to game the regulation. Section 5 concludes. Proofs not in the main text are contained in Appendix A.

[6] Freixas and Rochet (2008) offer a textbook exposition.

2 The model

We first present a model of executive project choice, and then solve for optimal remuneration in the benchmark case of the fully equity funded bank.

2.1 A model of project choice

We propose a principal-agent model in which the bank owner ("she") is the principal and the executive ("he") is the agent. Both are assumed to be risk-neutral. The timing of the game is as follows. At $t = 0$ the bank owner offers a compensation contract $\{f, b\}$ to the executive with a promise to pay him at $t = 1$. The parameter $f \geq 0$ is a fixed (dollar) salary and $b \geq 0$ is an equity share of the $t = 1$ market value of the bank. The executive accepts or rejects the compensation package, and his reservation utility is given by u.[7]

If he accepts the contract, the executive at $t = 0$ chooses between two projects: a high volatility project and a low volatility project. The high volatility project is fully described by its expected return Z which is drawn from a probability density function $f_H(\cdot)$ with support on $[1, \infty)$. A high volatility project with expected return Z will succeed at $t = 2$ with known probability χ and deliver payoff Z/χ, the project will fail with probability $1 - \chi$ and deliver a payoff of zero: hence it is 'risky'. The low volatility project is fully described by its expected return r which is independently drawn from a probability distribution $f_L(\cdot)$ with support $[1, \infty)$. A low volatility project with expected return r will succeed at $t = 2$ with certainty and deliver payoff r: hence it is 'safe'. The draws of Z and r are independent and it is natural to assume that riskier projects generate higher expected returns on average:

$$E_H(Z) > E_L(r). \tag{1}$$

In order to observe Z and r prior to choosing which project to invest in, the executive has to incur a private effort cost B at $t = 0$. If he chooses not to incur this effort cost, then he only knows that (1) holds. The executive selects the project which will maximise his expected pay.

At $t = 1$ the expected return of the project chosen – Z or r – is publicly revealed. Investors, however, cannot learn the expected return of the alternative project which the executive did not choose. This information structure allows us to study a project choice decision in which the

[7] The reservation utility, u, is exogenous here as we consider just one bank and take the wider executive labour market as exogenous. For a study of endogenous pay levels in banking see Thanassoulis (2012).

executive might choose the risky project when it actually has a lower net present value (NPV) than the safe project, with market participants unable to discern whether or not this is the case.

Both projects require a unit of investment. The bank raises debt $\mathbb{D}$ from the capital markets after the project has been decided and announced. The debt levels are exogenously set and are assumed to be independent of the project chosen. This allows us to study distortions in executive project choice independently of the known distortions created by changes in leverage.[8] We assume $\mathbb{D} < 1$, the total investment sum required. As the market observes the riskiness of the project undertaken at $t = 1$, the price of debt is actuarially fair, given the risks. Thus, we capture the case that, after a project choice decision is taken, investors will have an opportunity to buy debt at a price commensurate with the risks they are taking (see the discussion around Figure 1). The owner complements the debt $\mathbb{D}$ raised with sufficient equity $\mathbb{E}$ to fund the investment and the compensation costs for the executive, and the executive is paid. The $t = 1$ market price of the firm is therefore the expected $t = 2$ payoff from the selected project.[9] We normalise the discount factor to be 1 and so interpret payoffs as net present values. We will study the effect of implicit and explicit government guarantees on the debt $\mathbb{D}$ so making this model most closely suited to the banking sector.

The *ex ante* distribution of returns for both high and low volatility projects are bounded below by 1 to ensure that the executive always has at least one positive NPV project. The assumption that the manager has only one high risk and one low risk project is without loss of generality; these should be interpreted as the best low risk and best high risk projects available. The structure of the returns has been simplified for tractability. This is not an essential assumption, but it allows us to simplify the exposition while retaining the key feature that a high volatility project yields a greater spread of possible payoff realisations and has a greater probability of leading to bank default for any given level of debt.

The modelling choice that the executive is paid (at $t = 1$) after the investment is made but before the profits are realised is intended to capture the fact that banks typically make long-term investments, particularly when compared to the typical tenure of executives. We study more elaborate compensation regimes (clawbacks, deferral, options) for the regulator in Section 4.

[8]Invariance of the level of debt to project choice might arise naturally if: (i) the firm was fully leveraged given its pledgable or collateralizable assets; (ii) the owners decide on the levels of debt and equity they can contribute in advance of the executive's project choice; or (iii) regulatory capital requirements are not appropriately risk-sensitive.

[9]Alternatively, one could ignore the effect of the executive's pay on the equity value of the banks as it will be orders of magnitude smaller in any realistic calibration. If so, one could assume a fixed equity contribution of $\mathbb{E} = 1 - \mathbb{D}$ made any time prior to investment at $t = 1$.

2.2 Optimal remuneration for an all-equity funded bank

We first apply the model to the benchmark setting of an all-equity funded bank. The efficient, first best project choice is for the executive to select the risky project if it has the highest expected NPV: $Z > r$. Hence, the maximum expected payoff at $t = 0$ attainable by an efficiently run bank, gross of any executive remuneration costs, is given by:

$$S = \int_{Z=1}^{\infty} f_H(Z) \left\{ \int_{r=1}^{Z} Z f_L(r)\, dr + \int_{r=Z}^{\infty} r f_L(r)\, dr \right\} dZ \tag{2}$$

Suppose that the projects available to the executive at $t = 0$ are characterised by expected returns $\{Z, r\}$. The $t = 1$ bank value is the expected $t = 2$ payoff from the project selected. If the executive selects the low volatility project then at $t = 1$, the future payoff of r is observed by the market. This becomes the $t = 1$ value of the bank and the executive is paid $f + br$ at this point. If the executive selects the high volatility project then at $t = 1$, the market observes the expected return of the project, Z, so that the executive is paid $f + bZ$. It follows that:

Lemma 1 *If the executive of an all equity bank exerts project selection effort then he will select projects efficiently: he will select the high volatility project if and only if it has the higher expected return, $Z > r$.*

Proof. Compare the executive's compensation given the possible project choices. ■

At $t = 0$, the executive will anticipate that he will make an efficient project choice and so expects his bonus award to be bS, if he chooses to exert effort. The executive's participation constraint is determined by noting that the executive will accept the contract if the expected total pay exceeds the outside option of u:

$$f + bS \geq u \tag{3}$$

In addition, the bonus has to be sufficiently large in order to incentivise him to exert costly project selection effort:[10]

$$f + bS - B > f + bE_H(Z) \tag{4}$$

We now turn to the optimal compensation scheme for the bank. At $t = 0$, the expected

[10] Absent project selection effort, the executive will select the high volatility project due to condition (1).

payoff of the equity owner who finances the initial investment will depend upon the payments which must be made to the executive, and these will depend upon the project choice. The expected value for the equity holder at $t = 0$ is therefore:

$$\begin{aligned} E(\Pi_0) &= \text{[Expected payoff]} - \text{[Expected executive pay]} - \text{[Cost of Investment]} \\ &= (1-b)S - f - 1 \end{aligned} \quad (5)$$

This objective function can be optimised subject to the executive's participation constraint (3) and the incentive compatibility constraint (4). Doing so delivers:

Proposition 1 *The optimal remuneration scheme incentivises effort if the cost of effort is not too great: $B < \bar{B}$ for some $\bar{B}$. In this case the contract with lowest variable component for an all equity bank is characterised as follows:*

1. *The optimal wage contract satisfies:*

$$b = \frac{B}{S - E_H(Z)} \quad (6)$$

$$f = u - B - bE_H(Z) \quad (7)$$

2. *The expected return to the bank's equity owners is given by:*

$$E(\Pi_0) = S - u - 1 \quad (8)$$

3. *The executive makes efficient investment decisions and so selects the risky project if and only if it has the higher NPV ($r < Z$).*

Proof. All omitted proofs are in Appendix A. ■

Thus, in this benchmark case, the first best efficient project choice is delivered by a standard remuneration contract consisting of base pay and an equity stake. Note that in this set-up, AP2 and AP3 do not arise. The optimal contract can solve AP1, which is sufficient to achieve the socially optimal project choice.

The equity stake serves two purposes. The first is to motivate effort by allowing the executive to profit from better project selection. As a result the size of the equity stake required (6) grows the larger the incentive problem is (higher B), or the smaller the expected gain in equity values from screening and choosing projects optimally (smaller $S - E_H(Z)$). The second purpose of the equity stake is to ensure that the executive has the incentive to select a project that maximises shareholder returns given that he exerts effort (Lemma 1). Since the bank is not leveraged in this benchmark case, aligning the executive's incentives with shareholders' interests through equity-linked bonus is sufficient to achieve the socially optimal outcome, which coincides with the optimal outcome for shareholders.

The executive is assumed to be risk neutral, hence many contracts are possible as the executive is indifferent to extra risk. If the executive were risk averse to the smallest degree, then the bank would strictly prefer to lower the rate of variable pay whilst maintaining incentives to exert effort. Thus, the proposition focuses on the optimal contract with the lowest variable component.

We conclude this section by noting that the remuneration schedule generated via the contract (f, b) in Proposition 1 is first best optimal for the shareholders. The contract of Proposition 1 generates the first best project choice (Lemma 1). And the total expected cost of employing the executive to the shareholders is u (equation 8). This is the outside option of the executive and so cannot be reduced further. Thus, the contract generated by Proposition 1 cannot be improved on and so is fully optimal. This contract is also socially optimal as it generates the first best project choice at the lowest possible cost of the executive's outside option.

