Government Distortions, Bankers' Pay and Excessive Risk

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Abstract

If debt markets can price the risk of projects accurately, then the interests of shareholders and the regulator diverge. Shareholders see their value maximised by an equity-rewarded executive. However we demonstrate that such executives destroy welfare by selecting excessively risky projects due to two types of government-induced distortions: the debt tax shield and the implicit too-big-to-fail government guarantee. We analyse the compensation regulations open to the regulator, and assess how a bank can game the intervention. Rewarding in debt and deferred equity-based pay cannot serve the regulator by reducing excessive risk taking. Mandatory clawbacks can reduce excessive risk taking but are vulnerable to gaming via options and deferred pay. Rebasing RoE metrics can also serve the regulator and are robust to options and deferred pay based on EBIT, but not deferred equity. Bonus caps only serve the regulator if executives wish to maximise social welfare when indifferent.

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1 Introduction

In the recent global financial crisis, a number of banks accumulated large losses while their CEOs and other 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 led many to call for a review of bank executives' pay structure. Policy makers across the world have argued that bonus pay linked to equity encourages bank executives to take excessive risks from society's point of view.[1] Bank shareholders also accumulated significant losses as a result of the financial crisis. However shareholders have not welcomed many of the regulatory interventions which have been introduced. These regulations include the heavily encouraged deferral of bonuses in the US (mandatory 60% deferral in the UK); the mandatory subjection of bonuses to clawback over a period of seven years from the moment of award in the UK; caps on bonuses of no more than 100% of base pay in the EU.[2]

This paper studies executive project choice under optimal pay contracts when firms' debt is accurately priced after executives make their investment decisions. In our principal-agent model, shareholders offer an equity-linked bonus to the executive in order to incentivise him to exert costly effort to search for and select projects that maximise their return. Specifically, an executive can privately observe the expected returns of alternative projects by exerting costly personal effort. Once the project is selected, the executive raises the required debt and equity finance. The investors can observe the riskiness of the chosen project, so that debt can be appropriately priced. The executive is paid before the payoffs from the project are fully realised: this captures the difference in time scale between remuneration and the economic life-span of real world projects.

Using this model, we demonstrate that if debt markets can price the risk of projects accurately, then the interests of shareholders and the regulator diverge. Shareholders see their value maximised by an equity-rewarded executive. However we demonstrate that executives incentivised in this way destroy social welfare by selecting excessively risky projects due to two types of government-induced distortions: the tax deductibility of interest payments (the so-called debt tax shield), and the implicit subsidy arising from the government's incentive for bailouts, which remains relevant particularly for large and systemically important banks. We then use this model to evaluate the alternative forms of remuneration regulation aimed at curbing such excessive risk-taking incentives. We study which of the interventions, implemented or proposed, can move the executive's objectives towards those desired by a social planner. And we study how a bank might respond to such intervention by altering pay structures to seek to realign executives with the interests of shareholders as distinct from the broader society.

A large part of the existing literature on executive remuneration takes Jensen-Meckling's (1976) risk-shifting rationale as given and argues that equity-linked pay fails to deliver the optimal risk choice when the debt market cannot observe the riskiness of the chosen project. Under risk-shifting, equity holders lose out from the actions of their CEO. However we will argue below that executives, at major banks at least, are exposed to the discipline of informed debt

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[1]See for example the report of the UK Parliamentary Commission on Banking Standards 2013.

[2]For deferral see FSB (2009), and the UK explicit deferral percentages at PRA rule SYSC 19A.3.49; for clawback UK rules see PRA PS7/14; for bonus cap EU rules see DIRECTIVE 2013/36/EU.

markets, which mitigates standard risk-shifting concerns. And further we believe the objective of regulators is not purely to align executives' risk taking with that desired by their shareholders, but rather to address a perceived gap between the risks informed shareholders would tolerate and those acceptable to society.

In this paper, we demonstrate that equity-linked bonuses do not necessarily lead to excessive risk-taking when debt markets can efficiently price risks: they only do so when further frictions are present. We study two we believe are important: debt interest tax deductibility, and an implicit unpriced government guarantee against default. In a first best world an executive would select between projects by trading off the expected return of a project against any costs generated by the potential volatility of the cash flows. More volatile projects have a higher cost of debt so that equity fully internalises the trade-offs (Modigliani and Miller (1958)). Hence the equity-rewarded executive delivers first best project choice. But when the government subsidises debt interest payments the relationship between volatility and the price of debt is damped. Riskier projects increase the interest payable on debt financing, but the debt tax shield acts to subsidise this increased interest cost. The equity holders therefore benefit from selecting an overly risky project, and the equity-rewarded executive is incentivised to choose such overly risky projects. This damages welfare, though it maximises the equity value.

When the debt market is distorted due to the possibility of government bailouts (e.g. due to the *too-big-to-fail (TBTF)* effect) then we identify a second effect which interacts with the debt tax shield and results in executives being over-incentivised to select risky projects. When there is a positive probability that a bank may be bailed out, creditors are willing to finance risky projects at low interest rates. Thus, the possibility of government bailouts effectively subsidises risk-taking and hence induces bank executives remunerated in equity-linked bonus to take socially excessive risk. This incentive is only partly offset by the reduction in the value of the debt tax shield caused by the increased probability of bailouts and so reduction in the interest rate payable.

When these distortions are present, aligning the executive's incentive to that of the shareholders will not achieve the socially optimal outcome. Thus equity incentivisation becomes inadequate, giving rise to a case for remuneration regulation. We use our model to evaluate the effectiveness of the following alternative forms of remuneration regulation, and we study how a bank might seek to alter compensation to reintroduce the executive's distortion:

Include Debt in Compensation Including debt as part of the bank executive's pay has been suggested as a means of reducing risk-taking. We note in Section 5.1 that AIG has mandated that 80% of the value of some executives' bonus will be based on the value of AIG's junior debt. We demonstrate that, if the debt market efficiently prices credit risk, then the inclusion of debt in the executive's remuneration does not alter his risk-taking incentives. The debt receives the required return on debt capital which is independent of project choice. Forcing this into executive's pay does not correct the project distortion from society's point of view and leaves it at the shareholders' preferred level.

Deferred equity-linked pay This has been a major plank of the international regulatory response to the financial crisis. We demonstrate in Section 5.2 that deferring equity-linked remuneration will not alter the executive's incentives to the extent that equity value itself

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is distorted by the tax shield and the TBTF subsidy. The executive is fully exposed to shareholder value, albeit after a period of time, and so selects projects in the manner preferred by shareholders. The societal distortion in risk taking is not corrected.

Malus and clawback The implementation standards for FSB's *Principles* also suggest that bonus-malus and clawback must apply on cash bonuses. In the United Kingdom, the clawback rule will come into force in January 2015. We demonstrate that exposing part of the executive's compensation to the possibility of clawback can bring the executive's project selection closer to the social optimum. The tool is imperfect however, there will be projects over which clawback causes the executive to be excessively risk averse. We demonstrate that none-the-less some clawback is always optimal; and full clawback is optimal if the bank is sufficiently levered. Clawback is not robust to the introduction of convex bonus functions, e.g. by the use of options with tiered strike prices; nor to deferral of equity-linked pay. The addition of such compensation arrangements can turn the executive's decision making rule away from the regulator's desired level and back towards the distortions preferred by stock-holders.

Drop Return on Equity (RoE): Use Return Net of Tax Shield and TBTF Guarantee We note in Section 5.4 that regulators have become suspicious of RoE metrics in executive incentive plans. We propose and study an intervention which requires the executive to be judged on the return on equity net of the value of the debt tax shield and net of the TBTF subsidy. We show that this intervention returns project selection to society's first best. However shareholders see a value reduction. Such an intervention is robust to convex bonus arrangements, and so is robust to the use of options. The intervention is also robust to deferred pay based on EBIT; but deferred equity pay can be used to unwind the regulator's correction and move project choice back to the level preferred by stock-holders.

Bonus Caps As A Multiple Of Wages The European Union is the first major jurisdiction to introduce bonus caps as a multiple of the individual's base pay as part of bank regulation. We demonstrate that a bonus cap is ineffective at correcting project choice for all except project decisions between very high expected value projects. In this case the efficacy of the cap depends upon the assumptions one makes as to how executives will choose between projects when they are indifferent in pay terms. If one believes executives will break a tie in favour of the social good then bonus caps are effective over some ranges. But if executives break a tie in favour of shareholder interests then bonus caps will be ineffective at reducing excessive risk in project choice.

The paper is structured as follows. A review of related literature is offered in Section 2. Section 3 outlines the structure of our baseline model and applies it to the benchmark case of the all-equity financed firm. Section 4 examines the distortion in project choice due first to the debt tax shield, and then to the possibility of government bailouts. Section 5 examines alternative proposals for regulating executives' pay in order to correct the excessive risk-taking and assesses banks' possible attempts to game the regulation. Section 6 concludes with proofs not in the main text contained in Appendix A.

2 Literature Review

This paper seeks to contribute to the policy debate over how bank executives' compensation should be designed in order to prevent them from taking excessive risks from society's point of view. Jensen and Meckling (1976) have shown that an executive who is compensated in equity has the incentive to choose riskier investments if the debt holders cannot control his project choice after debt has been issued. They speculated that, if the executive is obliged to hold an equal proportion of the firm's equity and debt outstanding, then the agency costs of debt could be eliminated, which would be in shareholders' interests.

The more recent literature which examines the implications of agency problems, management compensation and risk-taking in banking – including Edmans and Liu (2011), Bolton, Mehran and Shapiro (2014), Hakenes and Schnabel (2014) – has largely built on the assumption that bank executives can shift risks to debt holders who are assumed to be unable to price the project risk. A number of proposals have been made for changing the remuneration structure in order to mitigate this risk-shifting problem. Edmans and Liu (2011) argue that the manager can be forced to internalise the riskiness of their decisions if they are obliged to hold some debt to maturity. Bolton et al. (2014) propose to link the executive's compensation in part to the bank's CDS spread in order to correct for this distortion, arguing that investors who trade CDS contracts will study a firm and be able to observe and assess its default risk. Hakenes and Schnabel (2014) argue that a bonus cap could help mitigate the problem of excessive risk taking caused by the possibility of bank bailouts.

In reality, however, we believe the scope for such risk-shifting may be limited for large systemically important banks or multinational firms, for several reasons. First, such large firms' debt is publicly traded, actively followed by analysts, and many such firms are also covered by credit default swap (CDS) contracts which explicitly estimate the default probability. The price of debt closely tracks the CDS-implied default probabilities (Blanco, Brennan, Marsh (2005), Hull, Predescu and White (2004)) suggesting that, when the firm returns to the market to issue debt, its price will reflect the riskiness of the project choice. Second, such large firms typically access the debt markets continuously to roll over existing debt contracts, making it unlikely that they can engage in systematic risk-shifting in equilibrium. Indeed, Figure 1 offers evidence that over the last decade the global systemically important banks (G-SIBs) – as defined by the FSB – accessed debt markets with new issuances of debt more frequently than once a quarter and sought to borrow over $800 million each time on average. This is likely to understate the normal frequency of debt issuance due to the difficulties in accessing capital markets during the height of the financial crisis.[3] Third, if creditors anticipate the executive's incentives to risk-shift, they would rationally try to minimise this possibility by only holding short-term debt contracts (Brunnermeier and Oehmke 2013). Finally, the link between the price of debt and the risk profile of the firm has explicit empirical support in the case of banks (Flannery and

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[3]During the financial crisis banks had more urgent need of capital and so one might be concerned that Figure 1 would over-estimate, and not understate as claimed, the frequency with which banks accessed the debt markets. Interrogation of the data indicates that this is not the case. Banks on average accessed the debt markets in normal times (2000Q1 to 2007Q4) 1.5 times a quarter, and so even more frequently than the 1.2 times a quarter indicated in Figure 1. Thus the debt markets are repeatedly asked to make a call on the value of fresh debt issued by banks, justifying the premise of this analysis.

