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**THE CASE FOR INTERVENING IN BANKERS' PAY**

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# The Case For Intervening In Bankers' Pay

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## Abstract

This paper studies banker remuneration in a competitive market for banker talent. I model, and then calibrate, the default risk of the banks generated by investments *and* remuneration pressures. Competing banks prefer to pay their banking staff in bonuses and not in wages as risk sharing on the remuneration bill is valuable. But competition for bankers generates a negative externality driving up rival banks' default risk. Optimal financial regulation involves an appropriately structured limit on the proportion of the balance sheet used for bonuses. However stringent bonus caps are value destroying, default risk enhancing and cannot be optimal for regulators who control only a small number of banks. The paper allows an assessment of the intellectual arguments behind widespread calls to regulate the pay of bankers. The paper uses US data to calibrate the analysis and demonstrate the significant contribution of remuneration to default risk.

**Keywords:** Bonuses, default risk, competition for bankers, financial regulation.

**JEL Classification:** G21, G34.

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*“We will not go back to the days of reckless behavior and unchecked excess at the heart of this crisis,”* President Obama, September 2009.

*“What is unfair is if you are an analyst who takes zero risk for the bank, and yet you can still be harmed by somebody who has been acting like they work for a mortgage hedge fund rather than an investment bank,”* former Lehman employee, October 2008.

## 1 Introduction

Is competition between banks for trader and executive talent destabilizing? Does the competition for bankers raise the risk of bank default? If so is there a case for financial regulation which intervenes in bankers’ pay? Many policy makers in the EU, US, and G20 feel that something is not right with bankers’ pay – that the high bonuses cannot just be the necessary incentives bankers require to work. Consequently the EU, US and individual countries within the EU have implemented or proposed policies which amount to the regulation of bankers’ pay.

This paper presents a model of banker remuneration in a competitive market for banker talent. This allows us to study, and then calibrate, the default risk of the banks generated by investments and remuneration pressures. We will show that competition by banks for bankers generates an empirically relevant negative externality driving up rival banks’ default risk. Optimal financial regulation will involve some intervention in the competitive market for bankers’ labour. In particular it will involve weak caps on the proportion of the balance sheet which can be used for bonus payments.

To appropriately frame a financial regulator’s problem, let us explore what problem intervention in the competitive market for bankers’ labour could hope to solve. At the level of the CEO and the other most senior executives in an organization the answer is immediate. Senior officers of a bank select the level of bank risk. It is important to ensure that these senior officers would not wish to take on more risk than their shareholders (Bebchuk 2009, Davies 2010) or more risk even than their debt holders (Bolton, Mehran and Shapiro 2010, Edmans and Liu 2010). However the argument for intervening in the labour market for all bankers is much less clear. Individual bankers work under a risk control regime overseen by the CEO and the Board. These senior executives can control bank risk through their policies on hedging, diversification and asset allocation. Financial regulation exists to make sure that CEOs and Boards properly

exercise their duties to understand and then build structures allowing them to manage the risks taken by their employees. Corporate governance failures may well exist in reality rendering the CEO and Board unwilling/unable to manage the risks (Thanassoulis 2009) – but if this is the problem then tackling corporate governance directly would be advisable. As Corporate Governance and risk supervision is improved by more active regulation, ill-founded interventions in the labour market for bankers will soon become constricting and outlive their usefulness. Rather, if there is a case for intervening in bankers' pay in general it must be that competition to hire the best bankers forces banks to, knowingly, pay and risk too much.

I offer a model of multiple banks of different sizes competing to hire a team of bankers from a population of bankers who are differentiated in terms of their skill, which is publicly observable. I model skill as affecting the expected return on assets. I assume that there are no corporate governance failings and so assume that the banks control the aggregate level of risk taken by their bankers so as to maximize bank value. The bankers can be paid in wages or bonuses or both - the choice is endogenous. If the net realization of the bankers' investments is to lower the bank's assets to below some given level, then a default event (or run) occurs which results in some extra cost for the bank. For example, the costs of premature liquidation of some of the assets to meet the higher than usual demands from debt holders, or the increased costs of capital which a weaker financial institution faces. Thus the banks compete to hire bankers and the remuneration and risk which the banks run are decided endogenously.

In the competitive market equilibrium I discover that the banks will opt to pay their bankers entirely in bonus. This is optimal for them not because of any incentive effects, instead a mechanism which has not been previously commented on is at work. Bonuses have much better insurance properties than wages do as the remuneration payment is better connected with the realized state of investments. If investment returns are low, the required compensation is also low – just when the danger of a default event is present. Thus banker bonuses, by facilitating risk sharing, allow banks to deliver utility to all their bankers in the least value reducing way.

Competition between banks for bankers creates a negative externality between the banks which drives banks' default risk upwards. Each bank would like to hire the best team of bankers they can. For a bank to ultimately hire a given team of bankers they must meet the competition for those bankers from the marginal competitor. The negative externality is exerted by

the marginal competing bank as by driving up remuneration they are imposing costs on the employing bank which they do not have to bear. The costs arise as the increased remuneration raises bank default risk, as a default event occurs even at smaller investment losses. Financial regulators would care about any increase in default risk as, firstly, the default of a financial institution has negative repercussions on all counterparties which are not internalised by the failing firm; and secondly, these negative repercussions may be so widespread that they cause other institutions to default resulting in a systemic crisis and so even greater costs for society as a whole.

Can remuneration payments by a bank ever appreciably add to the risk of a run or of default and so merit policy-maker attention? Just before the financial crisis the total remuneration bill in one year at Goldman Sachs and at Morgan Stanley was running at 50% of the entire stock of shareholder equity.<sup>1</sup> Looking at data on the banks and financial institutions traded on the NYSE over the last 10 years, in about 10% of cases the remuneration bill was worth more than 80% of total shareholder equity.<sup>2</sup> These are huge payments which can potentially make the difference between investors having and losing confidence in a bank. Thus it is imperative that a study of financial regulation considers remuneration.<sup>3</sup>

In the competitive equilibrium bonuses depend not only on the distribution of banker talent, but also on the size distribution of the banks competing to hire these bankers. We are able to solve for the equilibrium remuneration in closed form allowing an exploration of how financial regulation should adjust to properly reflect remuneration effects. This analysis is conducted in Section 4 and the results can be summarised as follows:

**Bonuses Limits.** A modest cap on the proportion of the balance sheet which can be used for bonuses – modest in that it is close to the current equilibrium rate of bonuses – lowers default risk and *raises* the value of the largest banks. If a *maximally weak bonus cap* is implemented then the default risk of almost all banks decline and their values rise. Such caps are purposefully structured to dampen the negative externality inherent in remuneration in the least costly way. The bonus cap as a proportion of the balance

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<sup>1</sup>Data from Thomson Datastream. See Figure 1 in Section 3.

<sup>2</sup>Data described and analyzed in Section 5. See in particular Figure 4.

<sup>3</sup>Haldane (2010), in a speech made as a member of the Bank of England monetary policy committee, notes that if UK banks had trimmed staff payments by 10% between 2000 and 2007 they would have saved £50 billion; roughly equalling the UK government bail out made available in October 2008.

sheet impacts the ability of rival banks to poach banking staff more than it impacts the equilibrium employer of a banker. Thus bonus rates for all banks fall. The bonus cap is weak in that, in equilibrium, the employing bank can still use bonuses. Thus the insurance problems of fixed wages are avoided. Such a regulation is of value even to a regulator who only controls a subset of the financial institutions. Features of this approach can be seen in the new Basel III restrictions on remuneration if tier 1 capital should fall below 7%.

However very stringent bonus caps, or a requirement to use wages rather than bonuses (as in the current EU proposals), increase bank default risk. The banks under such a regime are forced to use fixed wages. Competition for bankers keeps wages high and results in banks having high fixed costs they must pay whatever the outcome of their bankers' investments. As remuneration is such a large fraction of shareholder equity, the increase in risk is substantial. (See the calibration in Section 5). Appropriately designed bonus caps can therefore lower bank default risk even with well functioning corporate governance. If corporate governance were weak making it hard to control bankers' risk taking if they receive bonuses, then these bonus caps would be even more effective. Further, appropriately designed bonus caps, would not become constricting or outlive their usefulness once other corporate governance focused measures take effect.

**Taxation.** A financial regulator might consider taxing the bonus pools of the banks in the hope of dampening the negative externality created by remuneration. Such a policy was followed in the UK ("the 50% super-tax on bonuses") and in France. The taxation policy does lower the amount delivered to bankers, but it leaves bank default risks unaffected. In a competitive equilibrium, the amount a bank is willing to pay to hire a better banking team depends upon the quality of the alternative bankers it can hire. The tax does not alter this calculation. Though default risk is not altered, money is diverted from bankers' pay to the government.

**Increase capital adequacy ratios.** Financial regulators limit the risks that a bank can take on by requiring the bank to maintain a certain proportion of its risk weighted assets as equity (tier 1 capital). Changes in this capital adequacy requirement, or in the risk weightings, have the effect of altering the investment freedom of the bank for given equity levels. A reduction of the proportion of the balance sheet which can be put at risk does lower the

default risk of the banks. It will not lower the bonus rate which the bankers receive, but as they are restricted in the activities they can pursue with the balance sheet, their total pay declines. Thus if banks respond to stricter capital adequacy regulations by lowering the risk profile of their assets, then the negative externality inherent in remuneration is lowered, though so too is the value of the banks.

Choices as to the level of equity and the size of the balance sheet are outside the scope of this model. Admati et al. (2010) have argued that substantially higher equity requirements are called for which would force the banks to raise equity rather than lower the risk profile or size of their assets. They argue that, absent the tax deductibility of interest, such a rebalancing towards equity would be (close to) costless for the banks for the reasons described in the seminal work of Modigliani and Miller (1958). If banks do respond to stricter capital adequacy requirements by raising more equity then they would indeed become safer. Remuneration would still make up a part of the default risk in the manner this model describes – but the absolute level of risk would be reduced by the enhanced equity cushion.

**Too big to fail? Limit bank size.** There have been calls for a limit on bank size, or a tax which would have the same effect. An arbitrary cap on balance sheet size would result in a number of banks being of equal size at the bank size limit. These banks would compete with each other intensely for their bankers. The end result would be that banker bonus rates amongst the best bankers would rise and the default risk of all the banks affected by the size cap would be pushed up. (It is possible that a smaller bank will not be as important systemically and so the increased risk of default is acceptable.)

Of the possible regulatory tools analysed only two act to reduce the negative externality created by remuneration and so have the desired effect on default risk. These are capital adequacy and bonus caps. However only one of these, appropriately structured, can both lower default risk and raise the sum of bank values and remuneration. The promising intervention is, as described above, a modest cap on the proportion of the balance sheet which can be used for bonuses. Optimal bonus caps would be at least as strict as the *maximally weak bonus cap* defined in Section 4. Conversely, a more stringent bonus cap can be shown to not be optimal for regulators who do not control all of the banks in the market.

A calibration exercise suggests that remuneration can increase the risk of default of financial institutions by a quarter. For some institutions which are more likely to be shadow banks than commercial banks (ones where pay is an unusually large proportion of shareholder equity, and the amount of shareholder equity is greater), remuneration is almost the main component of default risk. Its inclusion can raise default risk by a factor of seventeen times (Table 1). Hence understanding how financial regulation should adapt to the impact of remuneration pressures is a first order issue.

### *Related Literature*

To be able to assess financial regulation in the light of bankers' pay I offer a model of a competitive labour market by banks for teams of bankers. Such an endeavour builds on the seminal contributions of Gabaix and Landier (2008) and of Edmans, Gabaix and Landier (2009). In this series of papers the authors offer a model of a competitive labour market for CEOs. My contribution is to reformulate the models to consider competition between banks which requires the introduction of the possibility of a bank default event into the labour market model. This addition is key. First it drives the risk sharing properties of bonuses as compared to wages. Secondly with no default possibility there can be no assessment as to how pay policy impacts default risk. The latter is of key interest in the case of banking. In a similar vein, Bulow and Levin (2006) consider a competitive labour market in which pay cannot be made worker specific and they demonstrate that wages are compressed. Here I allow banks to make offers conditional on who they are employing and so such remuneration compression does not result.

To capture the nature of a bank and the implications for default I have built on the model of banking offered by Wagner (2009). As in Wagner if the size of a bank's balance sheet should fall below some level (for example its level of liabilities) a default event or run occurs which results in an extra cost to the bank. Wagner however does not investigate the supply side competition for bankers and so is silent on banker pay in general.

The aim of this paper is to understand how intervention in the labour market for bankers would alter bank risk – widely considered policies go much broader than purely the regulation of CEO pay. Other researchers have used market equilibrium models to assess the effect of CEO pay regulation. Recently Dittmann, Maug and Zhang (2010) argue that capping CEO pay would lower firms' value in general. While Llense (2010) argues that pure pay for performance cannot



explain the full increase in French CEO pay. Edmans and Gabaix (forthcoming) argue that hiring decisions are more significant for wealth creation than optimising the CEO remuneration contract. The analysis I offer here makes at least two contributions. First it focuses on the market equilibrium of pay in a whole sector rather than just the CEO. Secondly it studies the risk of a run which banks have, which allows us to focus on the key policy question of the default risk accepted in equilibrium by the banking sector.

The work presented here identifies how competition between banks for bankers can create a negative externality which operates by driving up the remuneration rival banks must pay their bankers and so increases their default risk and expected costs of default. This new insight is related to a nascent literature which explores the externalities created for corporate governance by competition on the labour market. See Acharya and Volpin (2010), Acharya, Gabarro and Volpin (2010) and Dicks (2010).

An important insight from the model is that bonuses have a risk shifting role totally separate from incentive effects. Banks in my model have a concavity in their objective function which arises from the fact that, at sufficiently small investment realizations, a default event occurs which causes an extra cost for the bank. This insight has, to my knowledge, not been noted as being relevant to bankers' pay. That a risk averse entity would like to share risk with her contractees is known and parallels exist for example in the share-cropping literature which stemmed from Newberry and Stiglitz (1979). That contracts should be structured to share risk appropriately is known in the contracting literature as the Borch rule.<sup>4</sup> In a similar vein to this paper Nocke and Thanassoulis (2009) show that firms would seek to share risk with their suppliers if bad market outcomes would result in less investment than the first best in the future.

My model has focused on the aggregate level of risk which a bank would knowingly allow their team of bankers to take on rather than the risk choices of individual bankers. Others have focused on how competition between banks affects individual bankers' moral hazard in a parallel stream in the literature (Axelson and Bond 2009, Bijlsma Boone and Zwart 2010, Inderst and Pfeil 2009).