3 Debt financing and *too-big-to-fail (TBTF)*

We now analyse the impact of government guarantees combined with informed capital markets on the projects chosen by the executive receiving equity-linked bonus. We assess when the decisions made may be in the shareholders' interests, but not in society's interests.

3.1 Debt financing: 'no bailout' benchmark

Suppose that the owner decides that debt equal to $\mathbb{D}$ will be issued at $t = 1$ in order to finance part of the project. The debt is issued at an endogenously determined market interest rate i, repayable after the project is complete, at $t = 2$. The equity owner, as explained above, supplies sufficient equity to cover the costs of the investment and executive pay. The project choice and risk is observed by the market at $t = 1$ and so the interest rate the bank pays on the debt will depend upon the risks of the project. The risk-free interest rate is normalised to zero: none of the following results depend upon this normalisation.

Suppose that at $t = 1$ the executive selects the low volatility project with expected return r. Denote the equity value of the bank at $t = 1$ as $X_L(r)$. The executive will therefore receive pay of $f + bX_L(r)$. As the investment costs a unit of capital, the total equity which is required of the owners given the chosen level of debt issuance is:

$$\mathbb{E} = 1 + [f + bX_L(r)] - \mathbb{D} \tag{9}$$

Since the low volatility project yields r at $t = 2$ with certainty, the debt which is used to finance this project will carry the risk free rate. Hence, the $t = 1$ valuation of the bank is given by:

$$\begin{aligned} X_L(r) &= \underbrace{\mathbb{E} + \mathbb{D}}_{\substack{\text{Pre-investment} \\ \text{Balance sheet}}} - \underbrace{1 - [f + bX_L(r)]}_{\substack{\text{Investment} \\ \text{and staff costs}}} + \underbrace{r - \mathbb{D}}_{\substack{\text{Payoff less} \\ \text{repayment to} \\ \text{debt holders}}} \\ &\Rightarrow \quad X_L(r) = r - \mathbb{D} \text{ using (9)} \end{aligned} \tag{10}$$

Suppose instead that the executive selects the high volatility project with expected return Z. In this case, the bank will have $t = 1$ value denoted $X_H(Z)$. The executive will receive pay of $f + bX_H(Z)$. As the investment costs a unit of capital, the equity required given the debt issuance is

$$\mathbb{E} = 1 + [f + bX_H(Z)] - \mathbb{D} \tag{11}$$

The project is, however, risky and debt holders will not be repaid in the event the project fails. Failure occurs with probability $1 - \chi$. The cost of debt finance for the high volatility project is given by repayment $i\mathbb{D}$ such that debt holders receive the required expected return on debt capital. Hence, the equilibrium interest rate in an efficient debt market is given by:

$$\chi i\mathbb{D} = \mathbb{D} \Leftrightarrow i = 1/\chi \tag{12}$$

The $t = 1$ bank valuation is therefore given by

$$X_H(Z) = \underbrace{\mathbb{E} + \mathbb{D}}_{\substack{\text{Pre-investment} \\ \text{Balance sheet}}} - \underbrace{1 - [f + bX_H(Z)]}_{\substack{\text{Investment} \\ \text{and staff costs}}} + \underbrace{\chi\left(\frac{Z}{\chi} - i\mathbb{D}\right)}_{\substack{\text{Payoff less} \\ \text{repayment to} \\ \text{bond holders}}} \tag{13}$$

Simplifying using (11) and (12), the $t = 1$ value of the bank if the executive selects the high volatility project is given by:

$$X_H(Z) = Z - \mathbb{D} \tag{14}$$

Lemma 2 *If there is any equity-linked bonus $(b > 0)$, then an executive who exerts project selection effort makes a socially efficient project choice. The low volatility project is selected if and only if it has the higher expected return, $r > Z$.*

Proof. If the executive exerts project selection effort then at $t = 0$, he will know the expected return set available $\{Z, r\}$. If the executive chooses the high volatility project, then his payment at $t = 1$ will be $f + bX_H(Z)$, analogously for the low volatility project. The low volatility project is therefore only selected if $X_L(r) > X_H(Z)$. Comparing (10) to (14) yields the result. ■

If there is no government guarantee, the price of debt is not distorted, and so the executive receiving equity-linked bonus behaves in a socially optimal manner.

3.2 TBTF: the effect of implicit government guarantees

Particularly in the case of the banking sector, though not exclusively as the financial crisis has shown us, there exists a distortion caused by the TBTF effect: that is, the perceived unwillingness of the government to allow large or very connected banks to fail for fear of triggering a system-wide financial crisis. Indeed, bondholders of a number of large banks that failed during the recent financial crisis – for example, Bear Stearns, Northern Rock, RBS and Lloyds – did not suffer any losses thanks to government support. In the presence of the TBTF effect, systemic banks and other financial institutions benefit from an ambiguous government guarantee on their debt, which lowers their interest costs for any given level of asset risk.

To capture the interaction of an efficient debt market with an ambiguous government guarantee, we suppose that creditors are bailed out with a publicly known probability μ if the risky project were to fail and the bank is unable to repay its creditors. This distortion will of course affect the price of debt. We assume that the bank is not asked to pay an efficiently priced premium on this insurance, given that the bailout is implicit and not guaranteed.

The bank with debt $\mathbb{D}$ will have $t = 1$ valuation unchanged from $X_L(r)$ as given by (10), as the low volatility project ensures that the bank will not fail and so will not have to be bailed out.

Suppose instead that the executive selects the high volatility project. In this case, the $t = 1$

value of the bank is now a function of the bailout probability μ and is denoted $X_H(Z;\mu)$. The cost of debt finance is, once again, given by the interest rate which ensures that debt holders receive the required expected return on debt capital. The interest payable is altered from (12) as the creditors will allow for the possibility that the bank is TBTF. The equilibrium gross interest rate on debt is therefore now $i(\mu)$ and satisfies:

$$\chi i(\mu)\mathbb{D} + (1-\chi)\mu i(\mu)\mathbb{D} = \mathbb{D} \Leftrightarrow i(\mu) = \frac{1}{\chi + (1-\chi)\mu} \tag{15}$$

To cover the costs of investment and staff costs, given the debt issuance $\mathbb{D}$, the equity holders provide $\mathbb{E} = 1 + [f + bX_H(Z;\mu)] - \mathbb{D}$. Given the debt repayments, the $t = 1$ valuation for the bank which is pursuing the risky project is:

$$X_H(Z;\mu) = \underbrace{\mathbb{E}+\mathbb{D}}_{\substack{\text{Pre-investment}\\ \text{Balance sheet}}} - \underbrace{1-[f+bX_H(Z;\mu)]}_{\substack{\text{Investment}\\ \text{and staff costs}}} + \chi\underbrace{\left[\frac{Z}{\chi} - i(\mu)\mathbb{D}\right]}_{\substack{\text{Payoff less}\\ \text{repayment to}\\ \text{bond holders}}}$$

Note that the bank valuation is now distorted by the possibility of a government bailout, which is priced in the market interest rate. If the project fails, the equity holders receive zero payoff, even though the debt holders may be bailed out. By substituting for the equity supplied by the owner, the $t = 1$ value of the bank can be simplified to yield:

$$X_H(Z;\mu) = Z - \chi i(\mu)\mathbb{D} \tag{16}$$

Lemma 3 *If the bank is levered and if there is any equity-linked bonus* $(b > 0)$, *then an executive who exerts project selection effort makes a socially inefficient project choice by selecting the high volatility project too often. The low volatility project is selected if and only if the expected returns satisfy:*

$$r > Z + (1-\chi)\mu i(\mu)\mathbb{D} \tag{17}$$

The distortion in project selection grows monotonically as the bailout probability μ *increases.*

Lemma 3 demonstrates that, when the debt market prices in the possibility of a government bailout, then the executive chooses the high volatility project even if its expected return is below that of the low volatility project. Hence, the high volatility project is chosen too often from society's point of view. Note that the executive still maximises the shareholders' payoff, but maximising shareholder value is no longer consistent with maximising social welfare when the equity value is itself distorted by the implicit government guarantee on debt.

Expression (17) also shows that a capital adequacy requirement, which requires banks to keep $\mathbb{D}$ below a pre-determined level, will reduce the distortion, but cannot eliminate it as long as banks are partially funded by debt. This implies that appropriately designed remuneration regulation can potentially complement capital adequacy requirements. We consider this issue further in Section 4.