Sorescu (1996), Jagtiani, Kaufman, and Lemieux (2002)), thus undermining the notion that the price of debt is insensitive to risk.[4]

The above observations suggest that risk-shifting to uninformed creditors may not be the only, or even the primary, driver of excessive risk-taking by the executives of G-SIBs. And even when risk-shifting is possible, the need to return to the debt markets frequently implies that the gains and costs induced by having interest rates misprice risk for a period of time are likely to be short-lived. Our contribution is in studying project choice distortions, from society's point of view, when risk is accurately priced.
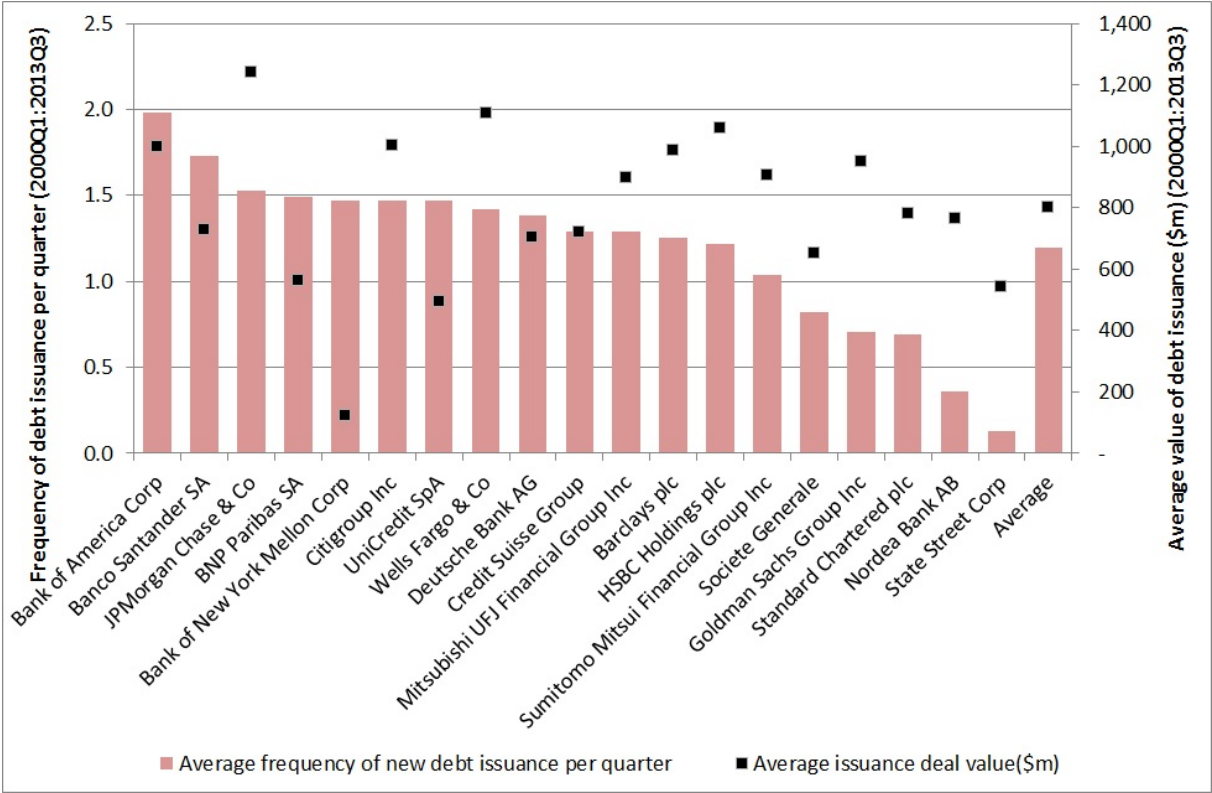

Figure 1: Frequency and Size of New Debt Issuance For G-SIBs

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 than once a quarter. For some banks the deal frequency was twice this. The points on the graph represent the average issuance size and are measured on the right hand axis. The average issuance was over $800 million. 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 a functioning debt market which evaluates firm risk after project decisions are taken. Data from Dealogic Primary Issue data for 2000Q1 through to 2013Q3.

This work is part of a general study of how executive compensation affects decision taking in banking and finance which has come to the fore following the recent global financial crisis. In earlier work John, Saunders and Senbet (2000) explore the relationship between management compensation and the FDIC's insurance premium scheme. They argue that banks' risk taking

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[4]Though Krishnan, Ritchken and Thomson (2005) caution that bank risk only accounts for a small part of changes in the price of debt – more important are changes to the cost of capital due to the macroeconomic and industry environment.

can be mitigated by making the insurance premiums that a bank pays a direct function of the parameters of the compensation contract. Here we study a government guarantee which differs fundamentally as it is (i) unpriced and (ii) ambiguous; and so the insights of John, Saunders and Senbet (2000) are not applicable. A related analysis of regulation and compensation is offered by Freixas and Rochet (2013). These authors argue that, when a bank is guaranteed to be bailed out, the owners will exploit the taxpayer by tolerating risk shifting so as to lower the required levels of compensation. In response, regulation must intervene to control the level of bonus and possible grace periods. Foster and Young (2010) caution that all compensation rules could potentially be gamed and lead to risk being pushed into the tails. For example, and in support of this thesis, Tzioumis and Gee (2013) note empirically that loan officers are more lenient towards the end of the month when exposed to non-linear pay arrangements which can be made more personally lucrative by issuing more loans. In our analysis, we explore the optimal response of the executive to any changes in pay arrangements to ensure we understand the consequences of structural pay regulation.

Our study also contributes to the part of the compensation literature which studies whether private firms would offer too little deferred pay from society's perspective. Thanassoulis (2013) links the level of deferral to market pay levels and industry structure and argues that deferral can be too slight in concentrated markets or ones where pay levels are high (such as in banking). However, Laux (2012) argues that a firm would optimally avoid using deferred pay if an executive can be fired in the light of short-term results. Deferred pay in such a setting would induce excessively risk-averse behaviour as the executives seek to retain their jobs long enough to get their bonus. Other authors have considered whether even if a manager could risk-shift, they would wish to. For example Hirshleifer and Thakor (1992) argue that the need to foster a good reputation will ensure that managers do not take excessive risks. Our contribution to this broader effort is to demonstrate that even if the debt market is efficient, distortions in project choice arise because of the debt tax shield and the implicit government guarantees. We demonstrate that some structural alterations to compensation can correct for their effects and return project choice towards the first best.

Finally, our study also contributes to the wider literature on optimal financial regulation to counter excessive risk-taking incentives caused by government-induced distortions. A vast body of work has noted that mispriced deposit protection insurance can encourage banks to take excessive risks.[5] Capital adequacy regulation – which requires each bank to hold a minimum amount of capital relative to its assets weighted by their riskiness (minimum risk-weighted capital ratio) – has been traditionally used to curb such risk-taking incentives for banks by ensuring that they have sufficient 'skin in the game'.[6] 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

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[5]Freixas and Rochet (2008) offer a textbook exposition. The literature on the effects of pricing of deposit insurance on bank risk began with Merton (1977). For a recent empirical discussion see Acharya, Anginer, and Warburton (2013).

[6]The theoretical justification for this approach was historically expressed in the form of the Pyle-Hart-Jaffee model. See Pyle (1971) and Hart and Jaffee (1974).

and Pfleiderer (2013)).[7] This paper therefore examines how compensation rules can assist capital adequacy regulation in curbing excessive risk-taking by bank executives.

3 The Model

We first present our model of CEO project choice, and then apply it to the benchmark case of the fully equity funded firm.

3.1 A Model of Project Choice

In order to analyse the optimal compensation structure, we develop a principal-agent model in which the firm owner ("she") is the principal and the executive ("he") is the agent: throughout the analysis, both are assumed to be risk-neutral. The timing of the game is as follows. At $t = 0$ the firm 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 firm. We will subsequently consider the case of adding different types of debt instrument to this compensation structure. We will also discuss the class of fully optimal compensation contracts – some of which can be generated solely with these two instruments: (f, b). The executive accepts or rejects the compensation package, and his reservation utility is given by u.[8]

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 an 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 what the expected return would have been of the alternative project which the executive did not choose. This information structure allows us to study a project choice decision in which the executive might choose the risky project when it actually has a lower net

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[7]Rochet (1992) notes that the risk weights for a security should reflect systemic risk, while Iannotta and Pennacchi (2012) argue empirically they do not.

[8]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 endogenising pay levels in banking see Thanassoulis (2012).

present value (NPV) than the safe project, with market participants unable to discern whether or not this is the case.

The socially optimal, 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 firm, gross of any executive remuneration costs, is given by $S = \int_{Z=1}^{\infty} f_H(Z) \left\{ \int_{r=1}^{Z} Z f_L(r) \, dr + \int_{r=Z}^{\infty} r f_L(r) \, dr \right\} dZ$. Using an integration by parts this can be written as:

$$S = E_H(Z) + \int_{Z=1}^{\infty} f_H(Z) \int_{r=Z}^{\infty} [1 - F_L(r)] \, dr \, dZ \tag{2}$$

After the executive selects the project at $t = 0$, the investment in the selected project occurs at $t = 1$. Both projects require a unit of investment. The firm raises debt $\mathbb{D}$ from the capital markets after the project has been decided and announced. The debt levels are assumed to not be a function of the project chosen. This allows us to study distortions in project choice independently of the known distortions created by changes in leverage.[9] The owner complements the debt $\mathbb{D}$ with sufficient equity $\mathbb{E}$ to fund the investment and the compensation costs for the executive. 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).

This model offers a tractable setting within which to study the executive's hidden project choice between high volatility and low volatility projects. 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: a two point distribution of realised values for high volatility and one point for low volatility. 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 firm default for any given level of debt.

The executive is paid at $t = 1$, after the investment is made but before the profits are realised. This captures the fact that banks typically make long-term investments, particularly when compared to the typical tenure of executives. We explore the benefits of more elaborate compensation regimes (clawbacks, deferral, options) for the regulator, and how these pay arrangements can be introduced to game the regulator's interventions, in our study of possible structural changes to the compensation regime (Section 5).

3.2 The Benchmark of the All-Equity Funded Firm

We first apply the model to the benchmark setting of the all-equity funded firm.

Suppose that the projects available to the executive at $t = 0$ are characterised by expected

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[9]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.

returns $\{Z, r\}$. The $t = 1$ costs of investment and compensation of the executive are funded by equity owner. The $t = 1$ firm value is therefore just the expected 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 firm and the executive is paid $f + br$. 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 equity-linked bonus is high enough, the executive will make the efficient project choice after exerting the project choice effort: select the high volatility project if and only if $Z > r$.*

Proof. Follows from comparison of the executive's compensation given the possible project choice. ∎

Lemma 1 suggests that the executive receiving an equity-linked bonus will make the optimal project choice, if he chooses to exert project selection effort.

At $t = 0$, the executive will anticipate that he will make an efficient project choice and so expects his bonus award to be $b \cdot S$, 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:

$$f + b \cdot S \geq u \tag{3}$$

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 firm. The $t = 0$, expected 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:

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

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 firm is characterised as follows:*

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

1. The optimal wage contract satisfies:

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

$$f = u - B - bE_H(Z) \tag{7}$$

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

$$E(\Pi_0) = S - u - 1 \tag{8}$$

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. See Annex. ∎

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. The equity stake serves two purposes. The first is to motivate effort by allowing the executive to profit from better project selection. 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 projects 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.

The executive is assumed to be risk neutral, hence many contracts are possible as the executive is indifferent to extra risk. However, if the executive is risk averse to the smallest degree, then the firm 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.

4 Government Debt Market Distortions

We now introduce two standard government debt market distortions: (i) tax deductibility of debt interest; and (ii) an ambiguous too-big-to-fail guarantee. We will show that these interventions cause the equity compensated executive to distort his project choice, and that the interests of the equity owners and the regulator diverge. We will study how a regulator can address this in the following section.

4.1 Debt Financing and Leverage: the effect of tax shields

We first look for possible project distortions in a part debt funded firm.

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 contractual interest rate i, repayable after the project is complete, at $t = 2$. The equity owner 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 firm pays on the debt will be endogenous and 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.

The realised profit of the firm is taxed at a rate τ, and interest payments over and above the the repayment of the principal made at $t = 2$ qualify as a tax shield against any corporate tax owed.[11]

Suppose that at $t = 1$ the executive selects the low volatility project with expected return r. Denote the value of the firm 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 firm is given by:

$$X_L(r) = \underbrace{\mathbb{E} + \mathbb{D}}_{\substack{\text{Pre-investment} \\ \text{Balance sheet}}} - \underbrace{1 - [f + bX_L(r)]}_{\substack{\text{Investment} \\ \text{and staff costs}}} + \underbrace{r(1 - \tau) - \mathbb{D}}_{\substack{\text{Payoff less} \\ \text{repayment to} \\ \text{debt holders}}}$$

$$\Rightarrow \quad X_L(r) = r(1 - \tau) - \mathbb{D} \text{ using (9)} \tag{10}$$

There is no tax shield here as repayments of principal do not qualify. (See footnote 11).

Suppose instead that the executive selects the high volatility project with expected return Z. In this case the firm 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 repayment on debt is given by:

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

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[11]Only the interest payment over and above the repayment of principal qualifies as an allowable expense against tax. See for example the Code of Federal Regulations 26 CFR 1.163-1 (a) available at http://www.gpo.gov/fdsys/pkg/CFR-2012-title26-vol2/pdf/CFR-2012-title26-vol2-sec1-163-1.pdf. For a simple description of how to calculate interest see CFA (2014).