### *Plan Of The Paper*

The model is given in Section 2 and is solved for the competitive equilibrium in Section 3. Financial regulation in the light of bankers' pay is analyzed in Section 4. Some empirical

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<sup>4</sup>See Bolton and Dewatripont (2005) for a textbook treatment.

evidence and calibrations are provided in Section 5 while the conclusion follows in Section 6. Technical proofs are provided in Appendix A.

## 2 The Model

We consider  $N$  banks labelled by  $n \in \{1, 2, \dots, N\}$ . Bank  $n$  has assets  $S_n$  ordered so that  $S_1 > S_2 > \dots > S_N$ . The balance sheet is made up of debt plus capital. We label the debt of bank  $n$  by  $D_n$ . The difference between  $S_n$  and  $D_n$  is the capital buffer the bank has. In empirical applications we use the interpretation that debt is measured by total liabilities, while the capital is measured by shareholder equity. Thus  $S$  is the size of the balance sheet or equivalently total assets. Banks are risk neutral and, given no corporate governance failures, seek to maximize their expected value.<sup>5</sup> This formulation is sufficiently general that it can approximate a general member of the financial intermediation sector: commercial bank, investment bank, or other shadow bank (see Pozsar et al. 2010 for a full definition).

We consider  $N$  teams of bankers labelled the  $A_n$ -team with  $n \in \{1, 2, \dots, N\}$ . These teams of bankers may be interpreted as the set of traders, fund managers and investment bankers whose investments and underwriting activities affect the risk profile of their institution. The  $A_n$ -team generate expected returns of  $\alpha_n$  where  $\alpha_1 > \alpha_2 > \dots > \alpha_N > 1$ . If the  $A_n$ -team runs money they will generate a random return given by the known distribution  $F_n(x)$  which is assumed to be supported on  $[0, \infty]$ . The lower bound of 0 is equivalent to assuming a limited liability constraint applying to the investments undertaken. Each team of bankers has an outside option which we normalize to a utility of 0. We assume that the team of bankers is risk neutral and so seek to maximize their expected remuneration.

The model assumes that bankers are risk neutral, as are the banks which employ them. That bankers are risk neutral, or at least not strongly risk averse, is quite defensible. First there is direct evidence that traders are myopically loss averse, and so risk loving over losses. This evidence begins with Haigh and List (2005) who in experimental work demonstrated that professional traders actually exhibit an enhanced bias towards loss aversion when compared

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<sup>5</sup>If banks were risk averse then the results of this paper would be reinforced. Risk neutrality for firms and banks is however arguably more standard, though portfolio theory methodologies (see for example Rochet 1992 for an early example) model banks as exogenously risk averse.

with that found in the general population.<sup>6</sup> Since that work the results have been corroborated by Coval and Shumway (2005) in US Treasury Bond market-makers, and in empirical data drawn from Taiwanese options traders by Liu et al. (2010). A second justification for the risk neutrality assumption on bankers is drawn from the medical literature. This evidence begins with Coates and Herbert (2008) who demonstrate that the most successful traders have higher testosterone levels than their peers; and it is known that increased testosterone levels act to raise the appetite for financial risk (Apicella et al. 2008) amongst other types of risk. Following this up Coates, Gurnell and Rustichini (2009) note that biological features generated by testosterone are a predictor of the longevity and success of traders. Sapienza, Zingales and Maestripieri (2009) corroborate these findings in a study of 550 MBA students at the University of Chicago. They demonstrate that in the cohort of Chicago MBAs that year, the ones with a low level of risk aversion (and high levels of testosterone) were the ones who selected careers in finance. Finally the evidence for weak risk aversion in financial markets comes from direct econometric analysis of market data. If one assumes a representative agent then any state-price density can be reconciled with a given set of asset prices by assuming an appropriate set of preferences for the representative agent. Hence estimates of risk aversion are possible. The assumptions which underlie this approach have been critiqued (Ziegler 2007 for example). Nevertheless, using this technique some prominent studies have been undertaken into reasonable risk aversion parameters for the representative investor. Jackwerth (2000) calculates an estimate of risk aversion using data from 1988 through to 1995 which is actually risk loving for the majority of the wealth scale, including the central estimate. Rosenberg and Engle (2002) is less categorical – however depending on the exact method used to extract beliefs from the price data they also find evidence of low and sometimes negative risk aversion. Hence I conclude that risk neutrality is a compelling assumption for the bankers of this model. Actually in the model which follows I do not require bankers to be risk loving, or even risk neutral; all the results apply as long as bankers are not too risk averse.

The  $N$  banks are in competition to each hire one team of bankers. This competition is modelled by the following full-information two stage game:

1. **Hiring Stage.** Each bank can offer a given team the remuneration package  $(w, q)$  where

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<sup>6</sup>There is a much longer history of work demonstrating loss aversion in experimental trading games performed by non-professionals. See, for example, Thaler et al. (1997), and Gneezy, Kapteyn, and Potters (2003).

$w$  is the fixed wage and  $q$  is the bonus rate which applies to the realized returns on any investments made. These offers are banking team specific – better bankers can be offered more generous packages. The matching and market remuneration is decided as the outcome of a standard simultaneous ascending auction for the teams of bankers. As each banking team is a substitute for another such auctions deliver the competitive equilibrium assignment (Milgrom 2000).<sup>7</sup>

**2. Investing Stage.** Once each of the  $N$  banks has hired one team of bankers then it must decide on the amount,  $y$ , of assets it will allow the team of bankers to invest, given their ability.<sup>8</sup> The bankers hired will then convert the assets  $y$  into assets  $ay(1 - q) - w$  for the bank, where  $a$  is the realized return. The remaining assets are invested at the risk free rate. Should the realized value of the bank fall below some given level – here we assume a multiple of  $(1 + \varepsilon)$  times the level of the debt – then there will be a run on the bank. We interpret this as an above normal draw down of funds resulting in the bank needing more liquid assets. The bank is therefore forced to liquidate some of its assets prematurely and so incurs a further cost of  $\lambda y$ .  $\lambda \in (0, 1)$  is the cost of a run on the bank (equivalently a default event) and is proportional to the initial sum put at risk and invested. To save on notation we set  $\varepsilon = 0$ . The bank remains a going concern and so does expect to bear the costs of any default event.

Capturing the default risks and so costs of a run faced by a bank in a simple and clean way is important to this paper. These costs could come from early asset sales as described, or a second interpretation would be the increased cost of capital which a bank must pay to refinance the liabilities on its balance sheet (via debt or equity) in the event of a poor investment realization. The model sets the cost of a default to be proportional to the initial sum put at risk and invested. Thus the greater the value of initial assets invested and subsequently lost, the greater the costs to the bank of any run on the bank. In reality the level of costs associated with a bank run are

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<sup>7</sup>Milgrom (2000) requires straightforward (that is non-strategic) bidding for the simultaneous ascending auction (SAA) to deliver the competitive outcome. Here, as we have substitutable goods, the competitive equilibrium would always be the outcome (in the absence of collusion between the banks) if we implement the SAA as a standard clock auction (Ausubel and Cramton 2004). Clock auctions have the bids rising continuously until there is no excess demand for each item. Such an auction is “a practical implementation of the fictitious ‘Walrasian auctioneer’.” (Ausubel, Cramton and Milgrom 2006). A similar process of bidding has been used in the labour matching literature and again shown to lead to a competitive equilibrium. (For example Crawford and Knoer 1981).

<sup>8</sup>The results of the model would be unchanged if the banks could commit to a given  $y$  at the hiring stage.

uncertain as they depend on the expectations of the creditors. All that matters for this model is that bank runs have a cost to the bank – we capture this cost in such a way as to make the model clean and the intuitions as clear as possible.

The benchmark model abstracts, robustly, away from two types of moral hazard as the distribution of returns for the  $A_n$ -team is known. The first type is that the team of bankers need to be incentivised to work. The model is entirely robust to this moral hazard as the expected returns can be measured net of any agency cost and we can further require bankers to receive at least some minimum bonus which creates sufficient incentives for work. We will see that in equilibrium the bonus selected will be above any such minimum threshold.

The second type of moral hazard is that bankers are tempted to engage in risk-shifting. If so the variance of the returns distribution,  $F_n$ , may be a function of the bonus,  $q$ , and the Board is unable to control this. I see this as a failure of Corporate Governance – the Board and senior executives are unable to adjust the aggregate risk profile of the bank as they would like. This model deliberately abstracts from this Corporate Governance failure. Such a failure may well exist, and if so should perhaps be (and indeed is) tackled directly through measures such as more intrusive regulatory risk assessment and stronger risk controls. The relevant question to be addressed here is whether intervening in the labour market of bankers would indeed lower the default risk of a properly governed banking sector.

It is possible to imagine more complicated non-linear relationships between the realized returns of the team of bankers and the proportion of the balance sheet used for bonuses ( $q$  as a function of the realized  $ay$ ). What matters for this model is that at the point at which a run would start the bank would still find itself needing to pay bonuses. Evidence from the recent financial crisis demonstrates that this is the relevant empirical case.<sup>9</sup> In the benchmark model I have opted for a very tractable formulation – and one which fits the key stylized facts in the data. Some might argue that if an individual banker doesn't make money then they are fired and certainly won't receive a bonus at all. Therefore, aggregating up, perhaps it would be preferable to consider the bonus rate  $q$  paid out by the bank in the aggregate as applying only when profits are made and so the balance sheet grows.

This reasoning is incomplete for at least three reasons. First if one accepts the argument that

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<sup>9</sup>For example in the height of the financial crisis as losses at Merrill Lynch mounted, the bank rushed forward \$3.6bn of bonus payments to be completed just hours before the transfer of ownership to Bank of America. See “Merrill delivered bonuses before BofA deal”, Financial Times, January 21, 2009.

in banking there is little sympathy for losses then consider the following thought experiment. Individual trader  $x$  begins with funds of 100, makes a 25% loss in 6 months, and is promptly sacked. Suppose that trader  $y$  is hired in their place and succeeds in making a 10% profit on the existing assets. Therefore  $y$  gets a bonus and yet for the bank assets have shrunk over the year from 100 to  $100 * 0.75 * 1.1 = 82.5$ , a reduction of 17.5%. Thus at the aggregate level bonuses are paid when losses are made even if they are not at the individual level. Secondly, and a variant of the above, is to note that the banks in this model hire a team. If one individual within the team makes a profit then they would expect a bonus. This remains true even if another member of the team has racked up a loss so great that it outweighs the profits of the first employee. Hence overall bonuses are still payable to some even though at the bank level a loss has been recorded. (Note that by focusing on remuneration at the team level the bank has sufficient flexibility to pay individuals who perform well even when others do not). Finally the simple argument that bonuses are unrealistic in the case of losses ignores the ability of bankers to argue that any losses are not their fault but rather a general sectoral effect. These arguments are borne out in the data (see section 5). In particular Figure 3 compares the remuneration per employee against the change in shareholder equity for a large sample of banks. The data confirm that large sums are paid out in remuneration even in the case of losses to shareholder equity.

We complete the model by adding some modest general structure on the distribution of bankers' investment returns. First we suppose that the density  $f_n$  of gross returns is a scaling of a standard mean 1 distribution  $f$  such that  $f_n(x) = (1/\alpha_n) f(x/\alpha_n)$  where the initial multiplication by  $1/\alpha_n$  guarantees that  $f_n$  has measure 1 and expectation  $\alpha_n$ . Therefore the distribution of the gross returns satisfies

$$F_n(v) = \int_{x=0}^v f_n(x) dx = \int_{z=0}^{v/\alpha_n} \frac{1}{\alpha_n} f(z) [\alpha_n dz] = F(v/\alpha_n) \quad (1)$$

This assumption states that the teams of bankers differ only in their skill. Thus each team of bankers makes returns which are, on average, a scaling of other teams. As the bank is risk neutral the distribution of the investment returns will only have relevance if they trigger a default event and so the extra costs of premature asset liquidation to stem a run on the bank. In any empirically relevant calibration of this model default will be a low probability event. Hence the relevant probability will lie in the tail of  $F_n$ . We now follow Gabaix and Landier (2008) and

seek to use insights from extreme value theory. We assume that the density  $f$  is regular as it approaches zero so that the following limit which describes the tail behaviour exists and is finite:

$$\lim_{x \downarrow 0} x f(x) / F(x) = \gamma \in (0, \infty)$$

Reflecting in the origin, it follows that the right hand tail of the distribution function  $F(-x)$  is in the domain of attraction of the right hand tail of the Weibull class of distributions. This is a class which includes, for example, the beta, power law and uniform distributions (Embrechts, Kluppelberg, and Mikosch Table 3.4.3). In this case a simple approximation to behaviour in the tail is possible (Resnick Proposition 1.16, p63 and Proposition 1.13 p59). Reflecting back on to the positive reals we have:

$$F_n(v) \sim G \cdot (v/\alpha_n)^\gamma \quad (2)$$

Where  $G$  is a slowly varying function.<sup>10</sup> As 0 is a lower bound of the support, and as default is a low probability event we require the tail to not be concave in the vicinity of zero. Hence we restrict to  $\gamma \geq 1$  and further we make the simplifying assumption that  $G$  is a positive constant.

### 3 Equilibrium Remuneration And Risk Under Competition For Bankers

We solve the model using backward induction to determine the competitive market rate of bankers' remuneration and the equilibrium default risk the banks run.

#### 3.1 Stage 2: The Investing Stage

Suppose that a bank of size  $S$  has hired the  $A$ -team of bankers. We will show that the bank will allow the team to invest all of her assets,  $S$ . We postpone analysis of any mandatory capital adequacy requirements until the discussion of financial regulation in section 4. Gross of any default, if the bank allows the bankers to invest an amount  $y$  then the value of the bank is  $S - y + a(1 - q)y - w$  where  $a$  is the realized value of the investments. There is a run on the

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<sup>10</sup> $G(x)$  is slowly varying at 0 if

$$\lim_{x \rightarrow 0} G(tx) / G(x) = 1 \text{ for any } t > 0$$

For a textbook treatment of extreme value theory see Embrechts et al. (1997) in particular chapter 3.2.

bank if

$$S - y + a(1 - q)y - w < D \Leftrightarrow a < \frac{y + w - (S - D)}{y(1 - q)}$$

Hence the probability of default will be

$$G \cdot \left[ \frac{y + w - (S - D)}{\alpha y (1 - q)} \right]^\gamma$$

Recall that  $a$  is supported on  $[0, \infty]$ . Hence the default risk is zero if  $y < (S - D) - w$ . But in this case the expected value of the bank is increasing in  $y$  if  $\alpha(1 - q) > 1$ . We assume this plus a little more as we wish to consider the case in which the bankers' skills are desirable:

**Assumption: Bankers Worth Having** We restrict attention to parameters for the bankers which satisfy:  $\alpha(1 - q) > [1 + \sqrt{1 + 4G\lambda}] / 2$  for all relevant  $\alpha$  and  $q$ .