3.3 Owner optimal contract

Given Lemma 3, the owner anticipates that if the executive is incentivised to exert effort, then project selection will be distorted from society's first best. This distortion will, however, increase equity value. The expected value of the bank, gross of any payments to the executive is therefore $S(\mu)$ which, using (17), is:

$$S(\mu) = \int_{Z=1}^{\infty} f_H(Z) \left\{ \begin{array}{l} \int_{r=1}^{Z+(1-\chi)\mu i(\mu)\mathbb{D}} X_H(Z;\mu) f_L(r)\, dr \\ + \int_{r=Z+(1-\chi)\mu i(\mu)\mathbb{D}}^{\infty} X_L(r) f_L(r)\, dr \end{array} \right\} dZ \tag{18}$$

The equity owner's expected payoff at $t = 0$ is $S(\mu) - \mathbb{E}$. The equity required is set to cover the costs of investment and executive pay, net of the debt issuance. Hence, the objective of the owner is to select compensation $\{f, b\}$ to maximise the following function:

$$(1-b) S(\mu) - f - 1 + \mathbb{D} \tag{19}$$

The owner seeks to maximise her objective function (19) subject to the executive being willing to accept the contract:

$$f + b \cdot S(\mu) \geq u \tag{20}$$

and subject to the executive being willing to exert effort. If the executive shirks and selects the high volatility project without exerting effort, then he receives $f + bE_H[X_H(Z;\mu)]$, whereas if the low volatility project is selected, the expected payment is $f + bE_L[X_L(r)]$. The executive therefore exerts effort if:

$$bS(\mu) - B \geq b \max\{E_H[X_H(Z;\mu)], E_L[X_L(r)]\} \tag{21}$$

The owner's problem is therefore to adjust $\{f, b\}$ to maximise (19) subject to (20) and (21). We can extend Proposition 1 to:

Proposition 2 *The optimal remuneration scheme which incentivises effort with the lowest variable component is characterised as follows:*

1. *The optimal wage contract satisfies:*

$$b = \frac{B}{[S(\mu) - E_H[X_H(Z;\mu)]]} \text{ and } f = u - B - bE_H[X_H(Z;\mu)] \tag{22}$$

2. *The expected return to the bank's owner is given by:*

$$E(\Pi_0) = (S(\mu) + \mathbb{D}) - u - 1 \tag{23}$$

3. *The executive over-invests in the risky project by selecting the safe project if and only if (17) holds.*

Incentivising project selection effort is optimal if $B < S(\mu) - E_H[X_H(Z;\mu)]$.

Proposition 2 solves the owner's optimisation problem given the TBTF guarantee. The bonus must be large enough to induce the executive to exert project selection effort. The size of the bonus therefore depends on the ex ante distribution of the expected returns of possible projects. We now conduct a comparative statics study of the optimal contract to generate further intuition as to how an optimising bank will adjust the executive's incentives to exert project choice effort.

Proposition 3 *The comparative statics of the optimal compensation are:*

1. *The bonus rate shrinks if the ex ante distribution of expected returns for the low volatility project* $(f_L(\cdot))$ *should increase in a first order stochastically dominant manner.*
2. *The bonus rate increases if the ex ante distribution of expected returns for the high volatility project* $(f_H(\cdot))$ *should increase in a first order stochastically dominant manner.*
3. *The bonus rate increases in the amount of debt selected by the owner* $(\mathbb{D})$.
4. *The bonus rate increases in the probability of government bailout* (μ).
5. *The bonus rate increases in the volatility of the risky project.*

6. *The project distortion grows in the volatility of the risky project; and*

7. *Inducing effort is optimal for a smaller range of parameters if the volatility of the risky project grows.*

The comparative statics on the bonus rate should be understood in the context of how likely it is, from the executive's point of view, that effort expended in researching the projects will result in a change of project decision. Without exerting effort, the executive would select the high volatility project as, on average, this generates a higher expected return and it exploits the taxpayer more fully. If the *ex ante* distribution of the expected returns of the low volatility project should increase in a first order stochastically dominant way, then the low volatility project will be more attractive, more often, than the default option of selecting the high volatility project. As this strengthens the executive's incentive to exert effort on project research, the optimal bonus rate can fall, whilst maintaining sufficient incentive for effort.

By a similar mental experiment, suppose that the *ex ante* distribution of the expected returns of the high volatility project should increase in a first order stochastically dominant manner. This makes selecting the high volatility project even more likely to be the outcome of project research and so saps the executive's appetite for incurring the effort costs. Thus, in order to incentivise effort (e.g. on appropriate due diligence), the bonus rate has to rise.

If i) the bailout probability μ grows, or ii) the level of debt the owner chooses grows, then the value of the high volatility project to shareholders rises relative to the value of the low volatility project. This makes it more likely that the executive will choose the high volatility project after incurring the effort of researching alternative projects. Once again, this saps the executive's appetite for incurring the effort costs. To ensure adequate incentivisation the bonus rate must rise.

Finally, consider an increase in the volatility of the risky project. A corollary of the volatility of the risky project growing is that the interest rate payable on the debt increases, and so the implicit subsidy from the TBTF guarantee has also increased. This makes choosing the high volatility project over the low volatility project more likely – the distortion in project choice is exacerbated. Further, the executive anticipates that he is very likely to select the risky project given the TBTF distortion. Hence, to incentivise project selection effort the bonus rate must rise to ensure the executive's interests are sufficiently aligned with those of the owner.

4 Socially optimal executives' pay

We have established that, in the presence of the TBTF effect which gives rise to AP3, the executive will make an excessively risky project choice from society's point of view. This project choice is, however, aligned with shareholders' interests. In this section, we ask what restrictions a regulator might wish to impose on the structure of executives' pay to limit the excessive risk-taking incentives arising from this distortion. We then extend the analysis further by studying the remuneration tools at a bank's disposal to seek to game, that is circumvent, the effectiveness of any regulatory intervention.

We will explore five interventions: (i) using debt as part of the executive's compensation; (ii) forcing deferral of equity-linked bonus; (iii) the use of malus and clawback on pay; (iv) adjusting the scorecard used for bonus calculations; and (v) exogenous caps on the bonus which can be paid in relation to the fixed salary.

4.1 Payment in debt

It has been proposed that excessive managerial risk-taking can be mitigated by remunerating the executive in part through debt. For example, AIG declared in its 2010 SEC filing that, for some of their executives, 80% of their bonus will be based on the value of the bank's junior debt, and 20% on its stock.[11] The Federal Reserve Bank of New York has offered its support for increasing the proportion of debt in pay.[12] We explore whether paying in debt can alleviate the agency problem AP3 by allowing the bank to remunerate the executive through a proportion c of the debt $\mathbb{D}$, in addition to the proportion b of shares and fixed pay f, all optimally chosen by the owner.

Given the debt issuance $\mathbb{D}$, the equity required will cover the costs of $t = 1$ remuneration and investment. The value of the bank at $t = 1$ is then given by $X_L(r)$ and $X_H(Z;\mu)$, depending on the project chosen. We allow the executive to discount his $t = 2$ pay by a factor of $\delta \leq 1$. The longer the time scale for projects to realise, the lower δ can be expected to be. By contrast, the bank discounts future payouts according to the prevailing financial interest rate:

[11] Reported in Fortune magazine:
http://archive.fortune.com/2010/07/02/news/companies/aig_executives_compensation_debt.fortune/index.htm

[12] See the speech by William C. Dudley, President and Chief Executive Officer of the Federal Reserve Bank of New York, given on October 20, 2014: "*Enhancing Financial Stability by Improving Culture in the Financial Services Industry.*"

thus normalising the associated bank discount factor to 1.[13]

If the executive selects the low volatility project, then the bank's debt is riskless and pays back $\mathbb{D}$. Hence, the executive's payment at $t = 1$ would be worth:

$$f + bX_L(r) + \delta c\mathbb{D} \tag{24}$$

If instead the executive selects the high volatility project, then the market value of the interest receivable on debt is $i(\mu)$ as given in (15). The project will succeed at $t = 2$ with probability χ and in this case the executive will receive payment $c \cdot i(\mu)\,\mathbb{D}$. With probability $1 - \chi$ the bank will default on its debt. In this case, the government bails out debt holders with probability μ. The executive's $t = 2$ expected payment is therefore $c \cdot [\chi i(\mu)\,\mathbb{D} + (1-\chi)\mu i(\mu)\,\mathbb{D}]$.

Note therefore that we are considering the case in which the executive's debt is not singled out for special treatment in the case of default – it is *pari passu* with the other creditors. It might seem more appropriate that the executive's debt should not be bailed out, or that the executive should be especially punished in the case of default. This would be to create a penalty regime specifically for the executive. We analyse this case below (Section 4.3). Here we are exploring the benefits of using standard debt in pay.

The competitive debt market ensures that the risk-neutral debt holders cannot make money in expectation, and so (15) delivers that the executive receives a $t = 1$ payment of:

$$f + bX_H(Z;\mu) + \delta c \cdot [\chi i(\mu)\,\mathbb{D} + (1-\chi)\mu i(\mu)\,\mathbb{D}] = f + bX_H(Z;\mu) + \delta c\mathbb{D} \tag{25}$$

Proposition 4 *The optimal executive remuneration scheme when debt repayments are allowed satisfies the following:*

1. *The availability of debt pay leaves the optimal share bonus unchanged at (22). The fixed salary is reduced by the amount $\delta c\mathbb{D}$.*

2. *The expected return to the bank's shareholder is unchanged at (23).*

3. *The executive behaviour is unchanged by the availability of debt pay. The executive over-invests in the high volatility project by selecting the low volatility project if and only if (17)*

[13] It is standard in dynamic models of financial contracting to assume that the executive has a discount factor which is strictly lower than her employer; the bank (e.g. DeMarzo and Sannikov (2006)). There is also experimental evidence of this effect (Harrison, Lau and Williams (2002)). However we need not insist on it and allow the executive to be as patient as the bank.

holds.

Proof. The executive's payments when he is in part paid in debt ((24), (25)) differ from the payments in the absence of payment in debt only by the constant $\delta c\mathbb{D}$. Interpreting $f + \delta c\mathbb{D}$ as the fixed fee ensures the owner's problem is isomorphic to the case absent this part payment in debt regulation. The result follows. ■

Proposition 4 demonstrates that including debt in compensation does not correct the project choice distortion caused by AP3, although the existing literature – e.g. Edmans and Liu (2011) and Bolton, Mehran and Shapiro (forthcoming) – have shown that it is effective in correcting incentives when the source of the problem is AP 2. With an informed debt market, the expected return on debt capital to debt holders is independent of project choice. Hence, the presence of debt in the executive's remuneration does not alter the project selection incentives. Proposition 4 therefore complements the existing literature on AP2, and suggests that payment in debt is not a robust way of curtailing excessive risk-taking caused by government-induced distortions.