The total interest here is $(i-1)\mathbb{D}$, as this is the amount in excess of the original sum borrowed. The $t=1$ firm valuation is therefore given by

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

The final bracket captures that the interest can be paid out of the gross profits, before tax is levied. The principal borrowed must then be paid out of net profits. In the event the project fails, probability $1-\chi$, there are no profits and so no tax is paid. Simplifying using (11) and (12) the $t=1$ value of the firm if the executive selects the high volatility project is

$$X_H(Z) = Z(1-\tau) + \tau(1-\chi)\mathbb{D} - \mathbb{D} \qquad (14)$$

Lemma 2 *If there is any equity-linked bonus $(b>0)$ then an executive who exerts project selection effort makes a socially inefficient project choice. The low volatility project is selected if and only if the expected returns satisfy:*

$$r > Z + \mathbb{D}\frac{\tau}{1-\tau}(1-\chi) \qquad (15)$$

Hence, the high volatility project is chosen even if its expected return is below that of the low volatility project.

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) and simplifying yields (15). ∎

The inefficiency wedge in project choice captured explicitly in condition (15) is the pre-tax expected value of the debt-interest tax shield.[12] Lemma 2 demonstrates that the tax deductibility of debt interest payments introduces a distortion in the executive's project choice. Increasing payoff volatility increases the probability of default and this increases debt interest payments. In a first best world the decision maker would balance the benefits of the return from the high volatility project against the costs from the increased volatility. However, with a positive tax shield, the repayment to debt holders is subsidised by government. This increased value from the tax shield accrues to the equity holders, and the executive wishes to maximise the size of his equity stake. Overall therefore the tax shield can be made greater by selecting higher volatility projects, and so the executive is incentivised to select high volatility projects. Note that this effect is distinct from the well known impact that the interest tax deductibility has on increasing leverage.

In this model, the interest rate payable on debt is endogenous and reflects risk. This model

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[12]To see this explicitly the post tax value of the debt interest tax shield is the tax rate τ times by the interest payment $(i-1)\mathbb{D}$. This tax shield is only received if the project is successful generating profits to set the interest against (probability χ); and the pre-tax value of this is calculated by multiplying by $1/(1-\tau)$.

allows outside investors (e.g. bond market participants) to research the firm after a business direction or project is selected. Outside investors are not obliged to invest for the project's duration in advance of project choice or in ignorance of the project choice which are the bedrock to the standard risk-shifting rationale. As noted above, we believe our formulation is natural, particularly for projects which are material enough to affect the solvency of the institution, or where debt is of shorter duration than the project and so has to be rolled-over.

We defer the discussion of the optimal contract to follow after the too-big-to-fail distortion has been introduced.

4.1.1 Debt-Induced Distortion in Project Choice – Aggravating Circumstances

As debt interest tax deductibility is ubiquitous, this distortion in project selection captured via Lemma 2 is potentially significant. We therefore pause to emphasize the assumptions upon which the result depends and consider possible reasons why this insight has been missed by prior work. In finance textbooks, the value of the debt tax shield is often studied in the context of a constant dollar debt level, with constant tax and the debt a perpetuity whose principal is only paid off at infinity.[13] In this setting the value of the debt tax shield is independent of the interest rate the company borrows at and is given by $\tau\mathbb{D}$. Riskier projects have their income stream discounted at a higher rate which in this setting exactly offsets the dollar increase in the per period tax shield. Hence, if the value of the tax shield is independent of the interest rate the firm pays then project choice cannot be distorted. However, the value of the debt tax shield here is captured within (15) and does depend upon the interest rate charged through the probability of there being profits to save taxes on χ. Hence, the tax shield leads to executive project distortion. We believe our result that the tax shield is distortionary is widely applicable for at least three reasons:

1. If debt interest is repaid, and not a perpetuity, then the value of the debt tax shield depends upon the interest rate charged.[14] Thus, the distortionary effect of the debt tax shield in project choice is greatest when the debt used to fund the project is intended to be repaid, and not to be permanently rolled over. An example would be debt used to fund a merger or acquisition, a leveraged buyout, or for project finance.

2. Even if the debt is intended to be rolled over, if the dollar value of the debt level is not to be held constant throughout time then the value of the debt tax shield depends upon the prevailing interest and the distortionary effect we document applies.[15] The case of non-constant dollar debt levels seems to us more relevant empirically. For example, in the run-up to the financial crisis, banks' leverage rose significantly in both dollar and proportional terms.[16] Indeed, this has given rise to the Basel III leverage ratio which

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[13]See, for example, Brealey, Myers and Allen (2011).

[14]Suppose a risk averse borrower secures debt tax shield each period of $\tau r D$ for T periods, and dicounts this payment at an interest rate r. The value of the tax shield is $\tau D \left[1 - \left(\frac{1}{1+r} \right)^T \right]$ which is increasing in r.

[15]In this case the value of the debt tax shield is $\tau r \mathbb{D} / (r_E - g)$ where g is the company growth rate and r_E is the required return on unlevered equity. See Cooper and Nyborg (2006, equation 10). By inspection this grows in the cost of borrowing, r.

[16]See for example FSA 2009, *The Turner Review: A Regulatory Response to the Global Banking Crisis*, Exhibit 1.11.

internationally active banks are expected to start disclosing from 2015.

3. Theoretically competing valuation methodologies have been proposed for the value of the debt tax shield and many of these, including those used most by practitioners, depend upon the interest rate.[17]

Our analysis has further normalised the risk free return to one, assumed risk neutral creditors, and risk neutral equity investors. These are not essential assumptions and their relaxation would not alter the result.

4.1.2 The History Of Interest Tax Deductibility and Likelihood of its Repeal

We have demonstrated through Lemma 2 that the tax deductibility of interest payments encourages equity-incentivised executives to undertake risky projects too readily. In Section 5, we will explore how regulation of the executive's remuneration can mitigate this effect. First, however, one might wonder whether it would not be possible to simply remove the source of the distortion by eliminating the tax deductibility of debt interest itself. Indeed, Admati, DeMarzo, Hellwig, and Pfleiderer (2013) is a recent prominent contribution arguing that tax policy as concerns debt interest should be restructured so as not to encourage leverage.[18]

Warren (1974) and Bank (forthcoming) document the origin of corporate debt interest tax deductibility in the US. The first attempt to impose a tax on corporations came in 1894. The initial proposal did not allow for interest tax deductibility. However, after lobbying by the heavily indebted railroad companies, interest payments became exempt through amendments in the Senate. This did not affect many firms at the time as "the great body of the corporations of our country [the US] make dividends covering practically [all] their earnings each year [rather than paying debt interest]."[19] Nevertheless, the inequity of the treatment of bonds and stocks was felt over time, and so in 1909 the tax law limited the interest tax deductibility to only debt equal to the value of the corporation's capital stock. In 1917 the United States entered the First World War and the tax law was changed once more so as to limit firms to only make an 'acceptable' rate of return on invested equity capital. As extra returns generated from leverage were taxed in their entirety at this time, it was felt fairer that the costs of debt needed to generate those extra returns should not fall on the equity holders. Thus, interest payments first acquired their fully tax deductible status. When the excess profits tax was repealed in 1921, the deductibility of interest as a cost of business persisted. The then status quo was not politically expedient to change.

It has remained politically difficult to change the tax deductibility of interest since that time. Warren (1974) notes that[20] the case for the equivalent treatment of interest and dividend payments becomes a case for the repeal of the tax deductibility of interest. If instead the tax law was changed to exempt both interest and dividend payments, then corporation tax would only apply to retained earnings which would, according to Warren, (a) discourage the

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[17]Fernandez (2004) documents at least 5 competing methodologies, the majority of which have the value of the debt tax shield being a function of the interest rate, including the one he argues is commonly used by practitioners.

[18]See the discussion at the top of p18.

[19]Republican Senator William Boyd Allison of Iowa, 26 Cong. Rec. 6869 (1894).

[20]See section III.B, p1609.

retention of earnings; and (b) lead to the collapse of the corporate tax base. Indeed, President Roosevelt attempted to charge a differential tax rate on retained earnings in 1936. However, as Warren (1974, p 1609) notes, "*Corporate managers experienced intense shareholder pressure to distribute earnings [...] in order to reduce corporate tax payments, and this development was said to threaten economic growth.*" The differential tax treatment was repealed shortly after its introduction.[21]

However, the arguments for the repealing of interest tax deductibility have foundered on at least three counts. First, countries are unwilling to risk raising corporation tax by moving to tax interest due to the anticipated hit on competitiveness. For example, the UK government expressly sees interest tax relief as providing a competitive advantage to UK businesses.[22] Second, if one were to tax debt interest, then this might encourage firms to identify substitutes for debt which remained tax deductible. For example, firms could make increased use of leasing and short term borrowing, such as trade credit. To capture debt interest payments it is possible that tax law would need to impute interest from rental charges, and in addition would need to determine when commercial deals of all kinds stopped being a legitimate business expense and instead become a proxy for interest. Finally, though in principle the government could tax interest and redistribute the tax so as to make firms indifferent, in practice it is feared that during the transition period highly indebted companies might be fatally damaged.

As the tax deductibility of interest appears likely to continue, it becomes increasingly important to study alternative ways any distortions in risk taking can be corrected. We will conduct such a study in Section 5.

4.2 "*Too-big-to-fail*" banks: 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 is an additional distortion caused by the so-called 'too big to fail' 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 to name a few – did not suffer any losses thanks to government support. The presence of the 'too big to fail' effect implies that 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, such that the bank is unable to repay them. This debt insurance is not however priced. This is the appropriate assumption as the debt insurance is implied and not

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[21]The UK did have a system of corporation tax which created an offsetting bias towards dividend payments and so penalised retained earnings between 1973 and 1999. The system was known as the Advanced Corporation Tax which allowed companies to pre-pay individuals' dividend tax liability and set this cost against their corporation tax. The system was scrapped by the UK government in 1999 which argued, as above, that the system biased against good business investment decisions (See http://webarchive.nationalarchives.gov.uk/+/http://www.hmrc.gov.uk/feedback/ctfeed.htm).

[22]HM Treasury & HMRC, Corporate Tax Reform: Delivering a More Competitive System, November 2010, p 14.

explicit. This distortion will of course affect the price of debt. Note that $\mu = 1$ would capture the case of a full deposit guarantee.

We now proceed to analyse the executive's project choice decision and call the firm 'a bank' as the too-big-to-fail distortion is most applicable to banks. We maintain the assumption that the bank faces a corporate tax rate of τ and benefits from the tax deductibility of interest payments. If the executive opts for the low volatility project, then the debt will be repaid with certainty. 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 to-big-to-fail. The equilibrium debt repayment is therefore now $i(\mu)$ and satisfies

$$\chi i(\mu)\mathbb{D} + (1 - \chi)\mu i(\mu)\mathbb{D} = \mathbb{D} \Leftrightarrow i(\mu) = \frac{1}{\chi + (1 - \chi)\mu} \tag{16}$$

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

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

The final term again captures that the interest can be paid out of the gross profits, before tax is levied, while the principal borrowed must is paid out of net profits. The only difference to the firm valuation is the changed market interest rate on debt. If the project fails, probability $1 - \chi$, then though the debt might be honoured by the government, the lost profits are not bailed out and so there is no payoff to equity holders in this case. By substituting for the equity supplied by the owner, the $t = 1$ value of the firm can be simplified to yield:

$$X_H(Z; \mu) = Z(1 - \tau) + \tau \chi (i(\mu) - 1)\mathbb{D} - \chi i(\mu)\mathbb{D} \tag{17}$$

Proposition 2 *If there is any equity-linked bonus ($b > 0$) then an executive who exerts project selection effort makes a socially inefficient project choice. The low volatility project is selected if and only if the expected returns satisfy:*

$$r > Z + \underbrace{\frac{\tau}{1 - \tau}\chi(i(\mu) - 1)\mathbb{D}}_{(\dagger)} + \underbrace{\frac{1}{1 - \tau}(1 - \chi)\mu i(\mu)\mathbb{D}}_{(\ddagger)} \tag{18}$$

Hence, the high volatility project is chosen even if its expected return is below that of the low

volatility project. Further the distortion in project selection grows monotonically as the bailout probability μ increases.

Proposition 2 demonstrates that there exists a distortion in the executive's project choice, and that this distortion is separable into two components. The first distortion, denoted by (†) in equation (18), corresponds to the distortion in (15) and is the expected pre-tax value of the debt tax shield secured by the *too-big-to-fail* bank which pursues the high volatility project. This distortion was discussed following Lemma 2. The second distortion, denoted by (‡), is the expected pre-tax value of the implicit government guarantee pertaining to the *too-big-to-fail* bank which pursues the high volatility project. The guarantee pays out if the bank should fail (probability $1-\chi$) in which case an amount $i(\mu)\mathbb{D}$ is paid out if the government does in fact step in to prevent default (probability μ). Both distortions cause the equity-remunerated executive to select the high volatility project too frequently.