This assumption is clearly always satisfied if  $\alpha$  is large enough. We will see that in the competitive equilibrium the *bankers worth having* assumption is always satisfied if a simplified form holds for the  $A_N$ -team of bankers. Namely the only parameter restriction required is that  $\alpha_N > [1 + \sqrt{1 + 4G\lambda}] / 2$ . Given the *bankers worth having* assumption we can prove:

**Lemma 1** *Under the bankers worth having assumption, the bank would allow the team of bankers to invest all the bank's assets:  $S$*

Lemma 1 follows by demonstrating that the value of the bank is increasing in the amount of funds the team of bankers are allowed to invest. As the expected return of the banking teams is greater than 1 the expected value of the bank, gross of the costs of default, is clearly increasing in the funds given to the bankers. The difficulty comes as the default risk which a bank runs is also increasing in the amount of funds which the bank allows to be invested. This is true as the greater the proportion of the balance sheet given to the bankers, the smaller the loss that can be withstood without the bank undergoing a default event.

The *bankers worth having* assumption guarantees that the expected return of the team of bankers is sufficiently great that it outweighs the increase in the risk generated from the possibility of extremely low investment returns which are very much in the tail of the returns distribution. Therefore, if a bank hires a team of bankers then the expected value of the bank,



and the default probability are given by:

$$\begin{aligned}\Pr(\text{default}) &= G \cdot \left[ \frac{w + D}{\alpha S (1 - q)} \right]^\gamma \\ E(\text{bank value}) &= \alpha (1 - q) S - w - \lambda S G \cdot \left[ \frac{w + D}{\alpha S (1 - q)} \right]^\gamma\end{aligned}\tag{3}$$

Note that, setting banker remuneration aside, default risk is a monotonic function of  $D/S$ . Hence banks with a smaller ratio of capital to assets are at greater risk of default as would be expected.

### 3.2 Stage 1: The Hiring Stage

Let us now consider the set of  $N$  teams of bankers. In stage 1 the banks bid against each other to hire the bankers. If the  $A_n$ -team of bankers secures the contract  $\{w, q\}$  from a bank of size  $S$  then the bankers' expected utility is

$$E[U(w, q)] = E[w + qaS] = w + q\alpha_n S$$

**Proposition 1** *The competitive outcome will be for the bankers to be paid entirely in bonus.*

Recall that there are no incentives in this model. Bonuses, in this model, provide an economically important function. They allow a more appropriate sharing of risk between the bank and the bankers than fixed wages allow. This role of bonuses has been absent from the policy debate and academic literature around bankers' pay.

Formally the result follows as competition for the bankers forces the banks to maximize their profits subject to delivering the market determined level of utility to the team of bankers. Both wages and bonuses allow rents to be transferred from the bank to the bankers, and so there will be indifference curves for both banks and bankers between the two. The main part of the proof is to show that

$$\left[ \frac{dw}{dq} \right]_{\text{iso-bank}} > \left[ \frac{dw}{dq} \right]_{\text{iso-banker}} \quad \text{if cost of default } \lambda > 0$$

This implies that the bank's profits can be maximized, keeping the bankers indifferent, by using bonuses instead of wages.

The economics of this result can be explained as follows. The bank is a risk neutral entity, or more exactly, is risk neutral conditional on not having a default event. Should the return provided by the team of bankers be low enough then a default event occurs. Such a default event creates extra costs for the bank. As a result the bank is de facto risk averse in that it suffers disproportionately in the event of very low investment returns. If the bank paid only in wages then competition would drive the wages up to high levels and the bank would have to pay this even when investment returns were poor. This would put the bank at risk of a default event and so the expected value of the bank would be reduced. If instead there is a transfer of remuneration from wages to bonus such that the team of bankers are indifferent, then the bank now gains. If investment returns are large then it pays out huge bonuses - but this is at no risk of a default event. If investment returns are poor then the remuneration bill falls at just the right time.<sup>11</sup>

The probability of a default event is increasing in the level of debt which makes up the balance sheet (equation 3). If a bank had a much lower level of debt, and so a much higher level of equity, then the probability of an investment loss so severe it wiped out a large proportion of the shareholder equity would be reduced. This would lessen the imperative a bank has to pay in bonuses rather than wages. But it would not remove that imperative as in the event of a bad investment realisation the flexibility of bonus pay would be valuable in helping to avoid a default event.

To determine the level of risk banks run we must first determine, in equilibrium, which banks will hire which teams of bankers.

**Lemma 2** *The equilibrium in the market for bankers results in positive assortative matching.*

If there were no risk or cost to default then Lemma 2 would follow from standard arguments. In particular efficiency is maximized by positive assortative matching as a bank of higher rank has a larger balance sheet which can benefit from a better team of bankers' skill. Here however the result is complicated by the fact that transfers between banks and bankers alter the banks' default risk and so alter the total surplus available. Thus we have a setting of non-transferable

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<sup>11</sup>Note that bonuses can be seen as a case of hedging as described in Froot et al. (1993). When investment returns are poor a bank's assets fall and its liabilities stay high. It would, at such a time, be expensive to access external capital as this would mean growing liabilities further. Hence a bank would seek to limit its call on cash at such times – a feat which can be achieved by bonuses.

utility. The proof calculates how high a bonus, if necessary, each bank is willing to offer a given team of bankers. I then show that a higher ranked bank would be willing, if forced, to deliver more expected utility to a team of bankers than a lower ranked bank. Hence we have positive assortative matching.

Therefore we can assert that in equilibrium bank  $n$  with balance sheet  $S_n$  would employ the  $A_n$ -team and pay them a bonus rate of  $q_n$ . The competition for the services of the  $A_n$ -team comes from the bank one place down in the league table of size: bank  $n + 1$ . We can therefore now solve for the competitive equilibrium:

**Proposition 2** *Competition for the teams of bankers implies positive matching between the teams of bankers ranked by average returns and the banks ranked by asset size. The bankers are paid all in bonus with fixed wages,  $w$ , set to 0. The equilibrium bonus rates for the  $A_n$ -team are given by*

$$q_n^{eqm} = \frac{1}{\alpha_n S_n} \sum_{j=n}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1} \quad (4)$$

The use of bonuses is proved by Proposition 1 and the positive assortative matching by Lemma 2. Hence in a competitive equilibrium for bankers the competitive pressure on the bankers' pay comes from the bank one notch down in the size league table. The hiring bank sets its bonus to its team of bankers to deliver just as much expected utility as the maximum which the smaller bank would be willing to offer. Hence in equilibrium the proportion of the balance sheet used for bonuses depends upon the size distribution of the rival banks as well as the distribution of skill in the population of bankers.

The analysis demonstrates that banks exert a negative externality on their rivals higher up the size league table. They compete to hire the best teams of bankers, driving up the remuneration which the larger banks must ultimately pay. This raises the default risk of the larger banks as smaller investment losses will trigger a default event, and so the expected costs of default are raised. The smaller banks, who bid up bonuses but fail to make the hires, do not internalise the increased costs they impose on others.

The insights of Proposition 2 carry over into more complicated versions of the model above in which one drills down further into the banking team. Suppose for example that a banking team can be decomposed into a foreign exchange (forex) team and a structured finance team

and that some banks have two teams (one devoted to structured finance, the other to forex), while other banks and shadow banks have just one or the other. Competition for each team would proceed as described above and the bonus rate received by a forex team would depend upon competition for forex teams and the size of the balance sheet which could be used for foreign exchange dealing. Similarly for the structured finance teams. Thus the relationships between balance sheet, remuneration and risk would be as described. (It is however difficult to solve the model explicitly without some structure on the shape and correlation of returns to the different activities). In particular banks would rather reward in bonuses as opposed to wages. Further the size of bonus required, and so the risk undertaken, would depend upon the competition to hire that team of bankers from the balance sheet one notch down in the league table of funds and balance sheets devoted to that activity (forex, structured finance etc.). The negative externality from competition for bankers on default risk would remain. Focusing on the whole team of bankers allows the important results to be developed cleanly and directly.

Proposition 2 draws together the result that competition for bankers results in bonuses being used for remuneration, and that the largest banks secure the best banking teams as they can allow the bankers to invest the greatest amounts and so maximize the bonus fueled returns. Before discussing the implications of Proposition 2 more fully we first remark on the parameter distribution of banker talent which satisfies the *bankers worth having* assumption.

**Remark 1** *The bankers worth having assumption is satisfied if*

$$\alpha_N > \left[1 + \sqrt{1 + 4G\lambda}\right] / 2$$

*This follows as using (13) it follows that higher ranked teams of bankers deliver higher expected returns net of bonus:  $\alpha_n(1 - q_n) > \alpha_{n+1}(1 - q_{n+1})$ ; and  $q_N = 0$  as the outside option is normalized to 0.*

### 3.3 Banking Market Structure And Default Risk

I have argued that bonuses play an important economic role aside from motivating bankers. Bonuses are an important tool for making the remuneration payments more state dependent – that is to manage risk. As bonus rates depend in a market equilibrium on the size of smaller

competing banks, so too will the default risks which the banks run depend upon the size of their rivals. Substituting (4) into (3) we see that the probability of bank default events (that is bank runs) in equilibrium is given by

$$\Pr(\text{default}_n) = G \cdot \left[ D_n / \left( \alpha_n S_n - \sum_{j=n}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1} \right) \right]^\gamma \quad (5)$$

The size of smaller competing rival banks therefore has a direct effect on the proportion of the balance sheet used for bonuses and so on the risk of bank default. The reason smaller rivals are the only ones which matter is that in equilibrium the competitive pressure to raise the bonus remuneration to the team of bankers comes from the bank one spot down in the league table of balance sheet size. Inspection of (5) yields that:

**Corollary 1** *The risk of default of the bank hiring the  $A_n$ -team increases if*

1. *rival banks of smaller size grow in asset size; or if,*
2. *the  $A_j$ -team of bankers with  $j > n$  become worse.*

If either the rival bank is large, or if the less good teams of bankers are a very poor substitute, then the rival bank will be willing to pay a lot for the  $A_n$ -team. To win the  $A_n$ -team bank  $n$  will therefore have to pay more in the form of a larger expected bonus. It is this which leads to the increase in default risk faced by the larger bank. Note that the history of investment banking in the recent decades has seen capital consolidating in a small number of banks so that concentration ratios have increased (see Morrison and Wilhelm 2008). The analysis we have conducted demonstrates that as rival banks expand, bonus payments are forced up and so is the default risk which banks must run.

Our model allows us to explore how the risk of default is spread across large and small banks in the competitive equilibrium. There has been a great deal of focus on banks which are “too big to fail” recently: a topic we explore further in the study of financial regulation considered in Section 4. On the other hand the banks which succumbed to the banking crisis were often not the largest ones: for example Northern Rock and Bradford and Bingley in the UK. Larger institutions will be paying more to their team of bankers – but they are in a position to hire the better bankers also. To address the question of bank size and default risk let us suppose for this

part only that all banks maintain a constant capital buffer equivalent to  $\kappa\%$  of their balance sheet. Thus a bank with balance sheet  $S$  will have liabilities of  $D = (1 - \kappa) S$ . The equilibrium default risk run by a bank of rank  $n$  in the league table of size is given by (5). Analysis reveals:

**Proposition 3 (Small Banks Are More Risky)** *Suppose all banks maintain a capital buffer of  $\kappa\%$  of their balance sheet. The default risk in equilibrium is increasing in  $n$  where  $n$  is the bank's position in the asset size league table.*

The result follows as the bonus payments made to better teams of bankers increase less than proportionately with respect to the rate at which larger banks have larger balance sheets. The reason is that the remuneration a team of bankers earn in a competitive equilibrium depends upon the size of the nearest rival bank one notch down in the league table of size. As we move up the bank league table the remuneration paid grows, but only as fast as the balance sheet of the bank one notch down in terms of size. Further this effect is reinforcing as we move to larger banks as more value from their own team of bankers makes them less willing to pay high levels of remuneration for banking teams which are better. Hence larger banks, though paying more for a better team of bankers, see their default risk decline in comparison to the smaller banks. To reinforce the relevance of this result, Figure 5 contained in Section 5 sheds light on the strength of the assumption that banks maintain a constant capital buffer using a large data set of banks traded on the New York Stock Exchange. Figure 5 demonstrates that an assumption of  $\kappa = 10\%$  has considerable empirical justification with most banks setting capital buffers very close to that figure.

But is bank remuneration in practice at the level at which it could precipitate a default event? We consider a fuller empirical answer to this question in Section 5. We can however here explore the importance of remuneration for a small number of systemically important banks. Acharya, Gujral and Shin (2009) compile a list of 21 systemically important banks, many of whom went on to receive some form of government aid during the financial crisis. Acharya, Gujral and Shin document that even during this crisis these banks made substantial dividend payments which have been large enough, they argue, to have had a measurable impact in altering the banks' capital structure and inhibiting further lending by these banks in recent years. I have collected remuneration, dividend and shareholder equity data on the same sample of banks

from Datastream.<sup>12</sup> Figure 1 displays the level of dividend payments against remuneration, both scaled by shareholder equity. The difference is striking. The figure demonstrates that remuneration payments are an order of magnitude greater than dividend payments in these institutions. The maximum remuneration payments have been over 90% of shareholder equity in the past, and they were on a rising trend in the run-up to the recent financial crisis. The median dividend payment by contrast is down at around only 5% of shareholder equity, and the maximum dividend payment was barely above 20% of shareholder equity. Most banks in this sample have paid out more than 20% of shareholder equity every year as remuneration throughout the decade considered. So I conclude that total remuneration is a non-trivial charge on the bank and can represent a non-trivial default risk after bad investment realizations.