4.2 Deferred equity-linked pay

Deferred equity-linked pay is often used in order to link the executives' interests with the long-term interests of the shareholders – i.e. to solve AP1. We now consider whether forcing banks to defer a proportion of the executive's equity-linked bonus could mitigate the excessive risk-taking caused by AP3. Forced deferral of pay and the requirement that it be linked to future performance is part of the Financial Stability Board's (2009a, principle #6), key responses aimed at reducing excessive risk-taking by bank executives and mitigating focus on short-term profits.

To examine whether such a policy can actually reduce excessive risk-taking caused by government-induced credit guarantee frictions, suppose that the regulator requires that the equity-linked bonus is split so that a proportion λ^d of the share award vests at $t = 2$, with only the remaining fraction $1 - \lambda^d$ of the bonus being permitted to vest at $t = 1$. This regulatory intervention will affect the equity value of the bank as $t = 2$ remuneration can be paid out of the realised earnings.

Suppose that the executive exerts project selection effort and selects the low volatility project.

The equity value of the bank at $t = 1$ is now:

$$X_L\left(r, \lambda^d\right) = \underbrace{\mathbb{E} + \mathbb{D} - 1 - \left[f + \left(1 - \lambda^d\right) bX_L\left(r, \lambda^d\right)\right]}_{\text{Equity adjusts to set to zero}} + \left(1 - \lambda^d b\right)[r - \mathbb{D}]$$

$$\Rightarrow X_L\left(r, \lambda^d\right) = \left(1 - \lambda^d b\right)[r - \mathbb{D}] = \left(1 - \lambda^d b\right) X_L(r)$$

The second equality follows from (10). In the case of the high volatility project being selected similar working delivers that:

$$X_H\left(Z; \mu, \lambda^d\right) = \left(1 - \lambda^d b\right) X_H(Z; \mu)$$

Proposition 5 *Deferred equity-linked pay does not improve the project selection decision. The project choice distortion remains as in Lemma 3.*

Proof. If the manager selects the high volatility project, then their expected pay is

$$\begin{aligned} & f + b\left(1 - \lambda^d\right)\left[\left(1 - \lambda^d b\right) X_H(Z; \mu)\right] + \chi\delta b\lambda^d\left[\frac{Z}{\chi} - i(\mu)\mathbb{D}\right] \\ = \; & f + b\left\{\left(1 - \lambda^d\right)\left(1 - \lambda^d b\right) + \delta\lambda^d\right\} X_H(Z; \mu) \end{aligned}$$

If, however, the manager selects the low volatility project, then their expected pay is

$$\begin{aligned} & f + b\left(1 - \lambda^d\right)\left[\left(1 - \lambda^d b\right) X_L(r)\right] + \delta b\lambda^d[r - \mathbb{D}] \\ = \; & f + b\left\{\left(1 - \lambda^d\right)\left(1 - \lambda^d b\right) + \delta\lambda^d\right\} X_L(r) \end{aligned}$$

Comparing these executive payoffs, the low volatility project is chosen if and only if $X_L(r) > X_H(Z; \mu)$, yielding the result. ■

Deferred equity-linked pay maintains the link between the executive's interests and those of the shareholders: the bonus is proportional to the realised equity values. Thus, the excessive risk-taking caused by AP3 is not solved by deferred equity pay, although this could correct for the excessive short-termism of the bank executive – i.e. AP1. This suggests that the payoff from deferral must be decoupled from the real-time equity values in order to achieve the regulator's objective. One way to achieve this is through the use of clawback – which puts a fixed monetary value at risk – which we explore next.

4.3 Malus and clawback

We now consider alternative forms of exposing the executives to compensation risks that may crystallise only in the long-run: malus and clawback. Both of these interventions have the effect of putting a fixed monetary value of the executive's pay at risk. Malus is an arrangement that permits the institution to prevent the vesting of all or part of the amount of deferred remuneration awarded in relation to risk outcomes or performance. Clawback is a contractual agreement whereby the staff members agree to return ownership of an amount of remuneration that has already been paid by the institution under certain circumstances. The intended aim of these policies is to discourage excessive risk-taking and short-termism, and to encourage more effective risk management. In the United Kingdom, for example, the variable remuneration of material risk takers will be subject to clawback for a period of seven to ten years.[14] We study the impact of this type of policy below.

Suppose that the executive expects to lose a proportion P of the bonus paid at $t = 1$ through application of malus or clawback in the event of a bank failure at $t = 2$, regardless of whether the bank is bailed out or not. We continue to allow the executive to discount $t = 2$ payments by a factor of $\delta \leq 1$, while the bank discounts future payouts at discount factor 1. For simplicity, we assume that, in the case of a bank failure, the bonus returned (or cancelled) does not accrue to the debt holders.[15]

At $t = 1$, the bank raises debt $\mathbb{D}$ and adds in sufficient equity to cover the costs of investment and staff pay. If the executive selects the low volatility project, then the bank will have a $t = 1$ valuation of $X_L(r)$ as given by (10). This valuation is unchanged as the bank pays out the full bonus due to the executive at $t = 1$. As the project is low volatility and so modelled as having no risk of default, the executive understands that he will not be subject to clawback. Hence, if the executive chooses the low volatility project, his pay will be:

$$f + bX_L(r) \tag{26}$$

Suppose instead that the executive selects the high volatility project. The $t = 1$ value of the bank will again be altered by the value of the implicit government debt guarantee. Since any

[14]For further details on the deferral and clawback periods in the UK, see the Policy Statement PRA12/15 FCA PS15/16. The final provisions on clawback and deferral will apply to variable remuneration awarded for performance periods beginning on or after 1 January 2016.

[15]This assumption is made to simplify analysis, and can be justified on the ground that the bonus withheld or clawed back will be small relative to the debt outstanding. However, it is not an essential assumption as the intuitions do not hinge upon it.

payments made through clawback in the case of bankruptcy are assumed not to accrue to the banks' creditors, the interest payable on debt remains at $i(\mu)$ given in (15). The $t = 1$ valuation for the bank which is pursuing the risky project remains $X_H(Z;\mu)$ given by (16). If he selects the high volatility project, the executive will be forced at $t = 2$ to repay proportion P of his $t = 1$ bonus with probability $1 - \chi$. The executive's $t = 1$ expected pay is therefore

$$f + bX_H(Z;\mu)[1 - \delta P(1 - \chi)] \tag{27}$$

Lemma 4 *If the executive exerts effort and learns $\{r, Z\}$ then he selects the low volatility project if and only if $r > W(Z, P)$ where*

$$W(Z, P) = Z + (1 - \chi)\mu i(\mu)\mathbb{D} - \delta P(1 - \chi)[Z - \chi i(\mu)\mathbb{D}] \tag{28}$$

Proof. The result follows by comparing the executive's payoff using (26) and (27). ■

We first note that, if the executive expects malus and clawback to be conditioned on the expected risk and return characteristics as they were at $t = 1$, and not on the $t = 2$ realised outcome, then these policies can induce the first best outcome. Specifically, the first best outcome is achieved if the proportion of bonus at risk of malus or clawback $P^*(Z)$ is set to solve the condition $W(Z, P) = Z$, requiring:

$$P^*(Z) = \frac{\mu\mathbb{D}}{\{[\chi + (1-\chi)\mu]Z - \chi\mathbb{D}\}\delta} \tag{29}$$

It can be seen that $\frac{\partial P^*}{\partial Z} < 0$. Hence for malus or clawback to induce the optimal risk-taking incentive, the executive should expect to lose more money in the event of a failure if he chooses a bad project *ex ante* (with a low ex ante net present value Z). In other words, malus and clawback are most effective in inducing optimal risk-taking when the executive believes that they will be conditioned on the evidence of serious failure of risk management.

Next, we illustrate that malus and clawback does not necessarily induce the first-best outcome if the executive does not believe that they will be applied in this fashion. For example, malus could be applied if the bank suffers a material downturn in its financial performance. Thus, suppose now that the executive bases his *ex ante* project choice on a belief that he will lose a proportion P of the bonus if his bank were to fail.

Proposition 6 *Suppose that the executive expects to lose a proportion P of the bonus in the* *event of a bank failure through malus or clawback. For any positive expected level of clawback,* $P > 0$,

1. *There exist high expected value risky projects over which the executive will be excessively risk averse; selecting the safe project even though it has a lower expected return than the risky project.*

2. *If the bank is sufficiently levered there exist low expected value risky projects over which the executive will be insufficiently risk averse; selecting the risky project even though it has a lower expected return than the safe project.*

Figure 2 summarises these results graphically. Under the first best project selection rule, the high volatility project is chosen whenever Z is above the black dashed 45^o line ($Z = r$). In the presence of the TBTF distortion, however, the executive chooses the high volatility project whenever Z is above the black solid line. If the malus or clawback rate can be set conditional on the project choice, as in (29), then it can shift the project selection rule to the first best (the black dashed 45^o line), thus inducing the first best project choice. However, if the executive expects that the loss on bonus will not be conditioned on project choice, then the project selection rule shifts and rotates to the red dotted line. The resulting regions of excessive risk aversion and risk lovingness (or insufficient risk aversion) are displayed as yellow and pink shaded regions labeled Av. and Lo, respectively This disparity between the first best and the clawback-induced project choice – due to the rotation of the project selection rule – is created because the value of the bonus and so the sums clawed back are proportional to the expected future equity values, while the size of the distortion caused by the implicit government guarantee is proportional to the value of the debt.