An increase in the bailout probability, μ, lowers the interest payable on debt. As this is effectively a subsidy for risk-taking, we would expect this to introduce distortions in the executive's project choice. However, the resulting reduction in the interest payable will also lower the benefit of the debt tax shield. The comparative statics in Proposition 2 demonstrate that the first effect always dominates: any increase in the likelihood of there being a too-big-to-fail guarantee worsens the project selection distortion. This is because as the probability of a government bailout increases, the reduction in the government's monetary contribution is proportional to the tax rate, however the increase in the government bailout in the event of default covers the whole debt and so dominates.

The expression (18) also shows that a capital adequacy requirement, which requires banks to keep $\mathbb{D}$ below a pre-determined level, will reduce the two distortions, but cannot eliminate them 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 5.

4.3   Owner Optimal Contract

We have built a tractable model of the project choice distortion induced by equity pay in the presence of interest tax deductibility and too-big-to-fail guarantees. We now determine the fully optimal owners' contract analogous to Proposition 1. We further conduct a comparative statics study of the optimal contract to generate further intuition as to how an optimising firm will endogenously adjust the forces pertaining to the executive's project choice.

First we establish the owner's objective function. Given Proposition 2, the owner anticipates that if the executive is incentivised to exert effort, the expected value of the firm, gross of any payments to the executive is $S(\tau,\mu)$ which, analogously to (2), and using (18), is:

$$S(\tau,\mu) = \int_{Z=1}^{\infty} f_H(Z) \left\{ \begin{array}{l} \int_{r=1}^{Z+\frac{\tau}{1-\tau}\chi(i(\mu)-1)\mathbb{D}+\frac{1}{1-\tau}(1-\chi)\mu i(\mu)\mathbb{D}} X_H(Z;\mu) f_L(r)\,dr \\ + \int_{r=Z+\frac{\tau}{1-\tau}\chi(i(\mu)-1)\mathbb{D}+\frac{1}{1-\tau}(1-\chi)\mu i(\mu)\mathbb{D}}^{\infty} X_L(r) f_L(r)\,dr \end{array} \right\} dZ \quad (19)$$

The equity owner's expected payoff at $t=0$ is $S(\tau,\mu) - \mathbb{E}$. The equity required is endogenous

and 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:

$$(1 - b) S(\tau, \mu) - f - 1 + \mathbb{D} \tag{20}$$

The owner seeks to maximise her objective function (20) subject to the executive being willing to accept the contract

$$f + b \cdot S(\tau, \mu) \geq u \tag{21}$$

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 $f + bE_H[X_H(Z; \mu)] + B$ whereas if the low volatility project is selected the expected payment is $f + bE_L[X_L(r)] + B$. The executive therefore exerts effort if

$$bS(\tau, \mu) \geq b \max\{E_H[X_H(Z; \mu)], E_L[X_L(r)]\} + B \tag{22}$$

The owner's problem is therefore to adjust $\{f, b\}$ to maximise (20) subject to (21) and (22).

Proposition 3 *The optimal remuneration scheme which incentivises effort with the lowest variable component is characterised as follows:*

1. *The optimal wage contract satisfies:*

$$b = \frac{B}{(1 - \tau) \int_{Z=1}^{\infty} f_H(Z) \left\{ \int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty} (1 - F_L(r)) \, dr \right\} dZ} \tag{23}$$

$$f = u - b\left[(1 - \tau) E_H(Z) + (1 - \chi)\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D} - \mathbb{D}\right] - B$$

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

$$E(\Pi_0) = (S(\tau; \mu) + \mathbb{D}) - u - 1 \tag{24}$$

3. *The executive over-invests in the risky project by selecting the safe project if and only if (18) holds.*

   Incentivising project selection effort is optimal if

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

Proposition 3 solves the owner's optimisation problem given the government distortions of the debt tax shield and the too big to fail guarantee. The bonus must be large enough to induce the executive to exert project selection effort. The size of the bonus therefore depends upon the ex ante distribution of possible projects. This therefore generates comparative static insights which we exploit below. Further the bonus pay induces a distorted executive project choice – however this is in the interests of the owners, though not of society. Equity holders derive a real

benefit from maximising the values from the tax shield and the implicit government guarantee. This benefit does not increase welfare however as it represents transfers from tax payers, and any project choice distortion damages overall welfare.

Proposition 4 *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 corporate tax rate* (τ) *and 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. 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 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 falls.

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, the bonus rate has to rise.

We have already seen above that if i) the tax distortion τ grows, ii) the bailout probability μ grows, or iii) 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 ends up choosing 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, or high volatility project. Given an expected return Z, the high volatility project has returns in the set $\{Z/\chi, 0\}$. The span of possible realised returns therefore grows as χ, the probability of success, shrinks. Hence a

corollary of the volatility of the risky project growing is that the interest rate payable on the debt increases, and further the implicit subsidy from the too-big-to-fail guarantee has also increased. Both of these effects make choosing the high volatility project over the low volatility project more likely – so the distortion in project choice is exacerbated. Further the executive appreciates that he is very likely to select the risky project as the government distortions strongly push in that direction. 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.

5 Socially Optimal Executives' Pay

We have established that the executive's project decision is distorted towards excessive risk-taking from the regulator's, though not from the owner's, point of view. The distortion studied arises from the presence of the debt tax shield and from an implicit government guarantee on debt stemming from the institution being *too-big-to-fail*. In this section, we first ask what restrictions a regulator might wish to impose on the structure of executives' pay to limit the excessive risk-taking incentives arising from these distortions. We further study the remuneration tools at a bank's disposal to seek to game and roll back 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 value of equity base for bonus calculations; and (v) exogenous caps on the bonus which can be paid in relation to the fixed salary. We continue to use the most general model of the distortion comprising both the tax shield and any *too-big-to-fail* implicit subsidy.

5.1 Payment in Debt: An Irrelevance Result

It has been proposed that the distortion introduced by mispriced debt can be corrected by remunerating the executive in part through debt. A concrete example of this approach is AIG which in a 2010 SEC filing declared that for some of their executives' 80% of the value of their bonus will be based on the value of AIG's junior debt, and 20% on AIG's stock.[23] Thus, we explore this proposition by allowing the firm 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 remuneration and investment. The value of the firm at $t = 1$ is given by $X_L(r)$ and $X_H(Z; \mu)$, depending on the project chosen. We assume that the executive discounts 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 firm discounts future payouts according to the prevailing financial interest rate. We normalise the associated firm discount factor to 1.

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

$$f + bX_L(r) + \delta c\mathbb{D} \tag{25}$$

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

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 (16). 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 firm 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 $c \cdot [\chi i\,(\mu)\,\mathbb{D} + (1 - \chi)\mu i\,(\mu)\,\mathbb{D}]$.

The executive's debt is not singled out for special treatment in the case of default – it is of equal seniority to 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 5.3). 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 (16) delivers that the executive receives a $t = 1$ payment of

$$f + bX_H\,(Z; \mu) + \delta c \cdot [\chi i\,(\mu)\,\mathbb{D} + (1 - \chi)\mu i\,(\mu)\,\mathbb{D}] = f + bX_H\,(Z; \mu) + \delta c\mathbb{D} \qquad (26)$$

Proposition 5 (Pay In Debt Irrelevance) *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 (23). The fixed salary is reduced by the amount $\delta c\mathbb{D}$.*

2. *The expected return to the firm's shareholder is unchanged at (24).*

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 (18) holds.*

Proof. The executive's payments when he is in part paid in debt ((25), (26)) 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 5 demonstrates that a regulator cannot correct the project choice distortion by forcing payments in debt. Crucially, in our analysis with an efficient debt market, the expected return 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.

This result appears to stand in contrast to both Edmans and Liu (2011) and Bolton, Mehran and Shapiro (2014), who advocate that debt payments to executives are required to bring the project choice closer to the first best. The difference in our result stems from the different assumptions about the information available to debt markets when they price project risk. With information asymmetries, as assumed in their analyses, the managers are able to risk-shift – i.e. they can take excessive risks at the expense of the debt holders, and at a cost to equity holders. Equity holders would wish to curtail this risk-shifting as it increases costs ex ante. Further, in these models the views of shareholders and the regulator coincide. We however study fully informed debt markets in a setting in which the regulator is not content with the project distortions which favour equity holders.

Proposition 5 is therefore complementary to these earlier analyses, and suggests that payment in debt may not be a robust way of curtailing excessive, from the point of view of the regulator, risk-taking when executives' risk choices are exposed to the scrutiny of the debt markets. As discussed in Section 2, it is reasonable to assume that large global banks are exposed to such scrutiny as they need to maintain continuous access to public debt markets and are actively followed by analysts. Moreover, financial institutions' flexibility to adjust their borrowing maturity leads to shorter maturity times and the repeated rolling over of debt (Brunnermeier and Oehmke (2013)).

5.2 Deferred equity-linked pay

We now consider whether forcing banks to defer a proportion of the executive's equity-linked bonus could mitigate the excessive risk-taking we have identified. Forced deferral of pay and the requirement that it be linked to future performance is part of the Financial Stability Board's (1999, principle #6), key responses aimed at reducing excessive risk taking by banking executives.

To study this, suppose that the regulator requires that the equity linked bonus rate b is split so that a proportion λ^d of the share award vests until $t = 2$. Only the remaining bonus, $\left(1 - \lambda^d\right) b$ is permitted to vest at $t = 1$. This regulatory intervention will affect the equity value of the firm.

Suppose that the executive exerts project select effort and selects the low volatility project. The equity value of the firm at $t = 1$ is now:

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

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

The second equality follows from (10).[24] In the case of the high volatility project being selected similar working delivers that

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

Proposition 6 *Deferred equity-linked pay does not improve the project selection decision. The project choice distortion remains as in Proposition 2.*

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

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

$$= f + b\left\{\left(1 - \lambda^d\right)\left(1 - \lambda^d b\right) + \delta \lambda^d\right\} X_H\left(Z; \mu\right)$$

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[24] The forced deferral lowers the value of the $t = 1$ equity as some of the executive's pay is deferred to $t = 2$ equity holders, whereas without the regulatory intervention, the $t = 1$ equity holders must supply more equity $\mathbb{E}$, to cover the full remuneration costs.

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

$$f + b \left(1 - \lambda^d\right) \left[\left(1 - \lambda^d b\right) X_L\left(r\right)\right] + \delta b \lambda^d \left[r\left(1 - \tau\right) - \mathbb{D}\right]$$
$$= \quad f + b \left\{\left(1 - \lambda^d\right)\left(1 - \lambda^d b\right) + \delta \lambda^d\right\} X_L\left(r\right)$$

Comparing these executive payoffs, the low volatility project is chosen iff $X_L\left(r\right) > X_H\left(Z; \mu\right)$, 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. As a result, project choice is not distorted from the owner's preferred thresholds. Project choice therefore remains distorted from the first best as the regulator and shareholders differ in their objectives. This suggests that the payoff from deferral must not be linked to real-time equity values in order to achieve the regulator's objective. One way to achieve this is through the use of Clawback which we explore next.

5.3   Malus and Clawback

We now consider alternative forms of exposing executives to risks that may crystallise only in the long-run: malus and clawback. Malus is an arrangement that permits the institution to prevent vesting of all or part of the amount of deferred remuneration award 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 to the institution under certain circumstances. The intended aim of these policies is to incentivise material risk-takers to take into account the long-term impact of their risk choice. Such clawback arrangements have been introduced in the UK where they will become obligatory for 'material risk takers' from January 2015, with pay susceptible to clawback for a period of seven years from issue.[25] We study the impact of this type of policy below.

Suppose that the firm subjects a proportion P of the bonus paid at $t = 1$ to potential clawback. Specifically, we assume that part of the bonus must be paid back by the executive if the bank were to default at $t = 2$. We continue to assume that the executive discounts $t = 2$ payments by a factor of $\delta \leq 1$, and that the firm discounts future payouts at discount factor 1. For simplicity, we assume that any clawed back payment in the case of bankruptcy is used by the resolution authority (or the government) to cover the cost of resolving the bank, and does not accrue to the debt holders.[26]

At $t = 1$, the firm 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 firm will have a $t = 1$ valuation of $X_L\left(r\right)$ as given by (10). This valuation is unchanged as the firm 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

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[25]See PRA PS7/14 available at http://www.bankofengland.co.uk/pra/Documents/publications/ps/2014/ps714.pdf

[26]We make this assumption for three reasons. Firstly, it could be confiscated by the government to fund creditor bailouts, or to fund the cost of resolution in the case of no bailouts. Secondly, even if an executive's penalty did accrue to creditors it is likely to be several orders of magnitude smaller than the outstanding debt of a firm and so be *de minimis*. Finally the assumption simplifies the analysis by simplifying the payoffs to creditors in the bankruptcy state. However it is not an essential assumption as the intuitions do not hinge upon it.

the executive chooses the low volatility project, his pay will be:

$$f + bX_L(r) \tag{27}$$

Suppose instead that the executive selects the high volatility project. The $t = 1$ value of the firm will again be altered by the value of the debt tax shield and the value of the implicit government debt guarantee. Since any payments made through clawback in the case of bankruptcy are assumed not to accrue to the firms' creditors, the interest payable on debt remains at $i(\mu)$ given in (16). The $t = 1$ valuation for the firm which is pursuing the risky project remains $X_H(Z; \mu)$ given by (17). 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

$$f + bX_H(Z; \mu)[1 - \delta P(1 - \chi)] \tag{28}$$

Lemma 3 *If the executive exerts effort and learns $\{r, Z\}$ then he selects the low volatility project iff $r > W(Z, P)$ where*

$$W(Z, P) = Z[1 - \delta P(1 - \chi)] + \frac{\mathbb{D}}{1 - \tau} \frac{(1 - \chi)}{\chi + (1 - \chi)\mu} \left[\begin{array}{c} \tau\chi(1 - \mu)[1 - \delta P(1 - \chi)] \\ +\mu + \delta P\chi \end{array} \right] \tag{29}$$

For this section studying clawback we restrict the parameters so that the debt levels satisfy:

$$\mathbb{D} < 1 - \tau \tag{30}$$

This upper bound on the debt levels implies that the debt repayments can be paid from post tax value for any of the projects which are available.