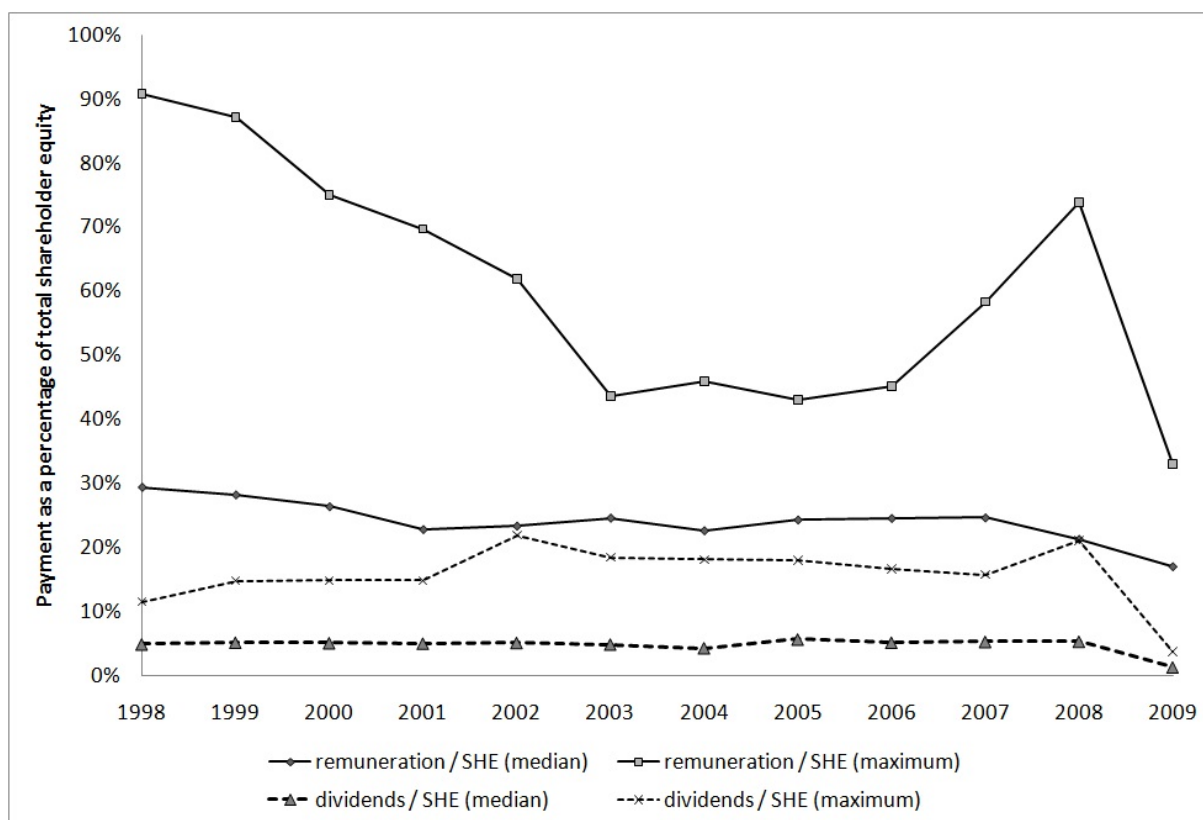


Figure 1: Comparison of Remuneration to Dividends For Some Systemically Important Banks. Notes: The graph shows the median and maximum remuneration payments as a proportion of shareholder equity (SHE) for 21 systemically important banks (footnote 12). The remuneration payments are compared against the total dividends paid out by the banks as a proportion of shareholder equity. The graph demonstrates that remuneration payments are an order of magnitude greater than dividend payments and so, I argue, make a first order contribution to a bank's default risk. [Data from Datastream].

<sup>12</sup> JP Morgan, Wells Fargo, Lehman Brothers, IKB, RBS, Wachovia Corporation, Citigroup, Washington Mutual, Merrill Lynch, Morgan Stanley, UBS, HSBC, Bank of America, Barclays plc, Credit Suisse, Deutsche Bank, Goldman Sachs, Fortis Bank, HBOS, Lloyds TSB, BNP Paribas.

## 4 Financial Regulation, Remuneration and Default Risk

Thus far we have established a framework which embeds banker remuneration into a setting of supply side competition. Using this machinery we are in a position to interrogate the impact of financial regulation on bankers' pay and hence on bank default risk. At the end of this Section we will use these results to characterise features of optimal financial regulation.

### 4.1 Bonus Limits and Default Risk

Let us begin by supposing that a financial regulator decides to impose limits on the proportion of each bank's balance sheet which can be used for bonuses to an upper bound of  $Q$ . The banks must now compete for the team of bankers without recourse to 'excessive' bonuses. I study whether such an action will increase or decrease the default risk and/or the value of the banks.

This proposal is similar in spirit to the updated Basel III regulations which deliver bonus restrictions based on an assessment of the size of the balance sheet.<sup>13</sup> The analysis is also similar to the bonus cap proposed by Democratic Senator Dodd in the US Stimulus Bill of early 2009.<sup>14</sup> In that proposal the bonus was expressed as a proportion of the total take home pay and was therefore more restrictive than the policy analysed here which leaves banks with discretion as to how to pay individuals. The analysis here is in addition similar to the current proposals from the EU parliament which require banks and hedge funds<sup>15</sup> "to establish limits on bonuses related to salaries".<sup>16</sup> In all of these proposals bonuses are restricted and banks are encouraged to use wages.

For this section only let us make the regularity assumption that the capital buffers are larger in magnitude in larger banks:  $S_n - D_n > S_{n+1} - D_{n+1}$  for all  $n$ . Then we have:

**Proposition 4** *Suppose a financial regulator limits each institution to using not more than a proportion  $Q$  of their balance sheet for bonus pay:*

1. *If the bonus cap is not too strong,  $Q^* \leq Q \leq \max_m \{q_m^{eqm}\}$ , then it strictly lowers the*

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<sup>13</sup>For banks whose tier 1 capital is less than 7% Basel III mandates a restriction on remuneration. See "Basel rewrites capital rules for banks", Financial Times, September 12th, 2010.

<sup>14</sup>See "Stimulus bill extends cap on bank bonuses," Financial Times, February 14, 2009.

<sup>15</sup>Formally this applies to all institutions in the EU covered by the Capital Requirements Directive. This is a wide net including both credit institutions and investment firms.

<sup>16</sup>See press release from the European Parliament: "European Parliament caps bankers' bonuses", Economic and monetary affairs - 30-06-2010.



*default risk and raises the value of all the largest banks, leaving all other smaller banks unaffected.*

*2. If the bonus cap is too strong,  $Q \leq Q_* \leq Q^*$  then relaxing the cap (increasing  $Q$ ) would*

*(a) strictly lower the default risk of some banks.*

*(b) If tail risks are close to flat ( $\gamma$  close to 1), then relaxing the cap would strictly lower the default risk and raise the value of all the banks except the smallest (bank  $N$ ).*

A modest cap on the proportion of the balance sheet which can be used to pay bonuses lowers default risk and raises bank value of all except the smallest banks, and these remain unaffected. The intuition for why is as follows. In equilibrium the competition bank  $n$  faces to hire its team of bankers comes from the bank one notch down in the league table of balance sheet size. As bank  $n$  has a bigger balance sheet it can match the remuneration offer of this rival bank with a lower bonus rate as it is applied to a larger pot of assets. A bonus cap is therefore more binding on the (smaller) rival than it is on bank  $n$ . Hence the bonus cap forces the rival bank to bid for the team of bankers with a bonus up to the cap and also with a fixed wage on top. However we established in Proposition 1 that wages have worse insurance properties than bonuses: they raise the bank's default risk. As a result the rival is willing to bid less hard. So bank  $n$  can pay less for her team of bankers. Further, as the cap is not too stringent bank  $n$  can still deliver the required utility to her bankers purely through bonus (this defines the lower bound  $Q^*$ ) – so the bad effects of fixed wages are not forced on the employing bank. Hence overall such a policy is good for banks and good for society due to the lower default risk. (Though bad for bankers).

It would however be wrong to conclude that bonus caps, however strict, are beneficial. If the bonus cap is too extreme  $Q < Q^*$  then some banks will have to revert to using wages as well as bonus to pay the team of bankers they actually hire. This recourse to wages increases the risk a bank is under. This negative effect must be set against the positive effect resulting from the dampening of the competition in the labour market for bankers which a strict bonus cap delivers.

Proposition 4 demonstrates this trade-off. Consider the case of a bonus cap so stringent that all banks find themselves affected by it and so forced to pay positive wages. (This defines the bound  $Q_*$ , and with only 2 banks  $Q_* = Q^*$  so that Proposition 4 becomes a full characterisation).

A relaxation of the cap now lowers the default risk of some of the banks. The relaxation of the cap does allow the rival bank ( $n + 1$  say) to bid more aggressively for the  $A_n$ -team. But the larger effect, as it is magnified by a larger balance sheet, is for bank  $n$  to be able to meet this challenge with more use of bonus which acts to lower its risk. Analytically we can show that if the tail risk faced by the banks is close to flat then bank  $n$  will actually attain a higher value (as well as being of lower risk) due to the transfer from wages to bonus. In this case bank  $n$  becomes less aggressive in its bidding for the  $A_{n-1}$ -team and so a process of induction lowers risk and raises value for all larger banks. Under the conditions of Proposition 4, part 2b, relaxing the bonus cap becomes especially compelling.

Proposition 4 demonstrates that there is a case for modest caps on bonus pot size, but not one for very stringent caps or for mandating that wages must be used as part of remuneration. The structure of optimal financial regulation for a social planner will be developed later. However a cap on bonuses seems to offer a free lunch with lower default risk and higher bank value. Is it however only a small free lunch? Figure 2 develops a numerical example to illustrate that the effect of introducing a cap on the proportion of the balance sheet which can be used for bonuses is modest but far from insignificant. In this numerical example we consider *maximally weak bonus caps* which I define as follows:

**Definition 1 (*maximally weak bonus caps*)** Set a cap of  $Q_n$  on the proportion of her balance sheet that bank  $n$  can use for bonuses and let  $q_n(\mathbf{Q})$  be the equilibrium bonus rate bank  $n$  pays to the  $A_n$ -team. The vector  $\mathbf{Q} = (Q_1, Q_2, \dots, Q_N)$  is defined implicitly by

$$Q_n = q_n(\mathbf{Q}) \text{ and } w_n(\mathbf{Q}) = 0 \quad (6)$$

The set of maximally weak bonus caps are such that each bank can employ their team of bankers solely using bonuses, but they have no extra flexibility to use higher bonuses to seek to bid for a better the team of bankers. There is one set of bonus caps which satisfies the simultaneous equations given in (6) and it can be found iteratively starting with bank  $N$  using the method of proof of Proposition 2. Using the results of Proposition 4 we would expect the benefits of bonus caps to be close to maximised: the competition for one's bankers from rival banks is curtailed (raising value and lowering risk) whilst no bank must use wages to pay its

staff so ensuring there is no rationale for raising the caps on any given bank. Figure 2 explores the impact of maximally weak bonus caps in a numerical example for a sample of 15 banks with balance sheet size close to the average in our data set (Section 5). The figure is a lower bound on the impact of this bonus cap regulation as the figure has assumed flat tails ( $\gamma = 1$ ) which allow for explicit solutions to the wages and risk levels. However if  $\gamma > 1$  then the tails will be more convex, so a reduction in remuneration would lead to a disproportionate reduction in the default risk faced by the banks. The reduction in default risk is increasing in the number of banks affected and, though only indicative, the remuneration saved by the regulation is substantial and the default risk reduction is not insignificant.

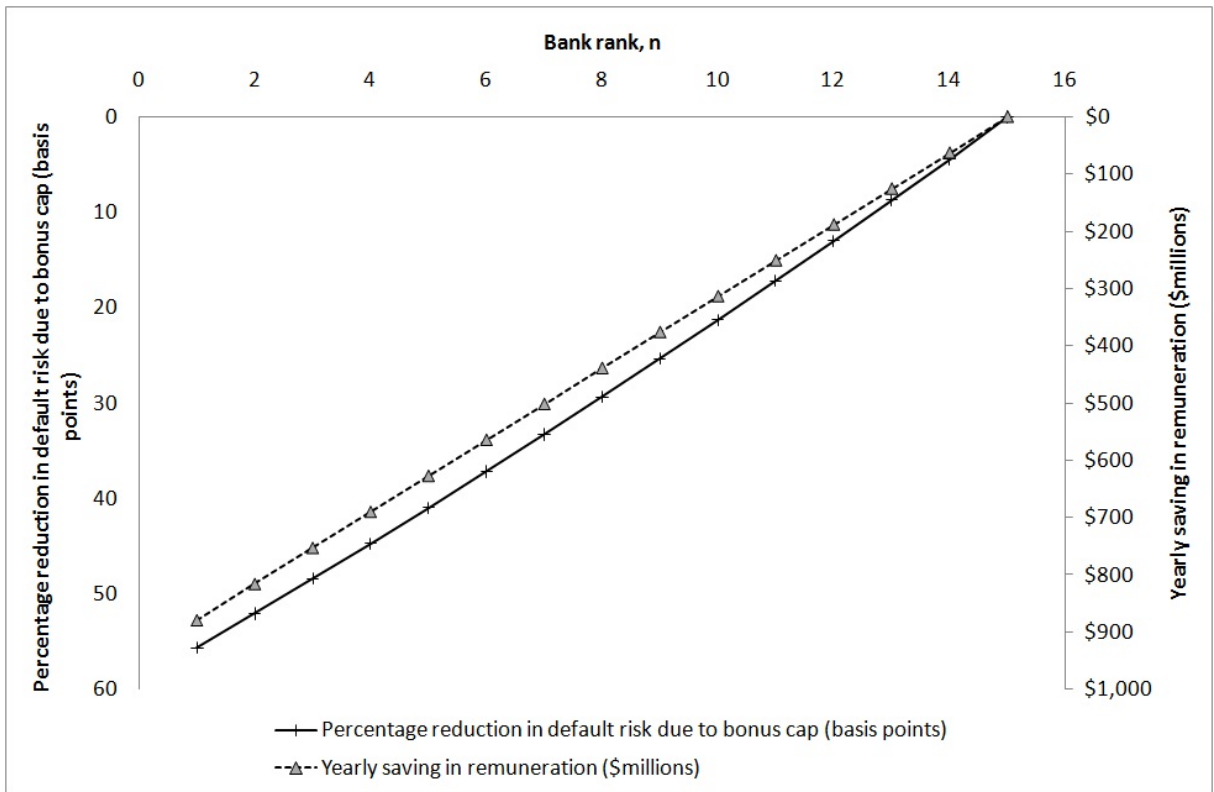


Figure 2: Graph of the impact of *maximally weak bonus caps* on default risk in a numerical example.