Thus, when the executive does not expect malus and clawback to be applied conditional on the *ex ante* project choice, then the second best outcome is achieved if the executive's expectation of a financial loss can be managed so as to minimise the regions Av. and Lo. This can be obtained by maximising the expected return from projects chosen by the executive, $\Omega(P)$, with respect to P :

$$\Omega(P) = \int_{Z=1}^{\infty} \left\{ \int_{r=1}^{W(Z,P)} Z f_L(r)\, dr + \int_{r=W(Z,P)}^{\infty} r f_L(r)\, dr \right\} f_H(Z)\, dZ$$

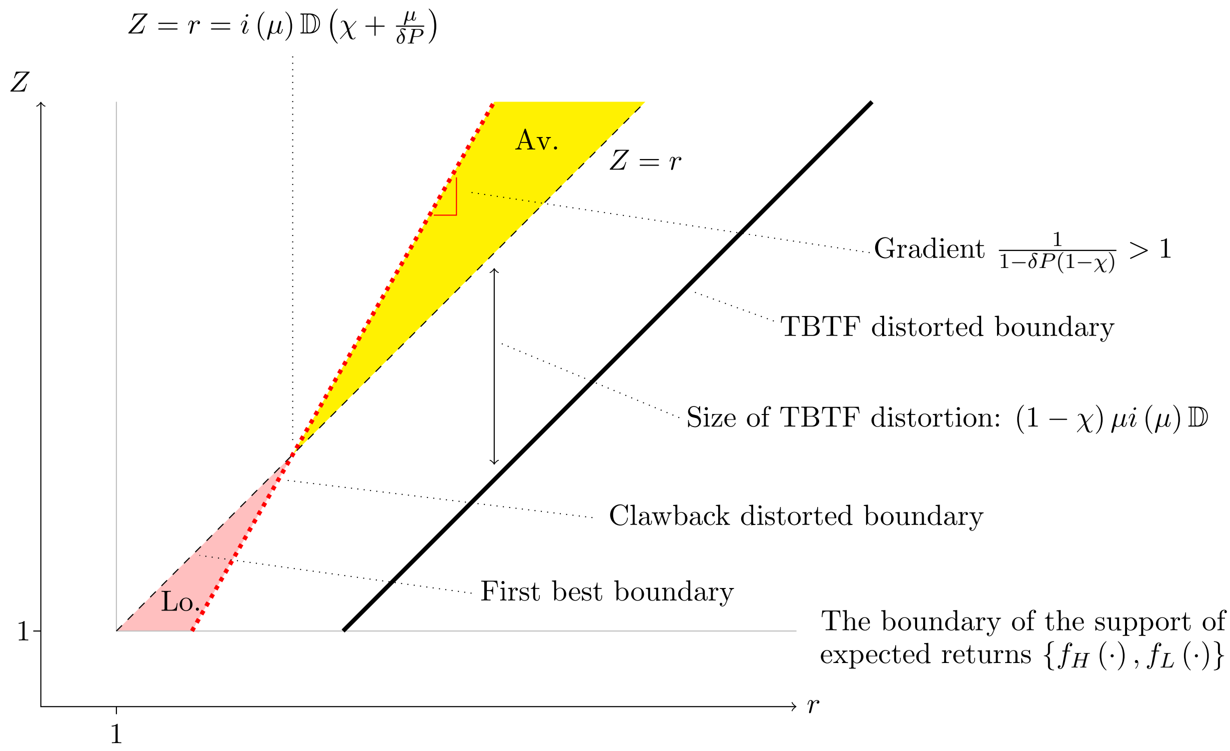


Figure 2: Executive's project selection regions.

Notes: The first best boundary is given by the black dashed line: select the high risk project iff it has the highest expected return, $Z > r$. The TBTF distortion moves the executive's selection to the black solid line. Clawback returns the project selection rule towards the first best: the red dotted line. However the correction is imperfect. The executive is too risk loving over projects in the pink shaded region labeled 'Lo.', and too risk averse over projects in the yellow shaded region labeled 'Av.'. By inspection the excessive risk loving region exists if $i(\mu)\,\mathbb{D}\left(\chi + \frac{\mu}{\delta P}\right) > 1$ (Proposition 6, part 2).

Proposition 7 *1. Creating an expectation of some financial loss for the executive in the event of a bank failure is always optimal for any positive level of leverage.*

2. Full clawback will be optimal if the bank is highly levered and the probability of high value risky projects existing is sufficiently low.

We know from Lemma 3 that, in the absence of malus or clawback, the executive will be excessively risk loving. Increasing the clawback rate up from zero increases expected social welfare as the executive is made a little less risk loving at all project values.[16] This can be seen in Figure 2: if the clawback proportion, P, is close to zero, then the gradient of the clawback-distorted boundary tends to 1 and the decision rule approaches the TBTF distortion (the black solid line). Increasing P up from zero causes the project selection rule under clawback (red dotted line) to shift and rotate back towards the first best (black dashed line).

If the leverage of the bank is high, then the value of the TBTF guarantee for shareholders is

[16]The tradeoff described in part 2 of Proposition 6 doesn't bite as the range of projects for which the executive is excessively risk averse is of smaller measure than the projects where the executive's incentives as corrected.

larger and hence the executive has greater incentive to take excessive risks.[17] Thus, if the bank is highly levered, the benefit associated with a high expected clawback rate outweighs the cost of making the executive excessively risk averse over risky but high expected value projects, if such projects are expected to be rare. This is the intuition underlying part 2 of Proposition 7. An implication of this reasoning is that the clawback rate should be a function of the bank's leverage, but the exact relationship depends upon the relative shapes of the density functions f_L and f_H of the possible project expected values.

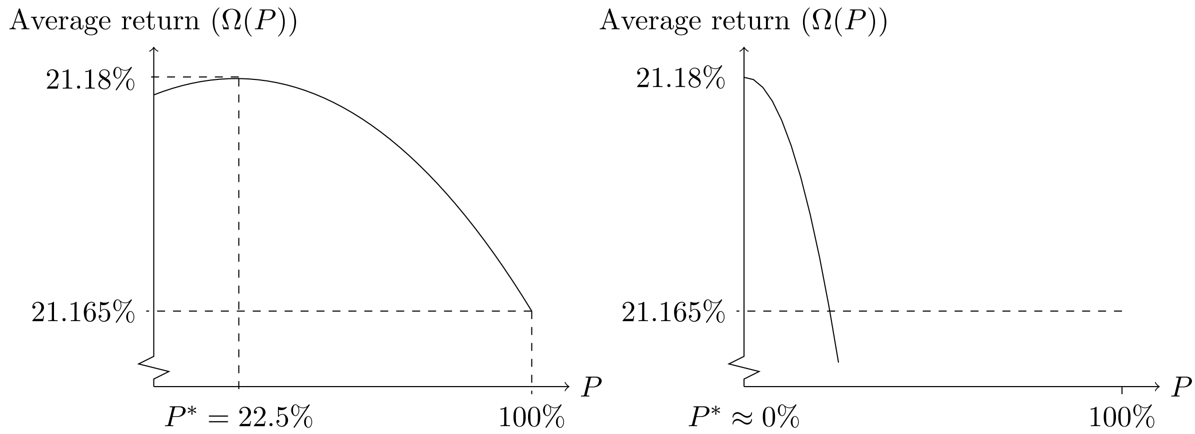
Variable	**Calibration**	**Justification**
Expected return on high risk project, Z	$Z \sim N(1.13, 0.17)$ truncated on $[1, \infty)$	S&P 500 Value weighted annual returns 1980 – 2014. Authors' calculations using CRSP data.
Expected return on low risk project, r	$r \sim N(1.08, 0.07)$ truncated on $[1, \infty)$	5 year US Treasury Bond annual returns 1980 – 2014. Authors' calculations using CRSP data.
Debt $\mathbb{D}$ for bank	90%	Modal ratio for large US banks in Thanassoulis (2012).
Debt $\mathbb{D}$ for non-financial firm	35%	Graham, Leary and Roberts (forthcoming); average US corporate debt ratio since 1970.
TBTF bailout probability μ for bank	5%	Assumes a 1 in 20 chance the bank will be TBTF and be bailed out conditional on distress.
TBTF bailout probability μ for non-financial firm	0.5%	Assumes a 1 in 200 chance a non-financial firm will be TBTF and be bailed out conditional on distress.
χ	0.95	Assumes a 1 in 20 chance enterprise will suffer significant distress including potential bankruptcy.

Table 1: Input data used for numerical calibrations.

To illustrate this point, we conduct two calibrations of the expected project return, $\Omega(P)$. We use both original source data and prior publications to study the level of financial loss that the executives of systemically important banks and non-financial corporations should expect to suffer in the event of a bank failure. The sources and numerical figures we use are documented in Table 1. The results of the calibration are plotted for a bank and a non-financial corporation in Figure 3. Our analysis suggests that a clawback regime is not warranted for non-financial corporations. By contrast, bank executives should be expecting to lose, on average, 20% of their bonus in the event of a bank failure, given the parameters in Table 1: this could, for example, mean expecting to lose all of their bonus with a probability of 20% in the event of a bank failure. These results should be interpreted as illustrative as the parameter values used for the analysis

[17] The black solid line in Figure 2 moves to the right.

will not be appropriate in all situations.