Proposition 7 *For any positive 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. *There exists a threshold level of debt $\tilde{\mathbb{D}} < 1 - \tau$ such that if the leverage of the bank is above this threshold then there exists low expected value risky projects over which the executive will be excessively risk loving; selecting the risky project even though it has a lower expected return than the safe project.*

Introducing clawback creates an imperfect off-setting distortion for the executive. The equity holders were well served by the executive selecting high volatility projects which optimally maximised the transfers via the debt tax shield and too-big-to-fail guarantee. The threat of clawback makes the prospect of selecting the high volatility project less appealing to the executive as there exists a possibility that bonuses received will be clawed back. However Proposition 7 demonstrates that clawback is always an imperfect counter to the government distortions. For all clawback levels there are project where, ex post, the clawback is in some too high: the

executive is deterred from selecting npv enhancing risky projects. However for a sufficiently levered bank, there are also projects where, ex post, the executive is too risk loving.

The reason for this disparity between the first best and the clawback induced project choice is that the sums clawed back are proportional to the expected future equity values, while the distortion was proportional to the value of the debt (through the tax shield or government guarantee).

The appropriate level of clawback would therefore seem to be a compromise for a regulator. To study this let us suppose that the regulator wishes to maximise the expected value of the economy. This would require the regulator to select the clawback rate to maximising the following objective function with respect to P :

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

Proposition 8 *Under condition (30), some clawback is always optimal whatever the level of leverage.*

We know from Proposition 2 that in the absence of clawback the executive will be excessively risk loving for all possible project expected values. Increasing the clawback rate up from zero increases expected social welfare as the manager is made a little less risk loving at all project values. The range of projects for which the executive is excessively risk averse (Proposition 7) is of vanishingly small measure as it requires the expected return of the high volatility project Z to be infinitely high.

The above analysis suggests that, while introducing the possibility of a clawback can improve social welfare, it could prevent investment in high volatility projects with very high expected returns. But to the extent that the probability of this is small enough, and the leverage is high enough, clawback can improve social welfare:

Proposition 9 *If the leverage of the bank is high ($\mathbb{D} \simeq 1 - \tau$) then full clawback ($P = 1$) is optimal if the probability of very high value risky projects is not great.*

If the leverage of the bank is high then the distortions in project choice induced by debt tax deductibility and too big to fail are more substantial. It follows that there is a need for the regulator to introduce high rates of clawback. From Proposition 7 this will cause the executive to be too risk averse over high expected value risky projects. This is costly to the regulator, but can be discounted if the ex ante probability of such projects is small enough. This yields Proposition 9. An implication of this reasoning is that the clawback rate should be a function of the firm's leverage, however the exact behaviour depends upon the relative shapes of the density functions f_L and f_H of the possible project expected values.

Our results are summarised graphically in panel (a) of Figure 2. The blue dotted line represents the socially optimal project decision rule, whereby the low volatility project is selected only if its expected return exceeds that of the high volatility project. In the absence of any regulatory intervention, however, the executive's decision rule will be given by the red dashed line, such that the high volatility project is chosen too often relative to the social optimum. By introducing the clawback, the regulator can bring the executive's decision rule closer to the
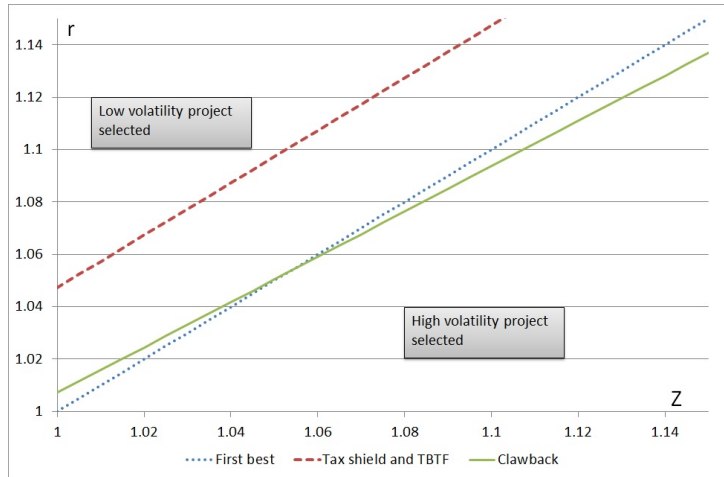
(a) Clawback.
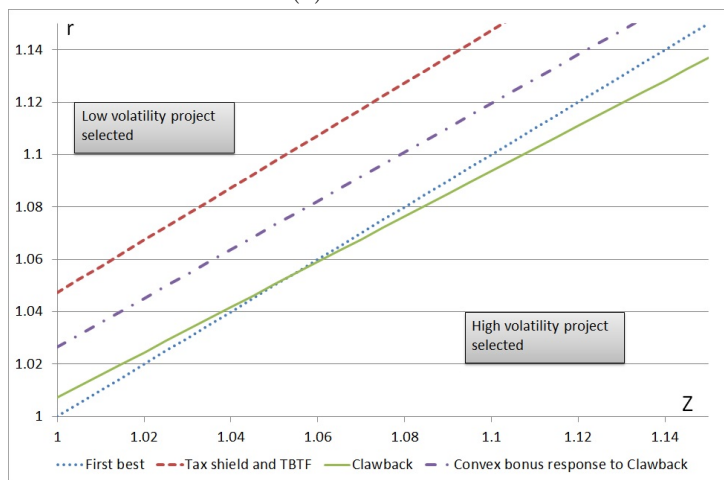
(b) Convex bonus.
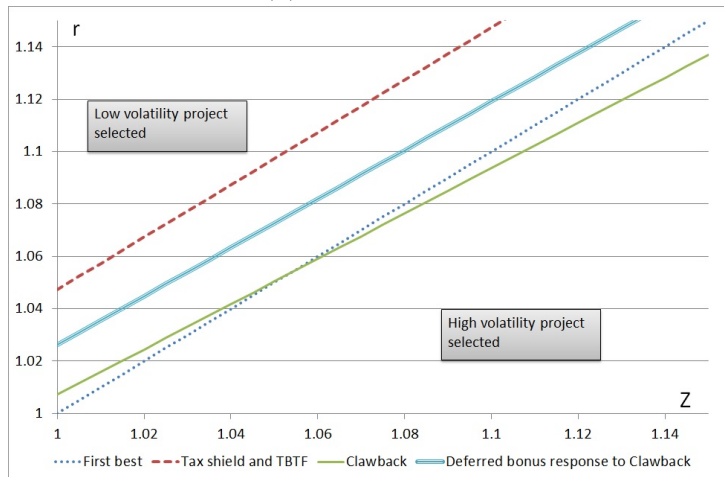
(c) Deferred Bonus.

Figure 2: The Effect Of Clawback On The Executive's Risk-Taking Incentives.

Notes: The graphs display the space of expected project returns and the decision rules created by a given numerical example. The low volatility project is only selected for projects $\{Z, r\}$ above the line drawn for each regulatory regime. In panel (a) the effect of clawback is displayed. The first best is given by the blue dotted line, while the project choice distortion in the absence of clawback is given by the red dashed line. The green solid line gives the clawback induced decision rule. In panel (b) the bank responds by introducing convex $t = 1$ bonus using, for example, a tiered option structure. This pushes the decision rule up to the purple dashed and dotted line. In panel (c) we model the bank adding deferred equity pay into the executive's compensation. This pushes the decision rule back up to the out to the blue three-banded line.

social optimum (the green solid line). As demonstrated in Proposition 7, however, the clawback could encourage the executive to become excessively risk averse by encouraging him to choose the low volatility project too often when the expected return from the high volatility project Z is very high (the green line being below the blue dotted line when Z is high).

Although we have called the above mechanism 'clawback' as a short-hand, the same outcome can be achieved via malus, which could be designed to prevent a fixed monetary amount of bonus from vesting if the firm were to go bankrupt. We will now see that what is crucial is that the deferred remuneration which is put at risk is fixed in monetary terms, and not linked to future equity value: only then can clawback or malus have the effect of curbing excessive risk-taking incentives.

5.3.1 How might the bank respond to the clawback?

We have shown that the clawback (or malus) which places a fixed monetary amount of the executive's variable bonus remuneration at risk can bring the executive's project choice closer to the social optimum. However, this is not optimal from the perspective of the shareholders, who wish to incentivise the executive to select projects of greater risk in order to maximise the benefit from the tax shield and the 'too-big-to-fail' subsidy. It is therefore possible that they alter the executive's compensation structure in response to the introduction of clawbacks. We now examine how the bank might respond in order to dilute the impact of the clawback.

Altering the bonus structure We first 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, given by (22), is satisfied. Given Lemma 3, the low volatility project is selected as long as $r > W(Z, P)$, this is independent of f and b. Clawback is 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. We demonstrate below that the bank's shareholders could respond by making the bonus more convex in equity value in order to encourage the executive to take greater risks in the presence of the clawback.

Proposition 10 *Suppose the firm introduces an increasing $t = 1$ bonus function $\beta(X)$, $\beta' > 0$, $\beta(0) = 0$, with X the $t = 1$ firm value.*

1. *If the bonus is made convex increasing in firm value, then only in the presence of clawback $P > 0$, the executive is more likely to choose the high volatility project than under clawback with equity based bonus.*

2. *If the bonus is made concave increasing in firm value, then only in the presence of clawback $P > 0$, the executive is more likely to choose the low volatility project than under clawback with equity based bonus.*

Further, using the convex bonus function $\beta(X) = bX^\alpha$ the effect of the clawback is completely undone in the limit of $\alpha \to \infty$ for any $b > 0$.

Proposition 10 shows that the shareholders could offset the impact of the clawback on the executive's incentives entirely by making the bonus very 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. The shareholders could, for example, create such convex payoff structure by offering call options with differing strike prices as part of their compensation.

The potential to counter the clawback by introducing a convex payoff function is demonstrated in panel (b) of Figure 2. The introduction of convex bonus (bX^α, purple dashed and dotted line) reverses the effect of the clawback (solid green line) by bringing the executive's project choice rule closer to the unregulated outcome (red dashed line).

Deferred equity-linked bonus We now explore how a bank might seek to counter the introduction of mandatory clawback by adding deferred equity-linked compensation into the executive's compensation arrangements.

Suppose that, in addition to the $t = 1$ bonus that could be clawed back at $t = 2$, the executive also receives a deferred bonus which is a function of the $t = 2$ equity value, conditional on the bank remaining solvent. For example, the executive could receive some shares at $t = 1$ which vest until $t = 2$: in this case, he can sell the vested shares at the price prevailing at $t = 2$ if the bank remains solvent while he loses them if the bank were to go bust.

To examine explicitly how this affects the executive's incentives, denote by v the proportion of the $t = 2$ equity value which the executive will receive at $t = 2$. As this deferred equity-linked bonus only needs to be paid out if the firm remains solvent at $t = 2$, it alters the value of the firm. If the executive selects the high volatility project then the equity supplied at $t = 1$ is: $\mathbb{E} = 1 + [f + bX_H(Z, \mu)] - \mathbb{D}$. The $t = 1$ value of the firm is therefore altered to:

$$X_H(Z; \mu, v) = \underbrace{\mathbb{E} + \mathbb{D} - 1 - [f + bX_H(Z; \mu)]}_{=0} + \chi(1 - v)\left[\left(\frac{Z}{\chi} - (i(\mu) - 1)\mathbb{D}\right)(1 - \tau) - \mathbb{D}\right] \tag{31}$$

Similarly, the value of the firm which selects the low volatility project is:

$$X_L(r, v) = \underbrace{\mathbb{E} + \mathbb{D} - 1 - [f + bX_L(r)]}_{=0} + (1 - v)[r(1 - \tau) - \mathbb{D}] \tag{32}$$

The manager continues to discount deferred pay at a rate δ. We continue to assume that the maximum amount of debt that the bank can take on satisfies (30).