Notes: *Maximally weak bonus caps* are bank specific caps on the proportion of the balance sheet used for bonuses defined such that  $Q_n = q_n(\mathbf{Q})$ , so that in equilibrium banks can hire their team of bankers using bonuses alone. The largest bank ( $n = 1$ ) has a balance sheet of \$150bn with the others declining by \$1bn each time. Shareholder equity is 20% for each bank ( $D_n = 0.8S_n$ ). The ability of the banking teams ( $\{\alpha_n\}$ ) ranges between (1.04, 1, 18) in equal increments of 0.01. Assumed flat tails [ $\lambda = 1, G = 1/2$ ]. If one relaxed this assumption the extent of default risk reduction is likely to be greater. Default reduction measured in basis points. Thus bank rank #4 benefits from the introduction of the bonus caps with a drop in its default risk of 45 basis points, that is the default risk falls from  $P$  say to  $P \times (1 - 0.0045)$  upon the introduction of the bonus caps in this numerical example.

In EU proposals at the time of writing the objective of linking the maximum bonus to a multiple of an individual banker's wage has been proposed. Such an approach has at least some

very clear drawbacks which our analysis above illustrates. By committing to pay a (high) wage the banks will have a substantial wage bill which does not fall even in the event of poor investment realizations. This committed spend on wages then drives up the default risk. Allowing banks to pay more in bonuses would reduce the default risk (Proposition 4). An analysis of exactly the EU policy is possible in the framework here and its effect on increasing risk can be demonstrated. (Though such a demonstration is somewhat tortuous as the realized pay is capped and so the utility of the bankers depends on the shape of the returns distribution function as well as its expected value.) Such a policy is also more stringent on the bank than the one analysed above as it restricts per person remuneration rather than overall remuneration payments. The insight of this work is that a modest cap on bonus remuneration at the balance sheet level is effective (whether or not there are Corporate Governance problems with controlling risk-shifting) whereas a stringent cap or a requirement to use wages is not.

## 4.2 Financial Regulation Through Taxation

A financial regulator, worried about the possibility of high pay feeding into increased default risk, could contemplate using taxation to lower default risks. The UK introduced exactly this policy as a one off windfall tax on banks in the pre-budget report of late 2009. France also introduced a similar measure. The tax in the UK was set at 50% of the bonus pool. It was suggested that this tax may encourage banks to rebuild “*their capital rather than paying out generous bonuses to their staff.*”<sup>17</sup> We can analyze whether such a policy would meet this stated aim, or indeed the aim of lowering default risk.

Let us consider therefore a tax of  $t^b$  on the bonus pot a bank decides to issue. This tax requires all banks to pay bonuses at a rate of  $q(1 + t^b)$  when it allows a proportion  $q$  of its realized revenues to be used for bonus payments to bankers. First note that (by continuity) for modest tax burdens the bank would still rather remunerate the team of bankers exclusively in bonus. Proposition 1 proved that banks prefer to pay in bonuses as if they transfer wage payments into bonuses of the same expected size, then the banks save the expected cost of the lower default risk. As long as the cost of the tax is less than the expected saving the intuition is unaffected. In the case of the 50% super-tax rate on bonuses in the UK this was the empirical reality – bonuses remained. Let us denote the equilibrium bonus rates paid by bank  $n$  under

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<sup>17</sup> “Bankers furious at UK bonus supertax,” Financial Times, December 9, 2009.

this tax as  $q_n^{\text{bank-tax}}$ . We can show:

**Proposition 5** *A bonus tax payable by banks lowers the bonuses paid to all bankers other than the  $A_N$ -team. However the default risk of all the banks is unaffected by the tax and remains at the pre-tax level. Banks are no better or worse off.*

The introduction of a bonus tax has the effect of lowering the total amount paid in bonuses to bankers; though there is no gain for default risk at all. We can understand this result in a couple of steps. Firstly the direct effect of the tax is to increase the cost to the bank of using bonuses to pay bankers. This therefore reduces how much a bank is willing to deliver to a better team of bankers in an attempt to hire them. This reduction in aggressiveness from the bank competing at the margin lowers the remuneration which needs to be delivered to the teams of bankers to secure their services.

Given that bonuses are lowered, why does default risk not follow? When a bank decides to offer a bonus of  $q$  to a team of bankers then, including the tax, this is equivalent to offering a scaled up bonus of  $q(1 + t^b)$ . If we fix the the payoff from employing the  $A_n$ -team, then the total extra bonus (inclusive of any tax) bank  $n$  is willing to offer to poach the better  $A_{n-1}$ -team of bankers is determined by the difference in skill and the size of the balance sheet. It is independent of the tax. Hence the gross bonuses offered, that is including the taxation cost, increase in the same increments that the equilibrium bonus rates did which were calculated in the absence of a tax. The resultant total cost to the bank is therefore unchanged so that the banks see no impact on their default risk or on their value. Further the intuition confirms why, as shown in the proof of Proposition 5, we have

$$q_n^{\text{bank-tax}} = \frac{1}{1 + t^b} q_n^{\text{eqm}}$$

Thus a bonus supertax meets neither an objective of lowering default risk, nor of lowering the bonus costs incurred. A tax on bonuses raises the cost of providing bonuses to staff, however bonuses retain their insurance feature of costing the bank less in the event that investments are poor. Hence banks still prefer to use bonuses as they can deliver a greater utility to bankers for a given risk or value level. Once bonuses are to be used, the bonus tax lowers the bonuses paid to the bankers by forcing the bank to divert money which would have gone to the banker to the

government instead.

Note that implementing the tax on the banker rather than on the bank would not alter the result. Indeed such a response is close the UK's recent introduction of a special top rate of tax in response to the financial crisis of 50% up from 40% on incomes in excess of a defined high level. Though this tax was not directed only at bankers they were certainly prominent in the public discussion of this proposal. The default risk of the banks depends upon the level of remuneration they are forced to offer to their team of bankers. This remuneration is set in a competitive market context and depends upon how high the rival bank one place down in the league table of size is willing to bid. This maximum bid level is unaffected by the tax as the tax is borne by the banker and not the bank, and so the expected return of the team of bankers is unchanged. Hence the equilibrium is unaffected as far as the default risk is concerned.

### 4.3 Costs And Benefits Of Altering Capital Adequacy Ratios

Financial regulators limit the risks that a bank can take on by requiring the bank to maintain a certain proportion of its risk weighted assets as equity (tier 1 capital). Changes in this capital adequacy requirement, or in the risk weightings, have the effect of altering the investment freedom of the bank for given equity levels. The Bank of International Settlements have proposed an increase in this “capital conservation buffer”. Let us explore therefore a requirement that only a proportion  $\rho$  of total bank assets can be invested by the team of bankers. The remaining funds,  $(1 - \rho)S$  must be kept in risk free assets.

The maximum investment that a bank of size  $S$  can make is therefore  $\rho S$ . Lemma 1 guarantees that the banks would like to invest up to this constraint. By using the same style of proof as in Proposition 1 adapted for the capital adequacy restrictions we can confirm that the banks would continue their preference for bonuses over wages in remuneration. Proposition 1 proved that banks prefer to pay in bonuses as if they transfer wage payments into bonuses of the same expected size, then the banks save the expected cost of the lower default risk. With an enhanced capital buffer this default risk is less, but it is still present and so the bank continues to value the insurance provided by bonuses.

We can determine the equilibrium bonus rate under the new capital adequacy rule,  $(\rho)$  and so the impact on default risk. We can demonstrate:

**Proposition 6** *Capital Adequacy Controls which limit the investment flexibility of the banks to a fraction  $\rho$  of the balance sheet:*

1. *Do not affect the bonus rate paid to the bankers for managed funds. The rate paid by bank  $n$  remains unchanged at  $q_n^{eqm}$ .*
2. *Greater capital adequacy levels (lower  $\rho$ ) lower bank default risk and also lower expected bank value.*

Thus if banks respond to stricter capital adequacy regulations by lowering the risk profile of their assets then such capital adequacy controls can control risk, but in a manner which diminishes the total surplus created. Lowering  $\rho$  lowers the amount which can be invested ( $\rho S$ ) to levels below those which the bank would itself choose (Lemma 1). Hence bank value must decline. The capital adequacy controls do not however alter the equilibrium bonus rates paid to the team of bankers. The reason is that the bonus rates depend upon *inter alia* the ratio of banks' assets. Capital adequacy controls do not alter this ratio as the controls affect each bank in proportion to its size. As this ratio stays unchanged so also bonus rates remain unchanged. The realized bonus payments made in aggregate will however be lower as the proportion of the balance sheet which the team of bankers have been allowed to invest has been regulated down.

A bank can however respond to stricter capital adequacy requirements by raising more equity to pay down debt. This would make the bank safer as larger investment losses could be absorbed by the larger equity cushion. Admati et al. (2010) have argued that substantially higher equity requirements are called for which would force the banks to raise equity rather than lower the risk profile or size of their assets. They argue that, absent the tax deductibility of interest, such a rebalancing towards equity would be (close to) costless for the banks for the reasons described in the seminal work of Modigliani and Miller (1958). The determinants of the costs of capital, and so of the size of equity and debt in a given bank, lie outside of this model. However the argument I put forward does not depend on a given level of debt to equity. Whatever the final level of equity, remuneration would remain a contributing factor to whatever default risk remained. Further, to the extent that capital adequacy regulations impinged on the investment decisions of a bank, its value would be reduced as a side-effect of the reduction in its risk of default (Proposition 6).

#### 4.4 Too Big To Fail? Limit Bank Size.

The difficulty many major economies faced in saving their banking systems has led to claims that some banks are “*too big to fail*.” One policy response to this, and a response which has received quite some attention, is to cap the size of banks or use taxation to make growing large unprofitable. President Obama has himself raised this possibility as part of the financial regulation possibilities spearheaded by former Federal Reserve Chairman Paul Volcker.<sup>18</sup> Smaller banks may be easier to save – here we ask whether they are less likely to get into trouble.

Proposition 3 established that if the banks all maintained a constant capital buffer as a fraction of their balance sheet then larger banks were under a smaller risk of default. This result followed as the remuneration bill increased at a rate slower than the increase in the size of the balance sheet. Let us therefore now consider the effect of setting an exogenous cap on bank size to  $\bar{S}$  say. Let us denote by  $k$  the rank of the smallest bank just affected by the cap. Thus  $S_k \geq \bar{S} > S_{k+1}$ . In the face of such a cap a natural approach a bank might take is to shrink the balance sheet so as to comply with the cap. (We are here ignoring the impact of other possible policies such as shrinking banks by forcing them to divest their proprietary trading). Thus after the introduction of the cap we would expect  $S_1 = \dots = S_k = \bar{S}$  while banks of rank  $k + 1$  and below are unaffected. The default risk faced by banks of rank  $n > k$  will be unaffected as the remuneration which these banks must pay is determined by banks even lower in the league table of balance sheet size and these are all unaffected by the cap. (Equation 4). The default risk of the largest banks will be affected:

**Proposition 7** *A cap on bank size, assuming that banks maintain their capital buffers at a constant proportion of their balance sheets, raises the default risk of all those banks affected by the size cap.*

Once a cap at  $\bar{S}$  is introduced the top  $k$  banks are all equal in size at this level and so offer perfectly symmetric Bertrand competition in their quest to hire one of the  $k$  best teams of bankers. Competition for the best  $k - 1$  teams of bankers will be unchecked therefore and result in all the banks paying a bonus which leaves them just indifferent between hiring these bankers or hiring the  $k^{th}$  best team of bankers (the  $A_k$ -team). The default risk run by the banks hiring

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<sup>18</sup>See “Volcker makes plea to Congress on bank reform,” Financial Times, February 3, 2010; and “Obama and US banks”, Financial Times, January 21, 2010.



the top  $k - 1$  teams of bankers will equal the default risk of the bank hiring the  $A_k$ -team.

For the bank hiring the  $A_k$ -team only the bank of rank  $k + 1$  must be beaten and this bank is unaffected in size from the policy change. However the hiring bank has been shrunk from above size  $\bar{S}$  down to  $\bar{S}$ . Hence the bonus rate which must be offered to win the services of the  $A_k$ -team rises as a result of the policy change. This follows as the bonus rate applies to a smaller balance sheet and so must rise to transfer sufficient utility to the team of bankers.

On balance therefore before the policy intervention larger banks were under a lower risk of default. After the policy intervention the risk of all the banks affected has been raised to the level of the bank hiring the  $A_k$ -team, and this default risk is itself raised compared to the pre-policy intervention level. It has been argued that the largest banks, confident of state support, face a lower cost of capital and associated cost of default than medium sized and smaller banks. In the notation of this model this is equivalent to assuming that the costs  $\lambda$  of default are smaller for these largest banks. If so then a large bank would discount the costs of default when competing for its team of bankers, and so consequently its risk of default would be higher than this model suggests. It may also be the case that the failure of one of the largest banks in an economy has much larger ramifications than the failure of one or more smaller banks. If one accepts this then shrinking banks can have a justification. What the analysis in this section shows is that there is a force working in the opposite direction.

## 4.5 Optimal Financial Regulation

In this final section let us suppose that a social planner wishes to maximize the weighted sum of bank value and bankers' pay subject to placing an upper bound of  $\theta$  on the probability of default of each institution. As taxes and capping bank size have been shown to be ineffective in achieving these aims in this model, I restrict the social planner to use bank specific bonus caps  $\{Q_n\}$  and/or bank specific capital adequacy requirements of  $\{\rho_n\}$ . Given these restrictions the equilibrium bonus levels will be given by  $q_n(\boldsymbol{\rho}, \mathbf{Q})$  and any wages paid by bank  $n$  will be given by  $w_n(\boldsymbol{\rho}, \mathbf{Q})$ . These can be determined in an inductive fashion following the method used in proving Lemma 2.

This section is silent on the optimal debt to equity ratio for a given balance sheet as the determinants of the cost of capital are outside of this model. Admati et al. (2010) call for more

equity on banks' balance sheets. A reduced debt  $\{D_n\}$  would certainly act to make banks safer without altering bonus rates (note equation (4) is independent of the level of debt,  $D$ ). This reduction in risk follows as the probability of an investment loss so great it wipes out shareholder equity is reduced. However swapping debt for equity would be costly for banks if debt interest remains tax deductible. Whatever debt/equity split is arrived at, optimal financial regulation would seek to maximise bank values subject to the default risk constraint.