(a) Bank data calibration

(b) Firm data calibration

Figure 3: Numerical simulation of optimal clawback proportions.

The figures plot the regulator's payoff function $\Omega(P)$ against the clawback proportions P. The parameters used in the calibration are documented in Table 1. The figures demonstrate that positive clawback is optimal for the bank, whereas clawback is calculated to be damaging in our calibration if used for remuneration at non-financial corporations.

We conclude this section by studying how the bank may respond to malus and clawbacks. Malus and clawback can bring the executive's project choice closer to the social optimum, but this is not optimal from the perspective of the shareholders. Shareholders would profit from incentivising the executive to select riskier projects in order to maximise the benefit from the TBTF subsidy. We examine two ways in which shareholders can respond in order to dilute the impact of clawbacks.

Altering the bonus structure. Note that the mix or the level of equity bonus relative to fixed pay cannot alter the project selection rule, as long as the incentive compatibility constraint to exert effort is satisfied.[18] Malus and clawbacks are therefore robust to any increase of the executive's share award (larger b). However, the bank's shareholders could alter the structure of the bonus itself in order to dilute the impact of the clawback on the executive's project selection:

Proposition 8 *Suppose the bank introduces a convex increasing $t = 1$ bonus function $\beta(X)$, $\beta' > 0, \beta'' > 0, \beta(0) = 0$, with X the $t = 1$ bank value. For any given positive clawback $P > 0$, the executive is more likely to choose the high volatility project than under clawback with a linear bonus function.*

[18]From Lemma 4, the low volatility project is selected as long as $r > W(Z, P)$, and this is independent of f and b.

Proposition 8 shows that the shareholders could offset the impact of the clawback on the executive's incentives by making the bonus convex in the value of equity. Clawback induces the executive to sacrifice some expected equity-holder value available from selecting the high volatility project due to the risk of having pay clawed back in bad states of the world. By introducing sufficient convexity in the executive's compensation the bank can make it disproportionately expensive to the executive to reduce the expected $t = 1$ equity value. This can essentially bribe the executive to run the risk of clawback.

Increasing leverage From Lemma 4, the executive selects the low volatility project if and only if $r > W(Z, P)$. As $W(Z, P)$ is increasing in the debt level, $\mathbb{D}$, increasing debt makes the low volatility project less likely to be selected. However, in the presence of regulatory capital requirements, the scope for banks to simply increase leverage in order to maximise the benefit of the implicit subsidy may be limited in practice.

4.4 Measuring executive performance against a re-based value of equity

The practice of using Return on Equity (RoE) as a key performance metric to reward senior executives has been criticised by senior banking regulators (e.g. Haldane (2011)) on the grounds that it encourages bank executives to increase leverage. In the UK, the Prudential Regulation Authority is introducing the proposed rule that simple revenue or profit-based measures may not be relied on to determine variable remuneration at aggregate or individual level, except as part of a balanced and risk-adjusted scorecard.[19] Our analysis provides one rationale explaining why linking remuneration to equity-based performance metrics could induce excessive risk-taking – that is, that the bank's equity value could be distorted by the TBTF effect. This section proposes and examines a regulation which requires executive pay to be based on the equity valuation corrected for the value of any implicit government guarantee. We explore how rebasing the equity metric away from raw RoE in this way alters the executive's incentives.

The value of the implicit government guarantee, $V^{\text{gov g'tee}}$, is the expected repayment from the government to debt holders which, at present, equity holders enjoy:

$$V^{\text{gov g'tee}}(\mu) = \begin{cases} 0 & \text{low volatility project selected} \\ (1-\chi)\,\mu i(\mu)\,\mathbb{D} & \text{high volatility project selected} \end{cases} \tag{30}$$

We will discuss the existing empirical estimates of this number at the end of this section. The

[19]See the Policy Statement PRA12/15 FCA PS15/16, paragraph 2.37.

intervention considered here is that the executive can only be rewarded in proportion to the $t = 1$ equity value of the bank *net* of the value of the implicit government guarantee $\left(V^{\text{gov g'tee}}\right)$.

Proposition 9 *When the executive is rewarded based on equity value net of the value of the implicit guarantee, the executive who exerts effort will make an efficient project choice: selecting the high volatility project if and only if $r < Z$.*

Proof of Proposition 9. If the executive selects the low volatility project, then the bank value is $X_L(r)$ given by (10). Rebasing the equity value as required in compensation, the executive in this case receives

$$f + b\left(X_L(r) - \underbrace{V^{\text{gov g'tee}}(\mu)}_{=0}\right) = f + b(r - \mathbb{D}) \tag{31}$$

If instead the executive selects the high volatility project, then the bank value is $X_H(Z;\mu)$ given by (16). Rebasing the equity value as required in compensation leaves the executive with

$$f + b\left(X_H(Z;\mu) - V^{\text{gov g'tee}}(\mu)\right) = f + b(Z - \mathbb{D})$$

Comparing these payments delivers that the executive will select the low volatility project, if and only if $r > Z$ yielding the required result. ■

Proposition 9 shows that requiring the bank to measure executive performance against the return on equity net of the implicit government guarantee will ensure that the equity-bonused executive will make the socially optimal project choice. By directly eliminating the distortions from the executive's performance measure, this policy aligns his incentives with the social optimum. But the shareholders are likely to oppose such a policy as the executive is no longer incentivised to maximise returns to shareholders by taking advantage of the *TBTF* distortions.

We conclude this section by offering an estimate of the likely size of the TBTF subsidy, and so determine the scale of correction which this section suggests be applied to bank values when calculating bonuses. The seminal estimate of the TBTF subsidy is perhaps due to O'Hara and Shaw (1990). O'Hara and Shaw conduct an event study on the day the Comptroller of the Currency in the US announced that eleven of the largest US banks were TBTF. This analysis estimated the TBTF value as 1.3% of total enterprise value. To the extent that the identity of these eleven banks was already known this will be an underestimate. Further, if a bank has a debt to value ratio of 90% (modal value from Thanassoulis (2012) - Table 1) then TBTF equates to 13% of the bank's equity value.

More recently scholars have proposed estimating the reduction in the cost of borrowing by comparing the interest charged against predicted interest rates generated using data from banks thought to not be TBTF. Acharya, Anginer and Warburton (2013) estimate that the TBTF advantage of US banks averaged 24 basis points over the 20 years 1990-2010. Li, Qu, and Zhang (2011) place the TBTF subsidy at 23 basis points before the crisis, and 56 basis points after the crisis. Multiplying these figures by the total debt of the TBTF bank yields an estimate of the *annual* value of the government guarantee as between 2% and 5% of equity value.[20] When capitalised at a rate of 13% (the average return on the S&P – Table 1) this generates estimates of TBTF of between 15% of equity value before the crisis and 38% of equity value after the crisis.

4.5 Bonus cap

The European Union is the first major jurisdiction to introduce a mandatory bonus cap on all material risk takers of banks and investment banks as part of financial regulation.[21] The legal code notes that "*to avoid excessive risk taking, a maximum ratio between the fixed and the variable component of the total remuneration should be set.*" Material risk takers can only receive variable pay up to a limit of 100% of their fixed salary. If preceded by an authorising vote at an AGM, this cap can be raised to 200% of the fixed pay. Here we consider whether the bonus cap can reduce the excessive risk taking arising from AP3: that is can the cap serve the regulator's interests which are at odds to those of the stockholders.

Suppose that if the executive has a fixed wage of f, then the maximum dollar variable bonus the executive can receive is f. A key insight is that, once the bonus cap becomes binding, the executive will have no incentive to choose one project over another. A key problem in analysing a bonus cap is therefore that there is no standard way of forecasting how the executive facing a binding bonus cap will behave. Thus, we proceed in our analysis by postulating the following two alternative assumptions about the executive's behaviour:

Assumption 1: if the expected value of the executive's pay is equal from the two projects, he chooses the project which maximises the social welfare, i.e. the project with the highest expected net present value.

[20] If TBTF yields an interest reduction of α basis points then this equates to a benefit of $\frac{\alpha}{100}\frac{D}{E}\%$ as a percentage of bank equity value. The figures then follow assuming $D/E \approx 9$ for a large bank, as used in Table 1.

[21] See DIRECTIVE 2013/36/EU Article 92(g)(i).

Assumption 2: if the expected value of the executive's pay is equal from the two projects, he chooses the project which maximises the shareholder value.

Proposition 10 *The bonus cap does not alter the executive's project selection decision from the case of no-intervention, as long as the executive facing a binding bonus cap seeks to maximise shareholder value rather than social welfare (ie Assumption 2 rather than Assumption 1 holds).*

We are not aware of any theoretical or empirical literature that suggests that Assumption 1 holds in general. Thus, we conclude that the bonus cap, by itself, is unlikely to be an effective tool to curb the executive's risk-taking incentives.

5 Conclusions

We have demonstrated that the interests of shareholders and the regulator can diverge in the presence of the TBTF effect. In this case, the compensation contract offered to the executive to maximise shareholder returns can lead to socially excessive risk choices. Our analysis therefore complements the existing literature on remuneration regulation which primarily focuses on resolving the agency problem between the bank executive and shareholders on the one hand, and the uninformed debt holders on the other. Although we acknowledge that risk-shifting to uninformed debt holders remains an important consideration, our analysis highlights another source of distortion which causes excessive risk-taking by bank managers even when the debt market is fully informed and can price the credit risk.