Proposition 11 *Under condition (30) the addition of any deferred equity-linked bonus to the compensation mix makes the selection of the high volatility project more likely. However given $v < 1$, the effect of clawback cannot be completely undone.*

Hence, adding deferred equity-linked bonus to the executive's compensation offsets the mitigating impact that clawback has on the executive's incentives to take excessive risks. By

ensuring that the executive loses a fixed amount of cash if the firm were to go bust, the claw-back reduces their risk-taking incentives. The deferred equity-linked bonus, by contrast, allows the executive to reap large rewards when the risky project succeeds while he receives nothing if it were to fail: this encourages the executive to take more risks. As the $t = 2$ equity value is also distorted by the tax shield and the 'too-big-to-fail' distortions, linking the pay to the $t = 2$ equity value re-introduces the distortions that the clawback is aiming to correct for.

The above results are summarised graphically in panel (c) of Figure 2. Like the convex bonus, the deferred equity-linked bonus (represented by the banded light blue solid line) reverses some of the effect of the clawback (solid green line) by bringing the executive's decision rule back to the unregulated outcome (dashed red line).

Increasing leverage From Lemma 3, the executive selects the low volatility project iff $r > W(Z, P)$. 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 tax shield and the implicit subsidy may be limited in practice.

5.4 Measuring Executive Performance Against A Re-based Value Of Equity

The practice of using Return on Equity (RoE) 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 this has led to a regulatory requirement that banks avoid excessive reliance on equity value linked metrics in determining senior executives's incentives.[27] This section proposes and examines a regulation which requires executive pay to be based on the equity valuation corrected for the debt tax shield and 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. We will then consider how such an intervention can be gamed by a bank's owners.

The value of the debt tax shield, $V^{\text{tax shield}}$ is equal to the expected reimbursement in tax from the government:

$$V^{\text{tax shield}}(\tau, \mu) = \begin{cases} 0 & \text{low volatility project selected} \\ \tau \chi (i(\mu) - 1) \mathbb{D} & \text{high volatility project selected} \end{cases} \tag{33}$$

The value of the implicit government guarantee, $V^{\text{gov g'tee}}$, is similarly the expected repayment from the government to debt holders which will allow equity holders to gain that value in an efficient capital market:

$$V^{\text{gov g'tee}}(\mu) = \begin{cases} 0 & \text{low volatility project selected} \\ (1 - \chi) \mu i(\mu) \mathbb{D} & \text{high volatility project selected} \end{cases} \tag{34}$$

We will discuss the relative empirical magnitude of these numbers and how they might be

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estimated at the end of this section. The intervention considered here is that the executive can only be rewarded in proportion to the $t = 1$ equity value of the firm *net* of the value of the tax shield $\left(V^{\text{tax shield}}\right)$ and *net* of the value of the implicit government guarantee $\left(V^{\text{gov g'tee}}\right)$.

Proposition 12 (Rebasing RoE) *When the executive is rewarded based on equity value net of the value of the debt tax shield and 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 12. If the executive selects the low volatility project then the firm value is $X_L(r)$ given by (10). Rebasing the equity value as required in compensation, the executive in this case receives

$$f + b \left(X_L(r) - \underbrace{V^{\text{tax shield}}(\tau, \mu)}_{=0} - \underbrace{V^{\text{gov g'tee}}(\mu)}_{=0} \right) = f + b(r(1 - \tau) - \mathbb{D}) \qquad (35)$$

If instead the executive selects the high volatility project then the firm value is $X_H(Z; \mu)$ given by (17). Rebasing the equity value as required in compensation leaves the executive with

$$f + b \left(X_H(Z; \mu) - V^{\text{tax shield}}(\tau, \mu) - V^{\text{gov g'tee}}(\mu) \right) = f + b(Z(1 - \tau) - \mathbb{D})$$

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

Proposition 12 shows that requiring the firm to measure executive performance against the return on equity net of the value of debt tax shield and the implicit government guarantee will ensure that the equity-remunerated 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 tax shield and the *too-big-to-fail* distortions.

5.4.1   How might the bank respond to re-basing the performance metric?

We now examine how the bank might respond to re-basing the executive's performance metrics away from the return on equity so as to eliminate the distortions arising from the tax shield and the implicit government guarantee. In the following analysis, we assume that the discount factor, $\delta > b$ the proportion of the bank's equity value promised to the executive. This is realistic, as an executive is typically rewarded with a small proportion of the total equity value of their bank or firm.

Proposition 13 *Consider possible firm changes to the bonus regime of the executive:*

1. *Introducing any increasing bonus function $\beta(\cdot)$, $\beta' > 0$, of the rebased equity value does not alter the project selection rule from the first best.*

2. *Adding deferred pay as a linear proportion of $t = 2$ EBIT (earnings before interest and tax) does not alter the project selection rule from the first best.*

   However

3. *Adding deferred pay as a linear proportion of realised $t = 2$ equity value can be used to reverse the effects of equity rebasing. The greater the weight of deferred pay, the more the effect of rebasing equity can be reversed.*

Once the executive's performance metric is re-based to strip out the distortions arising from the tax shield and the *too-big-to-fail* subsidy from the firm's equity value, he will adopt the socially optimal project choice rule as long as the bonus is increasing in this re-based metric. This implies that the rebasing of RoE in the executive's remuneration is robust to the introduction of any convex bonus arrangements which could be created by options as long as these options take the rebased RoE as their underlying fundamental.

The intervention is also robust to the addition of deferred pay which is proportional to EBIT. As EBIT is blind to tax and interest arrangements the decision rule of the executive remains undistorted from the regulator's point of view. However, the effects of this regulatory intervention can be reversed through deferred equity-linked pay. As the value of the deferred equity is altered by tax arrangements and the interest rate in debt, such deferral effectively re-introduces the distortions into the executive's pay. Deferred equity linked bonus therefore allows the owners to re-align the executive's incentives with their own and away from those of the regulator.

5.4.2 Empirical Plausibility of Estimating The Debt Tax Shield and TBTF value

Implementing such a policy in practice also requires credible measures of the value of the debt tax shield and the value of the implicit government guarantee.[28] Estimating the tax benefits of debt is not entirely straightforward as (i) cash flows generated in the future through the tax shield will depend upon the presence of profits to save tax on; and (ii) the net present value of the tax shield also depends upon whether the debt is to be repaid, and how the leverage levels are to be adjusted through time. Not withstanding these problems Graham (2000) and Kemsley and Nissim (2002) propose methods by which the value of the tax shield can be estimated using publicly available data. They estimate that on average in the US the value of the debt tax shield is approximately 10% of the total firm market value (debt plus equity). If assumptions as to (i) and (ii) above are made then the value of the debt tax shield is more readily calculated; this is the approach commonly taken by M&A practitioners (see for example Brigham and Erhardt (2007, Chapter 25.7)).

The size of the *too-big-to-fail* value is estimated as being at least 1.3% of total enterprise value (O'Hara and Shaw (1990)). O'Hara and Shaw establish this estimate via an event study on the day the Comptroller of the Currency in the US announced that eleven of the largest US banks were too-big-to-fail. In the absence of such an event scholars have proposed estimating the reduction in the cost of borrowing by comparing the interest charged against estimates

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[28]The fact that debt offers firms a tax benefit has been evidenced by, for example, Masulis (1980).

constructed from other banks. Acharya, Anginer and Warburton (2013) estimate that the too-big-to-fail advantage of US banks averaged 24 basis points over the 20 years 1990-2010. Li, Qu, and Zhang (2011) place the too-big-to-fail subsidy at 23 basis points before the crisis, and 56 basis points after the crisis. Multiplying these figures by the total debt of the too-big-to-fail bank yields an estimate of the value of the government guarantee.

5.5 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 firms as part of financial regulation.[29] 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 the implications of the bonus cap on the excessive risk taking in executive project choice.

Suppose that if the executive has a fixed wage of f, then the maximum dollar variable bonus the executive can receive is f. We demonstrate below that the impact of the bonus cap depends on how the executive behaves when the bonus cap binds. Consider the following two possible alternative assumptions:

Assumption 1: if the expected value of the executive's pay is equal from the two projects, he prefers the project which the regulator would choose: the project with the highest expected net present value.

Assumption 2: if the expected value of the executive's pay is equal from the two projects, he prefers the project which the owners would choose: the project with the highest expected value to stock holders.

Assumption 1 implies that the executive makes the socially optimal project choice when his own payoff leaves him indifferent, whereas Assumption 2 implies that he selects the project which maximises the shareholder value in that case. The effect of the bonus cap depends crucially on which assumption is a more accurate version of reality.

Proposition 14 *Given any compensation contract* $\{f, b\}$, *let* $\hat{Z}(f, b)$ *denote the expected value of the high volatility project at which the bonus cap just binds:*

1. *If the expected value of the high volatility project lies below* $\hat{Z}$ *then the bonus cap does not alter the executive's project selection decision.*

2. *If the expected value of the high volatility project lies above* $\hat{Z}$ *then:*

   (a) *Under assumption 1 the bonus cap distorts project choice in favour of the low volatility project. If the expected value of the high volatility project is large enough then the project choice is moved to the first best.*

   (b) *Under assumption 2 the bonus cap does not alter the executive's project selection decision from the case of no-intervention. The project choice distortion remains as per Proposition 2.*

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

Proposition 14 implies that the bonus cap has no impact on project choice as long as the expected return from the high volatility project is below a threshold. This follows as the bonus cap can only affect the project choice decision when it is binding after both project choices. To see this suppose that in the absence of the cap the high volatility project would be preferred to the low volatility project. Hence absent the cap the bonus from the high volatility project is larger than that available from choosing the low volatility project. If the cap binds on only one choice it must be the one with the higher bonus. Further, if the cap only binds on the one project then the bonus after the application of the cap will retain the same ordering as that prior to the cap. Hence the project choice decision is unaffected unless both projects would result in a bonus caught by the cap. This yields part 1.

As noted therefore, the bonus cap can only alter project choice decisions when it is binding on both project choices. But in this case the executive is indifferent in pay terms between the projects. The implications of the cap therefore depend on how the executive will choose to break the tie. If the executive would choose to behave in a welfare maximising manner when his bonus structure makes him indifferent between the two alternative projects (Assumption 1) then the bonus cap improves project choice over high expected value projects. If the executive is less socially minded (Assumption 2) the cap is ineffective in altering project choice. We therefore conclude that the bonus cap is unlikely to be an effective tool to curb the executive's risk-taking incentives.

6   Conclusions

We have demonstrated that if debt markets can price the risk of projects accurately, then the interests of shareholders and the regulator diverge. The shareholders see their value maximised by an equity rewarded executive. However such executives destroy welfare by selecting excessively risky projects due to two types of government-induced distortions: the debt tax shield and the implicit *too-big-to-fail* government guarantee. These distortions have the effect of lowering the price equity holders pay for debt to fund riskier projects, and so encourage the equity-rewarded executive to select risky projects. Our analysis concerned debt being secured for a project which was subsequently repaid. Hence, the distortion in project choices we describe will apply in situations, such as M&A, in which debt is not intended to be permanent; or in situations, such as the run-up to the financial crisis, in which debt levels are not held at a constant dollar level.

We have evaluated various options for regulating executives' pay. Payment in debt and the deferral of equity-linked bonus do not correct the executive's project choice form the regulator's point of view. These interventions preserve the equity holders' value. In the case of debt this is because interest payments adjust to project risk making the return on debt capital invariant to project choice. In the case of deferred equity the executive is fully exposed to the transfers available from the government via a reduced tax bill or via low interest payments. The introduction of mandatory malus or clawback improves executive choice from a social viewpoint, and full clawback is optimal under some conditions. However this intervention is not robust to the introduction by the bank of convex bonus schedules, or of deferred equity pay. Deferred equity pay reintroduces realised post-tax value into the executive's objective and so can return project choice back towards the shareholders' preferred distortions. Rebasing the metric against

which the executive is measured from RoE to equity value corrected for the value of the debt tax shield and the *too-big-to-fail* guarantee can also correct the project choice distortion. This intervention is robust to the introduction of bonus convexity, and deferred pay if it flexes on EBIT. But equity linked deferral returns the executive back to the distorted project choice. Finally bonus caps are unlikely to reliably curb the executive's risk-taking incentives as to work on any part of the project selection space the executive must wish to serve the regulator's objective rather than the shareholders' when he is indifferent in pay.

This analysis therefore suggests that passive remuneration regulation alone is unlikely to effectively mitigate banks' risk-taking incentives; it would need to be complemented by active monitoring of gaming and by balance sheet regulations aimed at limiting the bank's leverage itself.