The constraint on the default risk of bank  $n$ , with default probabilities given by (3), results in the condition:

$$w_n(\boldsymbol{\rho}, \mathbf{Q}) + D_n - (1 - \rho_n) S_n \leq \left[ \frac{\theta}{G} \right]^\gamma \cdot \alpha_n \rho_n S_n [1 - q_n(\boldsymbol{\rho}, \mathbf{Q})] \quad (7)$$

Normalising the weight the social planner places on banks' profits to unity we use  $\zeta \leq 1$  for the weight placed by the social planner on bankers' pay. Using the bank value equation (3) the social planners' problem is

$$\begin{aligned} \max_{(\boldsymbol{\rho}, \mathbf{Q})} \sum_n & \left[ \begin{array}{c} (1 - \rho_n) S_n + \alpha_n \rho_n S_n \\ - (1 - \zeta) [\alpha_n \rho_n S_n q_n(\boldsymbol{\rho}, \mathbf{Q}) + w_n(\boldsymbol{\rho}, \mathbf{Q})] \end{array} \right] - \lambda S_n G \left[ \frac{w_n(\boldsymbol{\rho}, \mathbf{Q}) + D_n - (1 - \rho_n) S_n}{\alpha_n \rho_n S_n [1 - q_n(\boldsymbol{\rho}, \mathbf{Q})]} \right]^\gamma \\ & \text{subject to (7)} \end{aligned}$$

We can offer the following characterisation of the social planner's optimal solution:

**Proposition 8** *The solution to the social planners' problem satisfies:*

1. *The social planner requires bonus caps for all banks  $n > 1$  at least as strict as the **maximally weak bonus caps** (Definition 1). Hence  $Q_n = q_n(\boldsymbol{\rho}, \mathbf{Q})$ ,  $w_n(\boldsymbol{\rho}, \mathbf{Q}) \geq 0$ .*
2. *Suppose a regulator only controls a subset of the banks. Use of a bonus cap more binding than the **maximally weak bonus caps** cannot be optimal for all regulators of any size.*

**Proof.** Part 1 is proved by contradiction. Suppose that the statement is false and so there exists bank  $n > 1$  such that at the optimum  $Q_n \neq q_n(\boldsymbol{\rho}, \mathbf{Q})$ . By the definition of a bonus cap we cannot have  $q_n > Q_n$  hence it must be that  $q_n(\boldsymbol{\rho}, \mathbf{Q}) \leq Q_n$ . Consider lowering the cap on bank  $n$  down to  $q_n(\boldsymbol{\rho}, \mathbf{Q})$ . This does not alter the value of bank  $n$ , but it makes bank  $n$  less aggressive in her bidding for the  $A_{n-1}$ -team (proof of Proposition 4). This lowers the amount that bank  $n - 1$

must pay to the  $A_{n-1}$ -team and lowers bank  $n-1$ 's default risk also. As  $\zeta \leq 1$  this increases the social planner's objective function without breaking the default risk constraint. Now bank  $n-1$  will herself reduce how much she is willing to bid for the  $A_{n-2}$ -team and so again this increases the social planner's objective function. Hence by induction we have the desired contradiction.

For part 2 consider a regulator only in charge of a single bank of rank  $m$ . Suppose for a contradiction the regulator mandates a bonus cap  $Q_m$  so binding that  $w_m > 0$ . Suppose that the regulator raises the cap, this allows the bank to win the  $A_m$ -team with a lower default risk (Proposition 1) and so raises the social planner's objective function (she is indifferent to the effect on other banks). A contradiction. ■

Proposition 8 shows that caps on the proportion of the balance sheet which can be used for bonuses are part of the optimal regulatory response. As the cap is set in proportion to the balance sheet, banks who grow their assets, either by reducing dividend payments or by being profitable, will find the cap less constricting. There is however a partial converse – pushing the bonus cap down so far that banks have to start using wages cannot be optimal for all regulators of any size. It is therefore ambiguous whether capital adequacy constraints or more draconian bonus caps would be preferable in lowering default risk further. Which will depend upon the parameters of the problem. More draconian bonus caps increase the risk incurred by some banks, this lowers their ability to bid for a rival's team of bankers which can help that bank. It may be in the social planner's interests to handicap one bank to aid another – but this will depend on the specifics of any situation. Thus Proposition 8 suggests a second best optimal regulatory policy for regulators of any size jurisdiction: First apply caps on the proportion of the balance sheet which can be used for bonuses down to the level of the maximally weak bonus caps. If this fails to bring down default risk sufficiently for the regulator then lower  $\rho$ . If the change in capital adequacy requirements is done in a bank specific way (as is the case in the current proposals of the Financial Stability Board<sup>19</sup>) then the bonus rates will change and so one would need to reset the bonus caps to again be at the maximally weak bonus cap level. Repeat until the default constraints are satisfied.

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<sup>19</sup>See Financial Stability Board (2010).

## 5 Empirical Discussion And Calibration

We have studied a model of bankers' remuneration which captures the competition between banks for bankers of different ability, and the default risk which the banks run in providing the rewards. In this section we ask to what extent the data supports the structure of our model, and using the data we seek a calibration of how large an impact remuneration can have on the default risk of banks.

### 5.1 The Data

Our model concerns bankers who use the balance sheet of their employers to take a risky action which forms part of financial intermediation in the economy. Such institutions include commercial banks, investment banks and other credit/investment companies known as shadow banks (Pozsar et al. 2010). In the EU all such institutions are bound by the proposed regulations on bankers' pay as all such institutions are covered by the Capital Requirements Directive (CRD) III.<sup>20</sup> In the US the Dodd-Frank Wall Street Reform and Consumer Protection Act is similarly wide in application. Section 956(b) (124 STAT. 1905) requires all appropriate federal regulators to consider what extra rules on remuneration are required for "covered financial institutions". Such institutions go much wider than purely commercial banks including broker dealers and indeed any other financial institution that the regulators view as being relevant. I therefore construct a data set consisting of all the banks and financial institutions listed on the New York Stock Exchange for which Datastream Worldscope data exists. The data consists of the number of employees, return on assets, total assets, total liabilities and total remuneration. The latter three are deflated by a GDP deflator from the Bureau of Economic Analysis into constant 2005 dollars. The data set covers ten years from 1998 to 2009 inclusive. There are 1,452 separate data entries. The average balance sheet size (in 2005 dollars) is \$85 billion while the largest has \$2 trillion.

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<sup>20</sup>See for example Committee of European Banking Supervisors (2010). The institutions covered by CRD III are broadly defined as credit institutions which take deposits and investment institutions who either provide investment services to third parties or who conduct investment activities on a professional basis.

## 5.2 Do Banks and Financial Institutions Not Pay Bonuses After Losses?

We consider this question using the whole data set. Figure 3 gives the relationship of remuneration per person to the shareholder equity return for the entire data set. The shareholder equity return is calculated here as the change in shareholder equity (total assets less total liabilities), normalized by the size of the balance sheet. If it is denoted by  $SHER_t$  then  $SHER_t := [SHE_t - SHE_{t-1}] / S_{t-1}$  where  $SHE$  is shareholder equity and  $S$  is the size of the balance sheet (total assets). A graph similar to Figure 3 arises if one replaces the shareholder equity return with the return on assets. There is no evidence of a remuneration collapse in the face of losses to shareholder equity. One reason why this is true is that institutions must reward those employees which have done well. This remains the case even if other employees have made larger losses thus registering a loss overall at the firm level. Hence there is no clear evidence that the model would be improved by assuming that bonuses would not be paid if the institution's investments caused overall losses to be recorded.

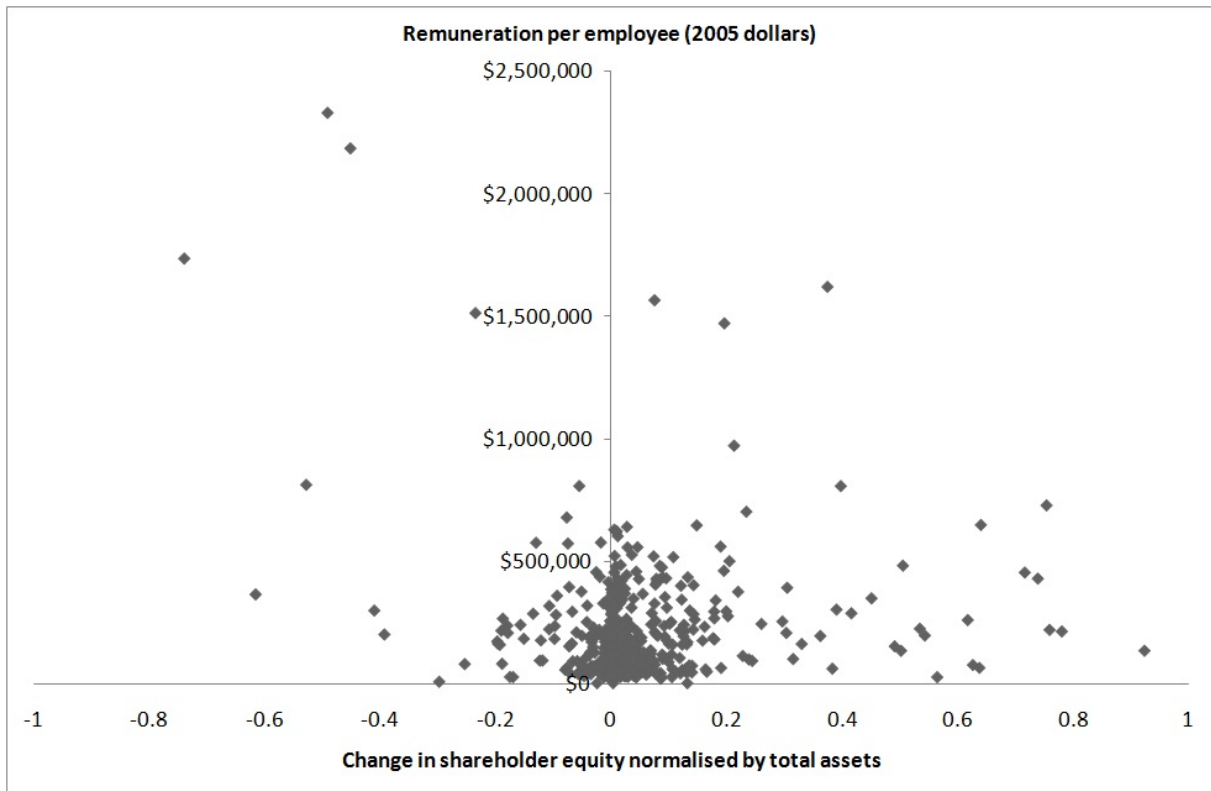


Figure 3: Remuneration and changes in shareholder equity.

Notes: The graph depicts the relationship between the remuneration per employee as set against the return in shareholder equity achieved ( $SHER$ ). Institutions need to reward individuals who have done well, even if overall a loss has been delivered. Hence remuneration payments are required even if shareholder equity declines, confirming the assumption used in this model. [Datastream data: all banks and financial institutions traded on the NYSE for which Worldscope data exists, 1998-2009 inclusive].

### 5.3 Is Remuneration Large Enough To Affect Bank Liquidity?

Figure 1 considered a list of 21 systemically important banks constructed by Acharya, Gujral and Shin (2009). The figure showed that remuneration payments in these banks were very sizeable in relation to shareholder equity and dwarfed dividend payments. The latter observation is important as Acharya, Gujral and Shin (2009) argue that the size of dividend payments alone was sufficient to affect the behaviour of the banks. The magnitude of remuneration in comparison to total shareholder equity can be quantified for the entire data set – and is by the histogram in Figure 4. For commercial banks, as for the full data set, the median bill for remuneration runs at 20% of shareholder equity. However there is quite wide variation around this figure, and it is especially pronounced for financial institutions which are not commercial banks. Figure 4 demonstrates that for about a third of the full sample the bill for remuneration of staff represented more than 30% of the total shareholder equity. (For purely commercial banks such high levels of pay were recorded in about 1 in 10 cases). For 10% of the full sample the bill for remuneration represented more than 80% of the total shareholder equity. Thus remuneration can represent a substantial expense for banks and financial institutions. Remuneration payments can therefore have a first order effect on the confidence investors have in the liquidity of a bank or financial institution. We will calibrate the size of this possible effect next.

### 5.4 Calibrating The Impact Of Remuneration

Let us consider a bank or financial institution with a balance sheet of \$100 billion. This is close to the average size of balance sheet in our sample data set of financial institutions traded on the NYSE. Let us suppose that the return  $R$  on a standard security is normally distributed according to  $R \sim N(\mu, \sigma^2)$ . If the bank or financial institution in this calibration invested in such a security their resultant balance sheet would be  $X = 100 \cdot R$  billions of dollars. A default event occurs if this realised value is below the level of the liabilities on the balance sheet. That is a default event occurs if losses made on the investments exceed the total shareholder equity ( $SHE$ ) in the institution. Ignoring remuneration effects the probability of default would

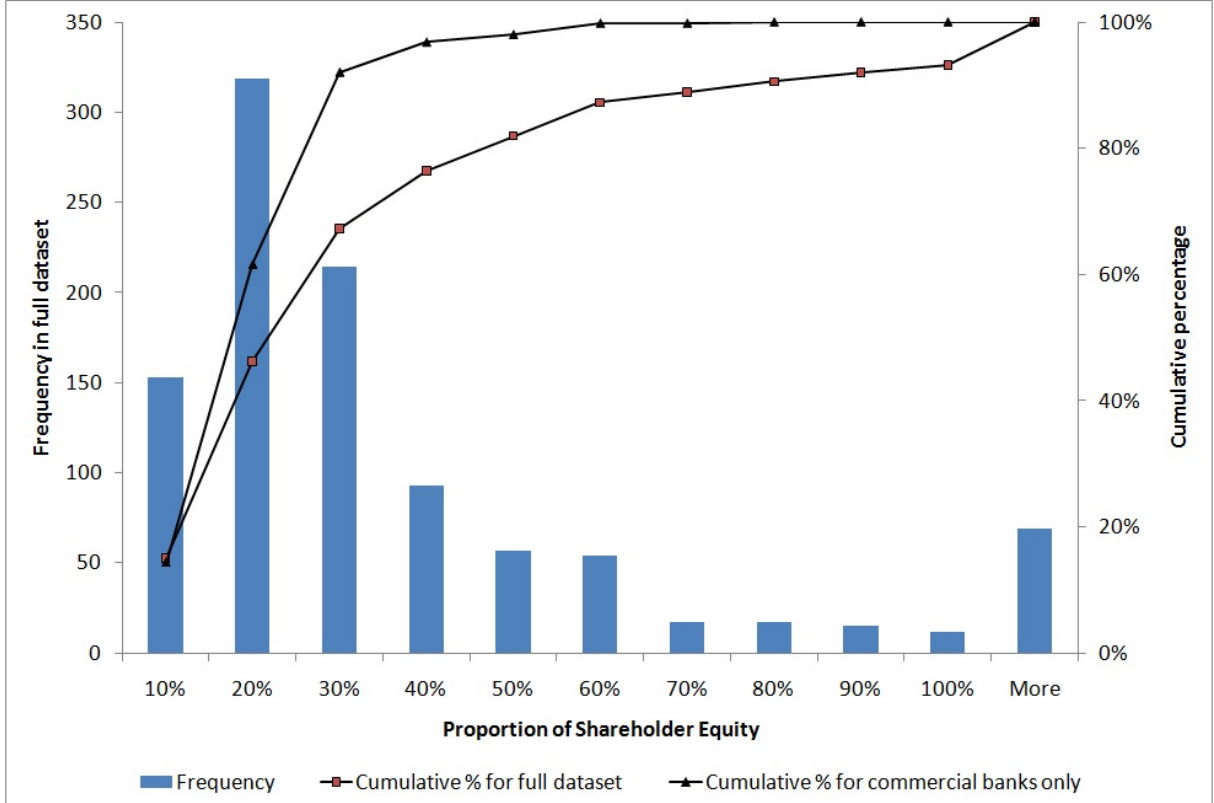


Figure 4: Remuneration as a proportion of shareholder equity.