We note that there are two main ways of correcting for the TBTF distortion. The first is to ensure that the bank managers suffer a financial penalty *ex post* when the bank fails, regardless of whether its creditors are bailed out or not. Thus, malus or clawback improves executive choice from a social viewpoint by imposing financial losses on risk-takers when the bank fails. However, malus and clawback on incentives cannot perfectly correct for the TBTF distortion, unless they are conditioned fully on the *ex ante* risks taken by the executive. Moreover, the impact of malus and clawback could be diluted, for example if the bank's shareholders choose to offer highly convex bonus schedules to risk takers. The second is to ensure that, *ex ante*, bank managers' performance metrics are not just based on raw RoE measures when these are likely to be distorted by the TBTF effect. Rebasing the performance metric which is used to determine the bank manager's pay from RoE to equity value corrected for the value of the TBTF guarantee can correct the project choice distortion.

By contrast, including debt which is *pari passu* with other creditors as part of variable remuneration, and the deferral of equity-linked bonus do not correct for the executive's excessive risk-taking incentives caused by the TBTF distortion. In the case of debt, this is because interest payments adjust to the risk borne by creditors, making the return on debt invariant to project choice; and to the extent that the price of debt itself is distorted by the TBTF effect, payment in debt will not correct the incentive of the executive. Similarly, the executive who received deferred equity-linked bonus remains fully exposed to the benefits of implicit government guarantee via low interest payments on debt, which artificially boosts equity value. Finally, we also show that bonus caps are unlikely to reliably curb the executive's risk-taking incentives: once the bonus caps become binding, it becomes indeterminate what project the executive will choose.

This analysis suggests that passive remuneration regulation alone is unlikely to effectively mitigate bank managers' risk-taking incentives. Hence, it would need to be complemented by the active monitoring of gaming of remuneration regulation. The analysis also underscores the importance of policy efforts to end the too-big-to-fail problem by, for example, establishing a credible resolution regime which can manage the impact of bank failure and force shareholders and debt holders to bear the losses.

A Technical proofs

Proof of Proposition 1. The owner's problem if they wish to incentivise effort, which we will assume for now and check subsequently, is to maximise (5) subject to (3) and (4).

The objective function (5) is declining in f and b. The optimal remuneration therefore lowers the fixed component f until the participation constraint (3) is binding, this does not affect constraint (4). Substituting back into the objective function, (5) is now independent of the bonus rate f and b. The proposition seeks the contract with the lowest variable component, and this is achieved by reducing the bonus rate b to the point that the incentive compatibility constraint (4) is also binding. This delivers (6). Substituting the resultant bonus b into the participation constraint (3) and reorganising, we obtain (7). Substituting (6) and (7) into (5) yields (8). Part 3 is given by Lemma 1.

Finally we derive conditions for incentivising effort to be optimal. If the contract does not incentivise effort then the high volatility project is chosen as noted in footnote 10. In this case the expected profit of the equity owners is $E_H(Z) - (f + bE_H(Z)) - 1$. To ensure the executive accepts the contract the fixed fee must satisfy $f + bE_H(Z) + B = u$. Hence the equity holders expected payoff is $E_H(Z) + B - u - 1$. Comparing this to (8) we see that effort is desirable if $B < S - E_H(Z)$ so the result follows by setting $\bar{B}$ to be equal to the right hand side of this expression. ■

Proof of Lemma 3. If the executive exerts project selection effort then at $t = 0$ he will know the expected return set available $\{Z, r\}$. If the executive chooses the high volatility project then his payment at $t = 1$ will be $f + bX_H(Z; \mu)$, analogously for the low volatility project. The low volatility project is therefore only selected if $X_L(r) > X_H(Z; \mu)$. Comparing (10) to (16) and using the fact that

$$(1 - \chi i(\mu))\,\mathbb{D} = \left(1 - \frac{\chi}{\chi + (1-\chi)\mu}\right)\mathbb{D} = \underbrace{\frac{(1-\chi)\mu}{\chi + (1-\chi)\mu}}_{\equiv G(\mu,\chi)}\mathbb{D} = (1-\chi)\,\mu i(\mu)\,\mathbb{D} \tag{32}$$

yields (17).

For the final part rewrite condition (17) as the low volatility project only being selected if $r > Z + G(\mu, \chi)\,\mathbb{D}$. As $\partial G / \partial \mu > 0$ we have the required result. ■

Proof of Proposition 2. We first simplify the incentive compatibility constraint (21). Using (16):

$$\begin{aligned} E_H[X_H(Z;\mu)] &= E_H(Z) - \chi i(\mu)\,\mathbb{D} \\ &> E_L(r) - \chi i(\mu)\,\mathbb{D} \\ &> E_L(r) - \mathbb{D} = E_L[X_L(r)] \end{aligned} \tag{33}$$

The first inequality follows from (1), the second from (15). Hence the incentive compatibility constraint (21) can be written:

$$b\,[S(\mu) - E_H[X_H(Z;\mu)]] > B$$

The proof then proceeds analogously to the proof of Proposition 1. ■

Proof of Proposition 3. We simplify the equilibrium bonus in (22) using an integration by parts as

$$
\begin{aligned}
b &= B \Bigg/ \left[\begin{array}{c} \int_{Z=1}^{\infty} f_H(Z) \left\{ \int_{r=1}^{Z+(1-\chi)\mu i(\mu)\mathbb{D}} X_H(Z;\mu) f_L(r)\, dr + \int_{r=Z+(1-\chi)\mu i(\mu)\mathbb{D}}^{\infty} X_L(r) f_L(r)\, dr \right\} dZ \\ - \int_{Z=1}^{\infty} f_H(Z) \int_r X_H(Z;\mu) f_L(r)\, drdZ \end{array} \right] \\
&= B \Bigg/ \left[\int_{Z=1}^{\infty} f_H(Z) \int_{r=Z+(1-\chi)\mu i(\mu)\mathbb{D}}^{\infty} [1 - F_L(r)]\, drdZ \right] \qquad (34)
\end{aligned}
$$

For part (1.): If if the ex ante distribution of expected returns for the low volatility project $(f_L(\cdot))$ increase in a first order stochastically dominant manner then $F_L(r)$ falls for every r in the support. This causes the denominator in (34) to increase so lowering the optimal b. For part (2.) we rewrite the denominator of (34) using the fact that:

$$
\begin{aligned}
& \int_{Z=1}^{\infty} f_H(Z) \int_{r=Z+(1-\chi)\mu i(\mu)\mathbb{D}}^{\infty} [1 - F_L(r)]\, drdZ \qquad (35) \\
= & \underbrace{\left[F_H(Z) \int_{r=Z+(1-\chi)\mu i(\mu)\mathbb{D}}^{\infty} [1 - F_L(r)]\, dr \right]_1^{\infty}}_{=0} + \int_{Z=1}^{\infty} F_H(Z) [1 - F_L(Z + (1-\chi)\mu i(\mu)\mathbb{D})]\, dZ
\end{aligned}
$$

Where we use that Z is supported on $[1, \infty)$. As the ex ante distribution of expected returns for the high volatility project $(f_H(\cdot))$ increases in a first order stochastically dominant manner, $F_H(Z)$ declines for every Z in the support, and so the denominator of the optimal bonus rate declines also. Hence the bonus rate increases as required.

Part (3.) follows from (34) directly. For part (4.) note that the lower bound of the integral in the denominator of (34) equals $Z + G(\mu, \chi)\mathbb{D}$ as given in (32). As $\partial G / \partial \mu > 0$ we have the result. For part (5.) we have that $\partial G / \partial \chi < 0$. Hence the denominator of the optimal bonus rate is increasing in χ. It therefore follows that the optimal bonus rate is falling in χ. The high volatility project has returns $\{Z/\chi, 0\}$ and so the volatility increases as χ decreases. Hence the optimal bonus rate rises as the volatility of the risky project increases, giving (5).

For (6) note that, from the proof of Lemma 3 the distortion in project choice grows in $G(\mu, \chi)$. Hence the result that $\partial G / \partial \chi < 0$ implies that if the volatility of the risky project increases, χ must fall, causing $G(\mu, \chi)$ to grow and so delivering the result. Finally the condition for inducing effort to be optimal can be written

$$
B < \int_{Z=1}^{\infty} f_H(Z) \left\{ \int_{r=Z+G(\mu,\chi)\mathbb{D}}^{\infty} (1 - F_L(r))\, dr \right\} dZ
$$

If the volatility of the risky project grows, χ is declining, and $\partial G/\partial\chi < 0$ implies that the upper bound on B above which effort is not worth inducing is reduced. ■

Proof of Proposition 6. For part 1 we must show that $W(Z,P) < Z$ for some Z. This is true for large Z given $P > 0$ as $\lim_{Z\to\infty} Z - W(Z,P) \to \infty$. For part 2 we must show that $W(Z,P) > Z$ for some Z when $\mathbb{D}$ is high enough. Consider $\mathbb{D} = 1$. We have $[W(Z,P) - Z]_{Z=1,\mathbb{D}=1} = (1-\chi)\,\mu i(\mu)\,[1-\delta P(1-\chi)] > 0$. The result follows by continuity of $W(Z,P)$ in both Z and $\mathbb{D}$. ■

Proof of Proposition 7. For part 1 we wish to show that $[\Omega'(P)]_{P=0} > 0$:

$$\left[\Omega'(P)\right]_{P=0} = \left[\int_{Z=1}^{\infty} [Z - W(Z,P)]\,\frac{\partial W(Z,P)}{\partial P} f_L(W(Z,P))\, f_H(Z)\, dZ\right]_{P=0} \tag{36}$$

To sign this note that $Z - W(Z,0) < 0$, and further $Z - W(Z,0)$ is independent of Z. So

$$\left[\Omega'(P)\right]_{P=0} =_{\text{sign}} \left[\int_{Z=1}^{\infty} -\frac{\partial W(Z,P)}{\partial P} f_L(W(Z,P))\, f_H(Z)\, dZ\right]_{P=0}$$

Now

$$\left[\frac{\partial W(Z,P)}{\partial P}\right]_{P=0} = -\delta(1-\chi)\,[Z - \chi i(\mu)\,\mathbb{D}] < 0 \tag{37}$$

The inequality follows as $Z \geq 1 \geq \mathbb{D} > \chi i(\mu)\,\mathbb{D}$. As $\left[\frac{\partial W(Z,P)}{\partial P}\right]_{P=0} < 0$ so $[\Omega'(P)]_{P=0} > 0$ yielding the result.