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

$$f = u - bS = u - b\left(S - E_H\left(Z\right) + E_H\left(Z\right)\right) = u - bE_H\left(Z\right) - B \tag{36}$$

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 shown earlier in this proof. In this case the expected profit of the equity owners is $Z - \left(f + bE_H\left(Z\right)\right) - 1$. To ensure the executive accepts the contract the fixed fee must satisfy $f + bE_H\left(Z\right) + B = u$. Hence the equity holders expected payoff is $E_H\left(Z\right) + B - u - 1$. Comparing this to (8) we see that effort is desirable if $B < S - E_H\left(Z\right)$ so the result follows by setting $\bar{B}$ to be equal to the right hand side of this expression. ∎

Proof of Proposition 2.   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 $f + bX_H\left(Z; \mu\right)$, analogously for the low volatility project. The low volatility project is therefore only selected if $X_L\left(r\right) > X_H\left(Z; \mu\right)$. Comparing (10) to (17) and using the fact that

$$\left(1 - \chi i\left(\mu\right)\right)\mathbb{D} = \left(1 - \frac{\chi}{\chi + \left(1 - \chi\right)\mu}\right)\mathbb{D} = \frac{\left(1 - \chi\right)\mu}{\chi + \left(1 - \chi\right)\mu}\mathbb{D} = \left(1 - \chi\right)\mu i\left(\mu\right)\mathbb{D}$$

yields (18).

For the final part rewrite condition (18) as the low volatility project only being selected if $r > Z + G(\tau, \mu)$. Then substituting for the interest $i(\mu)$ we have

$$G(\tau, \mu) = \frac{1 - \chi}{1 - \tau} \cdot \frac{\tau \chi (1 - \mu) + \mu}{\chi + (1 - \chi) \mu} \mathbb{D} \tag{37}$$

Partial differentiation with respect to μ then implies $\partial G(\tau, \mu) / \partial \mu =_{\text{sign}} \chi (1 - \tau) > 0$. ∎

Proof of Proposition 3. We first simplify the incentive compatibility constraint (22):

$$\begin{aligned}
E_H[X_H(Z; \mu)] &= E_H(Z)(1 - \tau) + \tau \chi (i(\mu) - 1) \mathbb{D} - \chi i(\mu) \mathbb{D} \tag{38} \\
&> E_L(r)(1 - \tau) + \tau \chi (i(\mu) - 1) \mathbb{D} - \chi i(\mu) \mathbb{D} \\
&> E_L(r)(1 - \tau) - \mathbb{D} = E_L[X_L(r)]
\end{aligned}$$

The first inequality follows from (1). Hence the incentive compatibility constraint (22) can be written:

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

To proceed further we need to evaluate the expected gross firm value $S(\tau, \mu)$. Using that $X_H(Z; \mu) = Z(1 - \tau) + \chi \left(\frac{\tau(1-\chi)(1-\mu)-1}{\chi+(1-\chi)\mu} \right) \mathbb{D}$ we have

$$S(\tau, \mu) = \int_{Z=1}^{\infty} f_H(Z) \left\{ \begin{array}{c} \left[Z(1-\tau) + \chi \left(\frac{\tau(1-\chi)(1-\mu)-1}{\chi+(1-\chi)\mu} \right) \mathbb{D} \right] F_L \left(Z + \frac{1-\chi}{1-\tau} \left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu} \right) \mathbb{D} \right) \\ + (1-\tau) \int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty} r f_L(r) \, dr \\ - \mathbb{D} \left[1 - F_L \left(Z + \frac{1-\chi}{1-\tau} \left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu} \right) \mathbb{D} \right) \right] \end{array} \right\} dZ$$

Now integrating by parts we have

$$\int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty} r f_L(r) \, dr = \left[r(1 - F_L(r)) \right]_{\infty}^{Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}$$

$$+ \int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty} (1 - F_L(r)) \, dr$$

so substituting in and simplifying we have

$$S(\tau, \mu) = (1 - \tau) E_H(Z) + (1 - \chi) \left(\frac{\tau \chi (1 - \mu) + \mu}{\chi + (1 - \chi) \mu} \right) \mathbb{D} - \mathbb{D}$$

$$+ \int_{Z=1}^{\infty} f_H(Z) \left\{ \begin{array}{c} \underbrace{\left[\begin{array}{c} \chi \left(\frac{\tau(1-\chi)(1-\mu)-1}{\chi+(1-\chi)\mu} \right) \\ - (1-\chi) \left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu} \right) + 1 \end{array} \right]}_{=0} \mathbb{D} F_L \left(Z + \frac{1-\chi}{1-\tau} \left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu} \right) \mathbb{D} \right) \\ + (1-\tau) \int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty} (1 - F_L(r)) \, dr \end{array} \right\} dZ$$

So the incentive compatibility condition can be written:

$$b(1 - \tau) \int_{Z=1}^{\infty} f_H(Z) \left\{ \int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty} (1 - F_L(r)) \, dr \right\} dZ > B \tag{39}$$

The objective function (20) is declining in f and b. The optimal remuneration therefore lowers the fixed component f until the participation constraint (21) is binding, this does not affect constraint (39). Substituting back into the objective function, (20) 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 (39) is also binding. This delivers (23). Substituting the resultant bonus b into the participation constraint (21) and reorganising, we obtain

$$
\begin{aligned}
f &= u - bS(\tau,\mu) = u - b\left(
\begin{array}{c}
(1-\tau)E_H(Z) + (1-\chi)\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D} - \mathbb{D} \\
+ \int_{Z=1}^{\infty} f_H(Z)(1-\tau)\int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty}(1-F_L(r))\,dr\,dZ
\end{array}
\right) \\
&= u - b\left[(1-\tau)E_H(Z) + (1-\chi)\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D} - \mathbb{D}\right] - B
\end{aligned}
$$

Using constraint (21) which is satisfied with equality in (20) yields (24). Part 3 is given by Proposition 2.

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 shown by (38). In this case the expected profit of the equity owners is $E_H[X_H(Z;\mu)] - (f + bE_H[X_H(Z;\mu)]) - 1 + \mathbb{D}$. To ensure the executive accepts the contract the fixed fee must satisfy $f + bE_H[X_H(Z;\mu)] + B = u$. Hence the expected equity holders payoff is $E_H[X_H(Z;\mu)] + B - u - 1 + \mathbb{D}$. Comparing this to (24) we see that effort is desirable if

$$
B < S(\tau,\mu) - E_H[X_H(Z;\mu)] = (1-\tau)\int_{Z=1}^{\infty} f_H(Z)\left\{\int_{r=Z+\frac{1-\chi}{1-\tau}\left(\frac{\tau\chi(1-\mu)+\mu}{\chi+(1-\chi)\mu}\right)\mathbb{D}}^{\infty}(1-F_L(r))\,dr\right\}dZ
$$

as required. ∎

Proof of Proposition 4. 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 (23) to increase so lowering the optimal b. For part (2.) we rewrite the denominator of (23) as:

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

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 (23) readily. For part (4.) note that the lower bound of the integral in

the denominator of (23) equals $Z + G(\tau, \mu)$ as given in (37). We showed that $\partial G / \partial \mu > 0$ giving the result. By differentiation $\partial G / \partial \tau > 0$ so the bonus rate grows in the tax rate also. 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 (6).

For (7) note that, from the proof of Proposition 2 the distortion in project choice grows in $G(\tau, \mu)$. Hence the result that $\partial G / \partial \chi < 0$ implies that if the volatility of the risky project increases, χ must fall, causing $G(\tau, \mu)$ to grow and so delivering the result. In addition the condition for inducing effort to be optimal can be written

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

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 Lemma 3. Low volatility preferred if

$$r(1 - \tau) - \mathbb{D} > [1 - \delta P(1 - \chi)] \left\{ Z(1 - \tau) + \frac{\chi \mathbb{D}}{\chi + (1 - \chi)\mu} [\tau(1 - \chi)(1 - \mu) - 1] \right\}$$

$$r(1 - \tau) > \left\{ \begin{array}{c} [1 - \delta P(1 - \chi)] Z(1 - \tau) \\ + \frac{\chi \mathbb{D}}{\chi + (1 - \chi)\mu} [\tau(1 - \chi)(1 - \mu) - 1][1 - \delta P(1 - \chi)] + \mathbb{D} \end{array} \right\}$$

This expression can be simplified to give the result. ∎

Proof of Proposition 7. The manager is excessively risk averse if there exist projects $\{r, Z\}$ such that $r < Z$ and yet the low volatility project is still selected. This is possible if $W(Z, P) < r < Z$ for some Z. This is always true for large Z given $P > 0$ as

$$\lim_{Z \to \infty} Z - W(Z, P) = \lim_{Z \to \infty} Z \delta P(1 - \chi) \to \infty > 0$$

This gives part 1. For part 2 the manager is excessively risk loving for low value projects if, by continuity, $[W(Z, P) > Z]_{Z=1}$ for all $P > 0$ when $\mathbb{D}$ is high enough. We have

$$\lim_{\mathbb{D} \to 1-\tau} [W(Z, P) - Z]_{Z=1} = -\delta P(1 - \chi) + \frac{(1 - \chi)}{\chi + (1 - \chi)\mu} \left[\begin{array}{c} \tau \chi(1 - \mu)[1 - \delta P(1 - \chi)] \\ + \mu + \delta P \chi \end{array} \right]$$

$$= \frac{(1 - \chi)}{\chi + (1 - \chi)\mu} [\tau \chi(1 - \mu)[1 - \delta P(1 - \chi)] + \mu - \delta P(1 - \chi)\mu] > 0$$

The inequality follows as $\mu > \delta P(1 - \chi)\mu$. The result then follows by the continuity of $[W(Z, P) - Z]_{Z=1}$ in debt level $\mathbb{D}$. ∎

Proof of Proposition 8. We wish to show that $[\Omega'(P)]_{P=0} > 0$:

$$[\Omega'(P)]_{P=0} = \left[\int_{Z=1}^{\infty} [Z - W(Z, P)] \frac{\partial W(Z, P)}{\partial P} f_L(W(Z, P)) f_H(Z) \, dZ \right]_{P=0} \tag{40}$$

To sign this note that

$$Z - W(Z, 0) = Z - \left\{ Z + \frac{\mathbb{D}}{1 - \tau} \frac{(1 - \chi)}{\chi + (1 - \chi)\mu} \left[\tau \chi (1 - \mu) + \mu \right] \right\} < 0$$

So

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

Now

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

As $\mathbb{D} \leq 1 - \tau$ then for $Z \geq 1$ we have $\left[\frac{\partial W(Z, P)}{\partial P} \right]_{P=0} < 0$ and so $[\Omega'(P)]_{P=0} > 0$ yielding the result. ∎

Proof of Proposition 9. We wish to show that $\Omega'(P) > 0$. First note that

$$\frac{\partial W(Z, P)}{\partial P} = \left[\frac{\partial W(Z, P)}{\partial P} \right]_{P=0} < 0$$

As $W(Z, P)$ is linear in P. Now we seek to sign $[Z - W(Z, P)]_{Z=1}$. We have

$$[Z - W(Z, P)]_{Z=1} = \delta P (1 - \chi) - \frac{\mathbb{D}}{1 - \tau} \frac{(1 - \chi)}{\chi + (1 - \chi)\mu} \left[\begin{array}{c} \tau \chi (1 - \mu)[1 - \delta P (1 - \chi)] \\ +\mu + \delta P \chi \end{array} \right]$$

At high leverage $\left(\frac{\mathbb{D}}{1 - \tau} = 1 \right)$ this is negative if

$$P \delta (1 - \chi) \mu < \tau \chi (1 - \mu)[1 - \delta P (1 - \chi)] + \mu$$

This condition is linear in μ. It holds at $\mu = 0$, and at $\mu = 1$. Hence it must always hold.

We therefore have that $\left[[Z - W(Z, P)] \frac{\partial W(Z, P)}{\partial P} f_L(W(Z, P)) f_H(Z) \right]_{Z=1} > 0$. If the mass of $f_H(\cdot)$ is sufficiently concentrated around $Z = 1$ then the result follows. ∎

Proof of Proposition 10. In the benchmark of equity linked pay $f + bX$, 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. Analogously to the analysis above, the value of the firm given the project choice is 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 iff

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

First suppose $\beta(\cdot)$ is convex increasing, then β^{-1} is concave, implying for $\lambda < 1$,

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

hence $X_L(r) > [1 - \delta P(1 - \chi)] X_H(Z;\mu)$ giving part 1.