Notes: The graph shows a histogram of the distribution of the ratio of remuneration to total shareholder equity for commercial banks and also for the full data set of banks and financial institutions. The median bill for remuneration runs at 20% of shareholder equity. However there is wide variation around this figure, especially for financial institutions which are not commercial banks. In around 1 in 10 cases from the full sample the bill for remuneration represented more than 80% of the total shareholder equity. Thus remuneration can represent a substantial expense for banks and financial institutions, and so it is a relevant factor in the institution's risk of default. [Datastream data: all banks and financial institutions traded on the NYSE for which Worldscope data exists, 1998-2009 inclusive].

therefore be

$$\left[ \begin{array}{c} \text{Ignoring remuneration} \\ \text{probability of default event} \end{array} \right] = \Pr(X < 100 - SHE) = \Phi\left(\frac{1 - \mu}{\sigma} - \frac{SHE}{100\sigma}\right) \quad (8)$$

Let us now turn to remuneration and label  $\nu$  as the proportion of  $SHE$  used for remuneration.

Including remuneration the probability of default becomes

$$\left[ \begin{array}{c} \text{Probability of default event} \\ \text{including remuneration} \end{array} \right] = \Pr(X < 100 - (1 - \nu) \cdot SHE) = \Phi\left(\frac{1 - \mu}{\sigma} - (1 - \nu) \cdot \frac{SHE}{100\sigma}\right) \quad (9)$$

The impact of remuneration on default risk can be captured by the ratio (9)/(8). This ratio shows by what multiple the probability of a default event is increased when one factors in

remuneration. To implement this process we need to determine what sensible figures would be to use in this calibration exercise.

We begin with the returns which one might expect a bank or financial institution to achieve. Dichev (2007, Table 4) calculates an average historical return on US stocks between 1973 and 2004. Dichev calculates this average return at 14% with a standard deviation of 17%. We use these figures setting  $\mu = 1.14$  and  $\sigma = 0.17$ .

Next we consider the proportion of shareholder equity which is paid out in remuneration. Referring to the histogram in Figure 4 we take as our central estimate that remuneration paid out is equal to 20% of shareholder equity. This is very close to the median figure in our full sample. For a low estimate of remuneration we use 10% of shareholder equity, which is the 25th percentile. Figure 4 demonstrates that the distribution of remuneration has a very long tail with a significant number of financial institutions paying out much higher proportions of shareholder equity as remuneration. However to be conservative we restrict ourselves to the 75th percentile and so for the high value we consider only 40% of shareholder equity being used for remuneration. Such a high level of pay was thus the case for more than 1 in every 4 bank/financial institution years in the sample. Summarising therefore, we consider  $\nu \in \{0.1, 0.2, 0.4\}$ .

Next we turn to the level of shareholder equity one might expect a bank/financial institution to have. To determine what a sensible estimate for this would be we can explore the level of shareholder equity as a proportion of the total assets for our full sample, as well as for the sub-sample of commercial banks. The results are presented in Figure 5. We see that the modal ratio of shareholder equity to assets is 10% for commercial banks as it is for the full data set of banks and other financial institutions. The distribution of shareholder equity for commercial banks is reasonably heavily concentrated around this modal value. However for the full data set there exists a substantial tail towards higher ratios of shareholder equity to assets. The 75th percentile of the whole data set lies at shareholder equity equaling 40% of assets. Guided by this we define a central estimate of the shareholder equity (*SHE*) equal to \$10bn for our bank with a balance sheet of \$100bn. We define low and high values of shareholder equity as \$5bn and \$40bn respectively.

We are now in a position to calibrate the impact of remuneration on default risk for our representative bank with a balance sheet of \$100bn. This is done in Table 1.



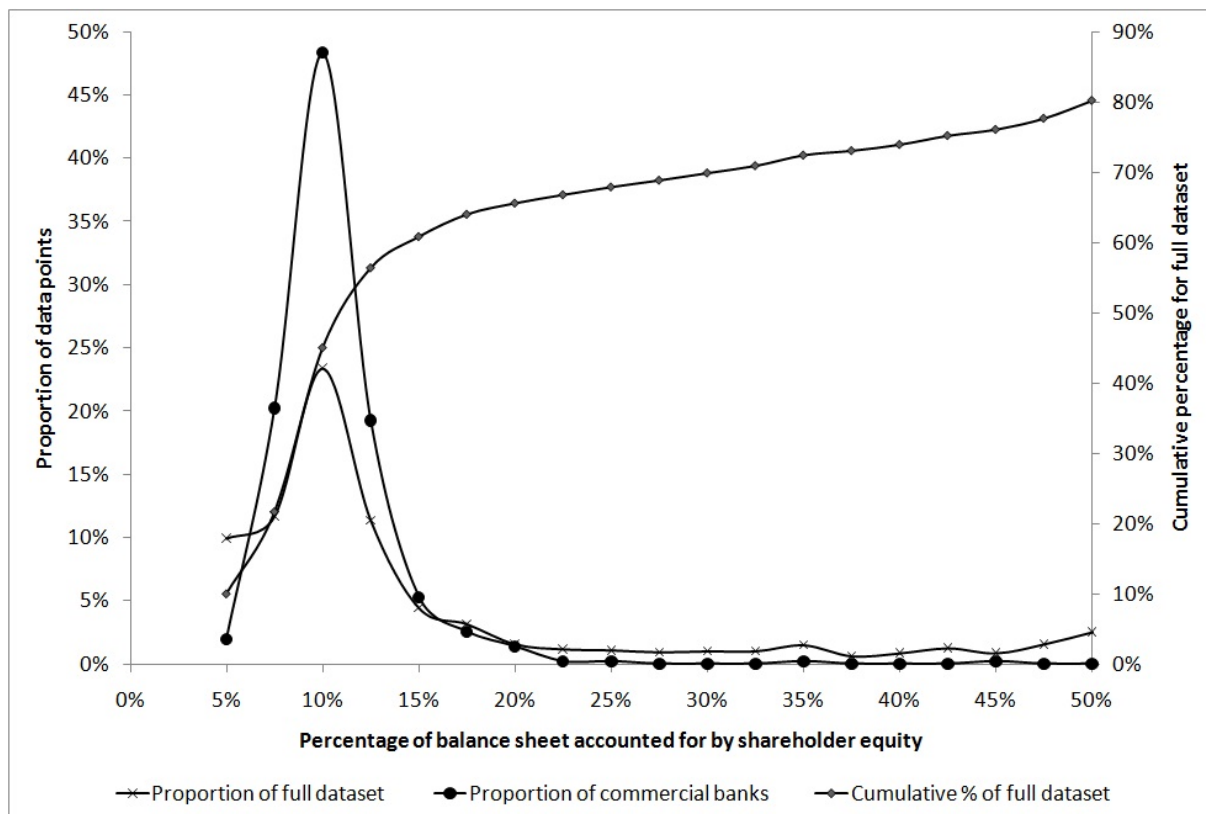


Figure 5: Shareholder equity as a proportion of total assets (equivalently total balance sheet). Notes: A graph depicting the amount of shareholder equity as a proportion of total assets held by banks and financial institutions in the sample. The distribution of shareholder equity for commercial banks is reasonably heavily concentrated around the modal value of 10%. However for the full dataset there exists a substantial tail towards higher ratios of shareholder equity to assets. For the calibration exercise we therefore use a central estimate of  $SHE/Assets$  of 10%, a low estimate of 5% and a high estimate of 40% which is at the 75th percentile. [Datastream data: all banks and financial institutions traded on the NYSE for which Worldscope data exists, 1998-2009 inclusive].

The central estimate is that remuneration multiplies the probability of a default event by a factor of 1.24. Some would argue that this in itself is a significant amount as remuneration increases the risk of default by almost a quarter. However now consider those financial institutions which have a larger base of shareholder equity, closer to 40% of assets. From Figure 5 these are more likely to be non commercial banks, that is they are likely to be investment banks and shadow banks (Pozsar et al. 2010). Such comparatively greater equity institutions may be safer in absolute terms, but the impact of remuneration on their risk of default is huge. For such institutions paying out remuneration according to the central case of 20% of  $SHE$ , the pay increases their default risk by over 4 times. If they pay out at the high level the default risk increase is more than 17 times. One can confirm that there is no correlation in our data set between the proportion of the balance sheet which is made up of shareholder equity, and the proportion of shareholder equity used for pay. Thus there is no sense in which the probability

Table 1: The calibration of the impact of remuneration on bank default risk. Notes: A bank with a balance sheet of \$100bn is considered, invested in US stocks, with staff remuneration given as a proportion  $\nu$  of shareholder equity with  $\nu \in \{0.1, 0.2, 0.4\}$  justified by Figure 4. Shareholder equity is modelled as being 5%, 10% or 40% of the balance sheet, justified by Figure 5. The central cell yields the calibration estimate that including remuneration raises the probability of default by nearly one quarter. If the financial institution has a greater amount of equity funding and pays out the central amount of remuneration then remuneration is the main determinant of default risk. There is no negative correlation in the data set of financial institutions between amount of equity and pay as a proportion of shareholder equity.

	Remuneration as a proportion of Shareholder Equity ( $\nu$ )		
Shareholder Equity of \$100bn bank	Low (10%)	Central case (20%)	High (40%)
Low (\$5bn)	1.0	1.1	1.2
Central case (\$10bn)	1.1	<b>1.24</b>	<b>1.52</b>
High (\$40bn)	2.2	<b>4.57</b>	17.0

of landing in the bottom right cell of the calibration table is especially small. Return now to the central case of *SHE* representing about 10% of the balance sheet (true for most commercial banks as well as many other financial institutions). If such firms fall within the 1 in 5 financial institutions which pay out the largest proportion of shareholder equity ( $\nu = 0.4$ ) then remuneration increases the risk of default by a multiple of over 1.5. Hence I conclude that remuneration is a relevant risk factor with first order significance for the default risk of banks and shadow banks alike.

## 6 Conclusions

This paper has modelled banker remuneration in the context of competition between banks. By doing so cleanly and tractably it has allowed financial regulation to be assessed in the light of its impact on the default risk arising from remuneration. Bonuses are important to banks – much more so than purely for their incentive effects. Bonuses have much better insurance properties than wages do as the remuneration payment is better connected with the realized state of investments. If investment returns are poor then the required remuneration payments shrink – just when the danger of a default event is present.

Competition between banks for bankers creates a negative externality which drives banks' default risk upwards. Each bank bids up bonuses on teams of bankers who they do not ultimately hire. This pushes up remuneration costs for the bank which does hire any given team. For 1 in 10 institutions these remuneration costs can represent over 80% of the shareholder equity.

Remuneration payments of this size increase the risk of default of the institution significantly: a default event occurs even at smaller investment losses. Hence the banks are forced to incur higher costs due to the increased chance of the costs of a default event (forced asset sales, higher costs of capital) being incurred.

In the competitive equilibrium the bonuses which are paid depend not only on the distribution of banker talent, but also on the size distribution of the banks competing to hire these bankers. Hence this model provides a cogent narrative for the stylized facts of bankers' pay over recent decades. Morrison and Wilhelm (2008) note that over recent decades banks have been consolidating and bankers have enjoyed historically unprecedented mobility. They ascribe this trend to the increased use of Information Technology which increased the returns to scale and allowed bankers to transfer their skills between banks more readily. During this period the partnership mode for banking, which had the effect of locking bankers into a given institution, has declined. Further, during this period pay for bankers has increased, most of it bonus led. The model presented here accounts for the link between bank consolidation, banker mobility and pay, both in terms of level and in terms of type (bonus).

Is there a case for regulating bankers' pay? The impetus to regulate may actually, in part, come from outside the economics of banking – to raise money for the government or to make a statement as to the appropriateness of bankers' remuneration in society. However it is preferable that such intervention should have the effect of lowering the default risk. Policies of taxation fall short on this measure. They do not lower default risk in the absence of corporate governance problems, and if such problems are present then they should be the focus of policy makers' efforts. Forcing banks to be smaller exacerbates the risk created by remuneration as the banks are forced to dedicate an even greater proportion of their funds to competing in the labour market for bankers. Forcing banks to use wages increases the risks they bear as they will be compelled to offer large wages to their bankers which must be paid in bad as well as good times. A cap on the proportion of the balance sheet which can be used for remuneration can lower bank default risk. This latter policy is one which, if applied correctly, can increase bank value, lower default risk and lower banker remuneration. The first two are economically relevant. The last one may be politically so.