For part 2 we wish to determine conditions such that $\Omega'(P) > 0$ for all $P \in [0,1]$. Using (37) $\frac{\partial W(Z,P)}{\partial P} = \left[\frac{\partial W(Z,P)}{\partial P}\right]_{P=0} < 0$. Further $[Z - W(Z,P)]_{Z=1,\mathbb{D}=1} = -(1-\chi)\,\mu i(\mu)\,[1-\delta P(1-\chi)] < 0$. We therefore have that $\left[[Z - W(Z,P)]\,\frac{\partial W(Z,P)}{\partial P} f_L(W(Z,P))\, f_H(Z)\right]_{Z=1,\mathbb{D}=1} > 0$. If the mass of $f_H(\cdot)$ is sufficiently concentrated around $Z = 1$ then the result follows. ■

Proof of Proposition 8. With a linear bonus function the low volatility project is selected iff

$$X_L(r) > [1-\delta P(1-\chi)] \cdot X_H(Z;\mu)$$

Suppose the executive's compensation is changed to $\tilde{f} + \beta(X)$. The change in pay alters the required equity from owners given the debt level. The $t = 1$ value of the bank given the project choice is therefore unchanged at $X_H(Z;\mu)$ and $X_L(r)$. The executive will choose the low volatility project iff $\tilde{f} + \beta(X_L(r)) > \tilde{f} + \beta(X_H(Z;\mu))\,[1-\delta P(1-\chi)]$. This inequality is independent of the fixed wage level $\tilde{f}$. Hence the low volatility project is selected if and only if:

$$X_L(r) > \beta^{-1}\left(\left[1 - \delta P(1-\chi)\right] \cdot \beta\left(X_H(Z;\mu)\right)\right)$$

As $\beta(\cdot)$ is convex increasing, β^{-1} is concave. This implies for $\lambda < 1$,

$$\beta^{-1}(\lambda X + (1-\lambda) \cdot 0) > \lambda\beta^{-1}(X) + (1-\lambda)\beta^{-1}(0) = \lambda\beta^{-1}(X)$$

where we have used $\beta(0) = 0$. Hence if the low volatility project is selected we have

$$X_L(r) > \beta^{-1}\left(\left[1 - \delta P(1-\chi)\right] \cdot \beta\left(X_H(Z;\mu)\right)\right) > \left[1 - \delta P(1-\chi)\right] X_H(Z;\mu)$$

giving the result. ■

Proof of Proposition 10. The bonus cap combined with $t = 1$ pay will alter the required equity from owners, $\mathbb{E}$, but will not alter the expected value of the bank. Following the methods above, if the manager selects the high volatility project his pay will be $f + \min(bX_H(Z;\mu), f)$. Whereas if the low volatility project is selected then expected pay is $f + \min(bX_L(r), f)$. There are therefore four cases to consider and within each the executive's decision rule can be determined:

	$X_L(r) < f/b$	$X_L(r) \geq f/b$
$X_H(Z;\mu) < f/b$	Select low volatility project iff $X_L(r) > X_H(Z;\mu)$	Select low volatility project.
$X_H(Z;\mu) \geq f/b$	Select high volatility project	Indifferent between both projects.

By inspection of the table above the executive decision rule matches that of Lemma 3 (choose project L if and only if $X_L(r) \geq X_H(Z;\mu)$) in all cells except the bottom right. Consider the bottom right cell: $X_L(r), X_H(Z;\mu) \geq f/b$. Hence, the executive is indifferent between both projects in terms of pay. Under Assumption 1, the low volatility project is selected if $r > Z$ and $X_L(r) \geq f/b$, so the project selection decision moves towards the first best. Under assumption 2, the executive maximises the equity value; selecting the low volatility project if and only if $X_L(r) > X_H(Z;\mu)$. Hence, the bonus cap does not alter the executive's project choice from the case of no-intervention. ■

References

[1]

[2] Acharya, Viral, Deniz Anginer, and Joseph Warburton, 2013, The End of Market Discipline? Investor Expectations of Implicit State Guarantees, SSRN working paper.

[3] Admati, Anat, Peter DeMarzo, Martin Hellwig, and Paul Pfleiderer, 2013, Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Socially Expensive. Stanford Working Paper.

[4] Anantharaman Divya , Vivian W. Fang, Guojin Gong, 2014, Inside Debt and the Design of Corporate Debt Contracts, Management Science 60(5):1260-1280

[5] Bebchuk, Lucian, and Holger Spamann, 2010, Regulating Bankers' Pay, *Georgetown Law Journal*, 98, 247.

[6] Berle, A.A. and G.C. Means (1932), The modern corporation and private property (New York).

[7] Bolton, Patrick, Hamid Mehran, and Joel Shapiro, forthcoming, Executive Compensation and Risk Taking, *Review of Finance*.

[8] Blanco, Roberto, Simon Brennan, and Ian Marsh, An Empirical Analysis of the Dynamic Relation between Investment-Grade Bonds and Credit Default Swaps, 2005, *Journal of Finance*, 60, 2255-2281.

[9] Brunnermeier, Markus, and Martin Oehmke, 2013, The Maturity Rat Race, *Journal of Finance*, 483-521.

[10] DeMarzo, Peter M., and Yuliy Sannikov, 2006, Optimal Security Design and Dynamic Capital Structure in a Continuous-Time Agency Model *Journal of Finance*, 61, 2681-2724.

[11] Edmans, Alex, and Qi Liu, 2011, Inside Debt, *Review of Finance*, 15, 75-102.

[12] Edmans A, Gabaix X, Sadzik T, Sannikov Y (2012) Dynamic CEO compensation. J. Finance 67:1603–1647.

[13] Financial Stability Board, 2009a, Principles for Sound Compensation Practices. Available at http://www.financialstabilityboard.org/2009/04/principles-for-sound-compensation-practices-2/

[14] Financial Stability Board, 2009b, Implementation Standards for the FSB Principles for Sound Compensation Practices. Available at http://www.financialstabilityboard.org/2009/09/principles-for-sound-compensation-practices-implementation-standards/

[15] Freixas, Xavier, and Jean-Charles Rochet, 2013, Taming Systemically Important Financial Institutions, *Journal of Money, Credit and Banking*, 45, 37-58.

[16] Freixas, Xavier, and Jean-Charles Rochet, 2008, Microeconomics of Banking, MIT Press.

[17] Graham, John, Mark, Leary, and Michael Roberts, forthcoming, A Century of Capital Structure: The Leveraging of Corporate America, *Journal of Financial Economics*.

[18] Harrison, Glen, Morten Lau and Melonie Williams, 2002, Estimating Individual Discount Rates in Denmark: A Field Experiment, *American Economic Review*, 92(5), 1606-1617.

[19] Hakenes, Hendrik, and Isabel Schnabel, 2014, Bank Bonuses and Bailouts, *Journal of Money, Credit and Banking*, 46, 259-288.

[20] Haldane, Andrew, 2011, Control rights (and wrongs), *Wincott Annual Memorial Lecture.*

[21] Hull, John, Mirela Predescu, and Alan White, The relationship between credit default swap spreads, bond yields, and credit rating announcements, *Journal of Banking and Finance*, 28, 2789-2811.

[22] Jensen, Michael, and William Meckling, 1976, Theory of the Firm: Managerial Behavior, Agency Cost, and Ownership Structure, *Journal of Financial Economics*, 3, 305-360

[23] Jensen, Michael, and Kevin Murphy, 1990, Performance Pay and Top-Management Incentives, *Journal of Political Economy*, 98, 225-264.

[24] John, Kose, Anthony Saunders and Lemma Senbet, 2000, A Theory of Bank Regulation and Management Compensation, *Review of Financial Studies*, 13, 95-125.

[25] Li, Zan, Shisheng Qu, and Jing Zhang, 2011, Quantifying the Value of Implicit Government Guarantees for Large Financial Institutions, Moody's Analytics.

[26] Modigliani, Franco, and Merton Miller, 1958, The Cost of Capital, Corporation Finance and the Theory of Investment, *American Economic Review*, 48, 261-297.

[27] O'Hara, Maureen, and Wayne Shaw, 1990, Deposit Insurance and Wealth Effects: The Value of Being "Too Big to Fail," *Journal of Finance*, 45, 1587-1600.

[28] Sundaram, Rangarajan, and David Yermack, 2007, Pay Me Later: Inside Debt and Its Role in Managerial Compensation, *Journal of Finance*, 62, 1551-1588.

[29] Thanassoulis, John, 2013, Industry Structure, Executive Pay, and Short-Termism, *Management Science*, 59, 402-419.

[30] Thanassoulis, John, 2012, The Case for Intervening in Bankers' Pay, *Journal of Finance*, 67, 849-895.