For part 2 note that if $\beta(\cdot)$ is concave increasing then $\beta^{-1}(\cdot)$ is convex implying that for $\tilde{\lambda} > 1$,

$$
\begin{aligned}
\beta^{-1}(X) &= \beta^{-1}\left(\frac{1}{\tilde{\lambda}}\tilde{\lambda}X + \left(1 - \frac{1}{\tilde{\lambda}}\right)\cdot 0\right) < \frac{1}{\tilde{\lambda}}\beta^{-1}\left(\tilde{\lambda}X\right) + \left(1 - \frac{1}{\tilde{\lambda}}\right)\beta^{-1}(0) = \frac{1}{\tilde{\lambda}}\beta^{-1}\left(\tilde{\lambda}X\right) \\
&\Rightarrow \tilde{\lambda}\beta^{-1}(X) < \beta^{-1}\left(\tilde{\lambda}X\right)
\end{aligned}
$$

So setting $\tilde{\lambda} = 1/[1 - \delta P(1 - \chi)] > 1$ and recalling that the high volatility project is selected iff

$$
\begin{aligned}
X_H(Z;\mu) &> \beta^{-1}\left(\frac{1}{1 - \delta P(1 - \chi)}\cdot\beta(X_L(r))\right) \\
&> \frac{1}{1 - \delta P(1 - \chi)}X_L(r)
\end{aligned}
$$

yielding that the high volatility project is selected less frequently as required.

For the final part, the low volatility project is selected iff

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

inverting this is true iff

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

The result follows as the right hand side tends to $X_H(Z;\mu)$ as $\alpha \to \infty$. ∎

Proof of Proposition 11. Comparing (31) and (32) the low volatility project is preferred if

$$
\begin{bmatrix} f + bX_L(r,v) \\ +\delta v[r(1 - \tau) - \mathbb{D}] \end{bmatrix} > \begin{bmatrix} f + bX_H(Z;\mu,v)[1 - \delta P(1 - \chi)] \\ +\delta\chi v\left[\left(\frac{Z}{\chi} - (i(\mu) - 1)\mathbb{D}\right)(1 - \tau) - \mathbb{D}\right] \end{bmatrix}
$$

This can be simplified to

$$
\left[b + \delta\frac{v}{1 - v}\right]X_L(r,v) > \left[b[1 - \delta P(1 - \chi)] + \delta\frac{v}{1 - v}\right]X_H(Z;\mu,v)
$$

This can be written

$$
\begin{array}{c} [b(1 - v) + \delta v] \\ \cdot[r(1 - \tau) - \mathbb{D}] \end{array} > \begin{array}{c} [b(1 - v)[1 - \delta P(1 - \chi)] + \delta v] \\ \cdot\left[Z(1 - \tau) + \frac{\chi\mathbb{D}}{\chi + (1 - \chi)\mu}[\tau(1 - \chi)(1 - \mu) - 1]\right] \end{array} \tag{41}
$$

Multiplying the right hand side by $[1 - \delta P(1 - \chi)]/[1 - \delta P(1 - \chi)]$ and then after further manipulations we have

$$
[b(1 - v) + \delta v][r(1 - \tau) - \mathbb{D}] > \left[\frac{b(1 - v)[1 - \delta P(1 - \chi)] + \delta v}{[1 - \delta P(1 - \chi)]}\right][W(Z,P)(1 - \tau) - \mathbb{D}]
$$

Which can be written as

$$
[r(1 - \tau) - \mathbb{D}] > \left[\frac{b(1 - v) + \frac{\delta}{[1 - \delta P(1 - \chi)]}v}{b(1 - v) + \delta v}\right][W(Z,P)(1 - \tau) - \mathbb{D}]
$$

Define
$$A\left(v\right) = \frac{b\left(1-v\right) + \frac{\delta}{\left[1-\delta P\left(1-\chi\right)\right]}v}{b\left(1-v\right) + \delta v}$$

The executive will select the low risk project iff

$$r > A\left(v\right) W\left(Z, P\right) + \frac{\mathbb{D}}{\left(1-\tau\right)}\left[1 - A\left(v\right)\right]$$

At $v = 0$ we have $A\left(0\right) = 1$ and so this collapses to $r > W\left(Z, P\right)$. The hurdle to take the low volatility project becomes harder to satisfy if the right hand side is increasing in v. The derivative of the right hand side with respect to v is $A'\left(v\right)\left[W\left(Z, P\right) - \frac{\mathbb{D}}{\left(1-\tau\right)}\right]$. Algebra confirms that $A'\left(v\right) > 0$ given $P > 0$. The result then follows if $W\left(Z, P\right) > \mathbb{D}/\left(1-\tau\right)$ and this follows given $\frac{\mathbb{D}}{1-\tau} < 1 \leq Z$.[30]

For the final part note that as $A'\left(v\right) > 0$ the risky project is most favoured at $v = 1$. Setting $v = 1$ in (41) and simplifying yields the condition given in (37): the pre-clawback cutoff. Hence the result follows given $v < 1$. ∎

Proof of Proposition 13. For part 1, suppose that the firm alters the pay to $\tilde{f} + \beta\left(\tilde{X}\right)$ where $\tilde{X}$ is the rebased equity value. If the executive selects the low volatility project then his pay is $\tilde{f} + \beta\left(X_L\left(r\right) - V^{\text{tax shield}}\left(\tau, \mu\right) - V^{\text{gov g'tee}}\left(\mu\right)\right) = \tilde{f} + \beta\left(r\left(1-\tau\right) - \mathbb{D}\right)$. Similarly, if he selects the high volatility project then his pay is $\tilde{f} + \beta\left(Z\left(1-\tau\right) - \mathbb{D}\right)$. The result follows as $\beta\left(\cdot\right)$ is increasing.

For part 2, the executive, in addition to his $t = 1$ bonus, receives deferred bonus v as a proportion of the $t = 2$ EBIT. If the high volatility project is selected then the EBIT is Z/χ if the project succeeds, and zero otherwise. The $t = 1$ equity value is therefore changed to:

$$X_H\left(Z; \mu, v\right) = \underbrace{\mathbb{E} + \mathbb{D} - 1 - \left[f + b\left(X_H\left(Z; \mu, v\right) - V^{\text{tax shield}}\left(\tau, \mu\right) - V^{\text{gov g'tee}}\left(\mu\right)\right)\right]}_{=0}$$
$$+ \chi\left[\left(\frac{Z}{\chi} - \left(i\left(\mu\right) - 1\right)\mathbb{D}\right)\left(1-\tau\right) - \mathbb{D}\right] - \chi \cdot v\frac{Z}{\chi} \tag{42}$$

The expected pay from selecting the high volatility project is therefore:

$$f + b\left(\begin{array}{c} \chi\left[\left(\frac{Z}{\chi} - \left(i\left(\mu\right) - 1\right)\mathbb{D}\right)\left(1-\tau\right) - \mathbb{D}\right] - \chi \cdot v\frac{Z}{\chi} \\ -\tau\chi\left(i\left(\mu\right) - 1\right)\mathbb{D} - \left(1-\chi\right)\mu i\left(\mu\right)\mathbb{D} \end{array}\right) + \chi \cdot \delta v\frac{Z}{\chi}$$
$$= f + b\left(Z\left(1-\tau\right) - \mathbb{D}\right) + \left(\delta - b\right)vZ$$

Analogously, the expected pay from selecting the low volatility project is $f + b\left(r\left(1-\tau\right) - \mathbb{D}\right) +$

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[30]

$$W\left(Z, P\right) - \frac{\mathbb{D}}{1-\tau} = Z\left[1 - \delta P\left(1-\chi\right)\right] + \frac{\mathbb{D}}{1-\tau}\frac{\left(1-\chi\right)}{\chi + \left(1-\chi\right)\mu}\left[\begin{array}{c} \tau\chi\left(1-\mu\right)\left[1 - \delta P\left(1-\chi\right)\right] \\ +\delta P\chi - \frac{\chi}{1-\chi} \end{array}\right]$$
$$= \left[1 - \delta P\left(1-\chi\right)\right]\left\{Z - \frac{\mathbb{D}}{1-\tau}\frac{\chi}{\chi + \left(1-\chi\right)\mu}\left[1 - \tau\left(1-\mu\right)\left(1-\chi\right)\right]\right\} > 0$$

$(\delta - b) \, vr$. Hence, the low volatility project is selected if and only if:

$$b \left(r \left(1 - \tau \right) - \mathbb{D} \right) + \left(\delta - b \right) vr > b \left(Z \left(1 - \tau \right) - \mathbb{D} \right) + \left(\delta - b \right) vZ$$

which is true iff $r > Z$ given $\delta > b$.

For part 3, the executive, in addition to his $t = 1$ bonus, receives deferred bonus v as a proportion of the generated $t = 2$ equity value. If the high volatility project is chosen and succeeds, then the total $t = 2$ equity value is $\left(\frac{Z}{\chi} - \left(i \left(\mu \right) - 1 \right) \mathbb{D} \right) \left(1 - \tau \right) - \mathbb{D}$. The bonus payment alters the $t = 1$ equity value to:

$$
\begin{aligned}
X_H \left(Z; \mu, v \right) = {} & \underbrace{\mathbb{E} + \mathbb{D} - 1 - \left[f + b \left(X_H \left(Z; \mu, v \right) - V^{\text{tax shield}} \left(\tau, \mu \right) - V^{\text{gov g'tee}} \left(\mu \right) \right) \right]}_{=0} \\
& + \chi \left(1 - v \right) \left[\left(\frac{Z}{\chi} - \left(i \left(\mu \right) - 1 \right) \mathbb{D} \right) \left(1 - \tau \right) - \mathbb{D} \right]
\end{aligned}
\tag{43}
$$

The expected pay from selecting the high volatility project now becomes:

$$
\begin{aligned}
& f + b \left(\begin{array}{c} \chi \left(1 - v \right) \left[\left(\frac{Z}{\chi} - \left(i \left(\mu \right) - 1 \right) \mathbb{D} \right) \left(1 - \tau \right) - \mathbb{D} \right] \\ - \tau \chi \left(i \left(\mu \right) - 1 \right) \mathbb{D} - \left(1 - \chi \right) \mu i \left(\mu \right) \mathbb{D} \end{array} \right) \\
& + \chi \cdot \delta v \left[\left(\frac{Z}{\chi} - \left(i \left(\mu \right) - 1 \right) \mathbb{D} \right) \left(1 - \tau \right) - \mathbb{D} \right] \\
= {} & f + b \left(Z \left(1 - \tau \right) - \mathbb{D} \right) + \left(\delta - b \right) v \chi \left[\left(\frac{Z}{\chi} - \left(i \left(\mu \right) - 1 \right) \mathbb{D} \right) \left(1 - \tau \right) - \mathbb{D} \right]
\end{aligned}
$$

Suppose instead the low volatility project is selected. Proceeding analogously the executive's expected pay is $f + b \left(r \left(1 - \tau \right) - \mathbb{D} \right) + \left(\delta - b \right) v \left(r \left(1 - \tau \right) - \mathbb{D} \right)$. The executive will select the low volatility project if and only if:

$$r > Z + \frac{\left(\delta - b \right) v}{b + \left(\delta - b \right) v} \left[\chi \left(i \left(\mu \right) - 1 \right) \mathbb{D} \frac{\tau}{1 - \tau} + \frac{1 - \chi}{1 - \tau} \mu i \left(\mu \right) \mathbb{D} \right]$$

As the deferred pay v increases the project selection rule can be returned to the original deformation given in Proposition 2. ∎

Proof of Proposition 14. 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 firm. Following the methods above, if the manager selects the high volatility project his pay will be $f + \min \left(b X_H \left(Z; \mu \right), f \right)$. Whereas if the low volatility project is selected then expected pay is $f + \min \left(b X_L \left(r \right), f \right)$. There are therefore four cases to consider and within each the executive's decision rule can be determined:

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

Recall that without the bonus cap the low volatility project is selected iff $X_L \left(r \right) > X_H \left(Z; \mu \right)$. Set $\hat{Z}$ to be the point the bonus cap becomes binding for the high volatility project.

For part 1, $Z < \hat{Z}$ corresponds to the top row. If $X_L(r) < f/b$ then bonus cap is not binding in either state. If $X_L(r) \geq f/b > X_H(Z;\mu)$ then bonus cap is binding on the low volatility project, but still yields a greater payoff than the high volatility project and so project choice is unaffected.

Now for part 2. Given the definition of $\hat{Z}$ this corresponds to the second row. If $X_L(r) < f/b \leq X_H(Z;\mu)$ then the high volatility project is always selected. Suppose therefore $X_L(r) \geq f/b$, the bonus cap is binding for both projects and so the executive is indifferent in terms of pay. Under assumption 1 the low volatility project is selected if $r > Z$ and $X_L(r) \geq f/b$. Note that $X_L(r) \geq X_H(Z;\mu)$ implies both of these constraints, and so the project selection decision moves towards the first best. Further, project choice is at the first best if Z is high enough that $r > Z$ is the binding constraint.

For part 2 again recall $X_H(Z;\mu) \geq f/b$, and so under assumption 2, if $X_L(r) < f/b \leq X_H(Z;\mu)$ then the high volatility project is always selected. Finally if $X_L(r) \geq f/b$, then the bonus cap is binding for both projects and so by assumption the executive maximises the equity value; selecting the low volatility project iff $X_L(r) > X_H(Z;\mu)$. Hence the decision rule is unchanged yielding the result. ∎

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