## A Further Technical Proofs

**Proof of Lemma 1.** Incorporating the probability of default, the expected value of the bank net of default is

$$S - y + \alpha(1 - q)y - w - \lambda y^{1-\gamma} G \left[ \frac{y + w - (S - D)}{\alpha(1 - q)} \right]^\gamma$$

The bank will seek  $y$  to maximize this expression. Differentiating wrt  $y$  yields

$$-1 + \alpha(1 - q) - \lambda G \left[ \frac{y + w - (S - D)}{\alpha y(1 - q)} \right]^\gamma \left\{ 1 - \gamma + \gamma \cdot \frac{y}{y + w - (S - D)} \right\}$$

We look for conditions when this will be positive. The above expression can be written

$$\begin{aligned} & -1 + \alpha(1 - q) - \frac{\lambda G}{[\alpha(1 - q)]^\gamma} \underbrace{\left[ 1 - \frac{S - D - w}{y} \right]^\gamma}_{<1} \left\{ 1 - \gamma + \gamma \left/ \left[ 1 - \frac{S - D - w}{y} \right] \right. \right\} \\ & > -1 + \alpha(1 - q) - \frac{\lambda G}{[\alpha(1 - q)]^\gamma} \underbrace{\left\{ 1 - \gamma + \gamma \left[ 1 - \frac{S - D - w}{y} \right]^{\gamma-1} \right\}}_{<1} \\ & > -1 + \alpha(1 - q) - \frac{\lambda G}{\alpha(1 - q)} \end{aligned}$$

Where we have used the fact that  $\gamma \geq 1$  and  $\alpha(1 - q) > 1$ . This quadratic takes positive values if  $\alpha(1 - q) > [1 + \sqrt{1 + 4G\lambda}] / 2$ . Hence under the conditions of the lemma the bank would choose to increase  $y$  to the upper bound,  $S$ . ■

**Proof of Proposition 1.** Competition forces the banks to seek to maximize the utility delivered to the bankers for a given expected bank value. The indifference curve of the bankers satisfies  $dw + \alpha S dq = 0$ . For the bank, using (3), her indifference curve satisfies

$$\begin{aligned} -\alpha S dq - dw - \lambda S G \gamma \cdot \left[ \frac{w + D}{\alpha S(1 - q)} \right]^{\gamma-1} \left\{ \frac{dw}{\alpha S(1 - q)} + \frac{w + D}{\alpha S(1 - q)^2} dq \right\} &= 0 \\ dw \left\{ -1 - \lambda S G \gamma \cdot \left[ \frac{w + D}{\alpha S(1 - q)} \right]^{\gamma-1} \frac{1}{\alpha S(1 - q)} \right\} &= \\ dq \left\{ \alpha S + \lambda S G \gamma \cdot \left[ \frac{w + D}{\alpha S(1 - q)} \right]^{\gamma-1} \frac{w + D}{\alpha S(1 - q)^2} \right\} & \end{aligned}$$

Therefore increasing the bonus slightly and lowering the wage to keep the bank indifferent raises

the utility of the banker if  $dw > -\alpha S dq$ . That is if

$$dq \left\{ \begin{array}{c} \alpha S + \\ \lambda SG \gamma \cdot \left[ \frac{w+D}{\alpha S(1-q)} \right]^{\gamma-1} \frac{w+D}{\alpha S(1-q)^2} \end{array} \right\} < \alpha S dq \cdot \left\{ \begin{array}{c} 1 + \\ \lambda SG \gamma \cdot \left[ \frac{w+D}{\alpha S(1-q)} \right]^{\gamma-1} \frac{1}{\alpha S(1-q)} \end{array} \right\} \quad (10)$$

$$w + D < (1 - q) \alpha S$$

Suppose that this were not true, then  $w + D \geq (1 - q) \alpha S$  and so the expected payoff of the bank would be bounded above by, using (3),  $D - \lambda SG$ . But this is a contradiction as the bank could guarantee a value of  $S$  by not hiring the banker, and this exceeds  $D$ .

Finally note that at the equilibrium we must have  $q < 1$  as at  $q = 1$ , bank value is negative.

The result therefore follows. ■

**Proof of Lemma 2.** Consider banking teams  $i$  and  $i + 1$  and suppose that they have outside option  $u_i$  and  $u_{i+1}$  respectively. Consider banks  $n$  and  $n + 1$  bidding for them. To hire the  $A_{i+1}$  team a bonus  $q_{i+1,n+1}$  must be offered by bank  $n + 1$  where  $u_{i+1} = \alpha_{i+1} S_{n+1} q_{i+1,n+1}$ . Bank  $n + 1$  will therefore bid for the (better)  $\alpha_i$ -team up to the point at which:

$$\begin{aligned} & \alpha_i (1 - q_{i,n+1}) S_{n+1} - \lambda S_{n+1} G \left[ \frac{D_{n+1}}{\alpha_i S_{n+1} (1 - q_{i,n+1})} \right]^\gamma \\ = & \alpha_{i+1} (1 - q_{i+1,n+1}) S_{n+1} - \lambda S_{n+1} G \left[ \frac{D_{n+1}}{\alpha_{i+1} S_{n+1} (1 - q_{i+1,n+1})} \right]^\gamma \end{aligned} \quad (11)$$

This has a solution

$$\begin{aligned} \alpha_i (1 - q_{i,n+1}) &= \alpha_{i+1} (1 - q_{i+1,n+1}) \\ \Rightarrow q_{i,n+1} &= 1 - (1 - q_{i+1,n+1}) \frac{\alpha_{i+1}}{\alpha_i} = 1 - \left( 1 - \frac{u_{i+1}}{\alpha_{i+1} S_{n+1}} \right) \frac{\alpha_{i+1}}{\alpha_i} \end{aligned} \quad (12)$$

The maximal bonus bank  $n + 1$  is willing to offer the  $A_i$ -team is given by (12). A similar expression gives the maximal bonus from bank  $n$ . The result follows if the (better)  $A_i$ -team would rather work for the larger bank  $n$ . This follows as

$$\begin{aligned} \alpha_i S_n q_{i,n} - \alpha_i S_{n+1} q_{i,n+1} &= S_n \left[ \alpha_i - \left( 1 - \frac{u_{i+1}}{\alpha_{i+1} S_n} \right) \alpha_{i+1} \right] - S_{n+1} \left[ \alpha_i - \left( 1 - \frac{u_{i+1}}{\alpha_{i+1} S_{n+1}} \right) \alpha_{i+1} \right] \\ &= [S_n - S_{n+1}] [\alpha_i - \alpha_{i+1}] > 0 \end{aligned}$$

■

**Proof of Proposition 2.** The use of bonuses is proved by Proposition 1 and the positive assortative matching by Lemma 2. For the equilibrium bonus rate for the  $A_n$ -team note that the nearest rival bank would be willing to offer this team of bankers an expected utility as high as  $q_{n,n+1}\alpha_n S_{n+1}$ , given by (12). For bank  $n$  to hire the  $A_n$ -team they must provide this level of utility. This can be done at a lower bonus level as bank  $n$  is larger and so the same investing skill is spread across a greater volume of assets. This delivers

$$q_n \alpha_n S_n = q_{n,n+1} \alpha_n S_{n+1} \Rightarrow S_n q_n = \left[ 1 - (1 - q_{n+1}) \frac{\alpha_{n+1}}{\alpha_n} \right] S_{n+1}$$

This can be written as follows and then iterated:

$$\begin{aligned} q_n \alpha_n S_n &= [\alpha_n - \alpha_{n+1}] S_{n+1} + \alpha_{n+1} q_{n+1} S_{n+1} \\ &= \sum_{j=n}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1} + \alpha_N q_N S_N \end{aligned} \tag{13}$$

As the  $N$ 'th team of bankers have outside option normalized to 0, we have  $q_N = 0$  and the result follows. ■

**Proof of Proposition 3.** Given the equilibrium default risk in (5), the result follows if

$$\frac{D_n}{\alpha_n S_n - \sum_{j=n}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1}} < \frac{D_{n+1}}{\alpha_{n+1} S_{n+1} - \sum_{j=n+1}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1}}$$

Using the fact that  $D_n = (1 - \kappa) S_n$  this can be written

$$\begin{aligned} \alpha_n - \alpha_{n+1} &> \sum_{j=n}^{N-1} [\alpha_j - \alpha_{j+1}] \frac{S_{j+1}}{S_n} - \sum_{j=n+1}^{N-1} [\alpha_j - \alpha_{j+1}] \frac{S_{j+1}}{S_{n+1}} \\ [\alpha_n - \alpha_{n+1}] \left[ 1 - \frac{S_{n+1}}{S_n} \right] &> \left[ \frac{1}{S_n} - \frac{1}{S_{n+1}} \right] \sum_{j=n+1}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1} \end{aligned}$$

Note that as  $S_n > S_{n+1}$ , the left hand side is positive while the right hand side is negative.

Hence the result is proved. ■

**Proof of Proposition 4.** From (12) bank  $n$  would, absent any cap, bid for the  $A_{n-1}$ -team a bonus  $q_{n-1,n} = (1 - \alpha_n/\alpha_{n-1}) + (\alpha_n/\alpha_{n-1}) q_n^{eqm} > q_n^{eqm}$ . Suppose that  $n$  is the bank of lowest rank (largest  $n$ ) such that  $q_{n-1,n} > Q$ . Such an  $n$  must exist as  $Q \leq \max \{q_m^{eqm}\}$ . For banks

of rank below  $n$  the analysis of Proposition 2 does not change. These banks do not see their bonuses change nor their equilibrium value. Further for bank  $n$  we have  $q_n^{eqm} < Q$  as if not then  $q_{n,n+1} > q_n^{eqm} \geq Q$  which is a contradiction to bank  $n$  being the one of lowest rank affected by the cap. Hence bank  $n$  could hire the  $A_n$ -team using the bonus  $q_n^{eqm}$ .

Bank  $n$  however, as it finds itself bound by the bonus cap in its bidding for the  $A_{n-1}$ -team will substitute in part to wages to try to attract this better team of bankers. Bank  $n$  is willing to offer a wage up to  $w_{n-1,n}$  where

$$\begin{aligned} & \alpha_n S_n (1 - q_n^{eqm}) - \lambda S_n G \left[ \frac{D_n}{\alpha_n S_n (1 - q_n^{eqm})} \right]^\gamma \\ = & \alpha_{n-1} S_n (1 - Q) - w_{n-1,n} - \lambda S_n G \left[ \frac{w_{n-1,n} + D_n}{\alpha_{n-1} S_n (1 - Q)} \right]^\gamma \end{aligned} \quad (14)$$

*Proof of part 1.*

To hire the  $A_{n-1}$ -team bank  $n - 1$  must therefore offer the bonus  $q_{n-1}$  such that

$$\alpha_{n-1} q_{n-1} S_{n-1} = w_{n-1,n} + \alpha_{n-1} S_n Q \quad (15)$$

The definition of  $Q^*$  is such that this equation has a solution – that is bonuses are sufficient for every bank to hire its team of bankers. Note that the risk placed on bank  $n - 1$  is reduced and its value is raised if  $q_{n-1} < q_{n-1}^{eqm}$ . This is true, using (13) and (15) if

$$\begin{aligned} \alpha_{n-1} q_{n-1} S_{n-1} = w_{n-1,n} + \alpha_{n-1} S_n Q & < [\alpha_{n-1} - \alpha_n] S_n + \alpha_n q_n^{eqm} S_n \\ \alpha_n S_n (1 - q_n^{eqm}) & < \alpha_{n-1} S_n (1 - Q) - w_{n-1,n} \end{aligned} \quad (16)$$

We will show that this is true from (14). To see this suppose (16) were false and the reverse inequality held  $[w_{n-1,n} \geq \alpha_{n-1} S_n (1 - Q) - \alpha_n S_n (1 - q_n^{eqm})]$ . Then (14) would have a contradictory implication, namely that

$$\begin{aligned} \left[ \frac{D_n}{\alpha_n S_n (1 - q_n^{eqm})} \right] & \geq \left[ \frac{w_{n-1,n} + D_n}{\alpha_{n-1} S_n (1 - Q)} \right] \\ \implies w_{n-1,n} & \leq \underbrace{\left[ \frac{D_n}{\alpha_n S_n (1 - q_n^{eqm})} \right]}_{<1 \text{ by bankers worth having assumption}} \cdot [\alpha_{n-1} S_n (1 - Q) - \alpha_n S_n (1 - q_n^{eqm})] \end{aligned}$$

Therefore (16) holds and so the risk bank  $n - 1$  faces declines as it hires the  $A_{n-1}$ -team at a lower bonus rate than before the intervention. [The positive assortative matching remains true as bank  $n - 1$  now gains increased value from the  $A_{n-1}$ -team.]

To complete the proof we now show the inductive step. Consider bank  $n - 2$ . When bank  $n - 1$  is bidding for the  $A_{n-2}$ -team it either finds that the cap  $Q$  is binding or not. Suppose not then  $n - 1$  is willing to bid a bonus of  $q_{n-2,n-1}$  for the  $A_{n-2}$ -team to the point where

$$[\text{Value with the } A_{n-1}\text{-team}] = \alpha_{n-2}S_{n-1}(1 - q_{n-2,n-1}) - \lambda S_{n-1}G\left[\frac{D_{n-1}}{\alpha_{n-2}S_{n-1}(1 - q_{n-2,n-1})}\right]^\gamma$$

It is immediate that as the value with the  $A_{n-1}$ -team rises,  $q_{n-2,n-1}$  falls. Thus  $n - 1$  bids less aggressively for  $A_{n-2}$ -team and so the result for bank  $n - 2$  follows. (The positive assortative matching can be proved as in Lemma 2). If instead the cap is binding on  $n - 1$ 's bid for the  $A_{n-2}$ -team then the result follows by identical working to the case of bank  $n$ . Hence the full result follows by induction: all larger banks see their default risk fall and their value rise.

*Proof of part 2a.*

Let us now turn to a cap  $Q$  sufficiently strict that all banks  $n < N$  find themselves affected by the cap in remunerating their banking team. Thus (15) has no solution as bank  $n - 1$  must use wages as well as bonus up to the cap to secure the  $A_{n-1}$ -team.

Consider banks  $N - 1$  and  $N$ . Bank  $N$  is willing to offer the wage  $w_{N-1,N}$  and the bonus  $Q$  to the  $A_{N-1}$  team according to (14) with  $n$  set equal to  $N$ . Bank  $N - 1$  must therefore offer the wage  $w_{N-1}$  which the  $A_{N-1}$ -team will be willing to accept:

$$w_{N-1} + \alpha_{N-1}QS_{N-1} = w_{N-1,N} + \alpha_{N-1}QS_N \quad (17)$$

The risk born by bank  $N - 1$  is an increasing function of  $[(D_{N-1} + w_{N-1}) / \alpha_{N-1}S_{N-1}(1 - Q)]$ . Differentiating this with respect to  $Q$  we see that risk for bank  $N - 1$  decreases in  $Q$  if

$$(1 - Q) \frac{dw_{N-1}}{dQ} + D_{N-1} + w_{N-1} < 0$$



Using (17) we can express this as a condition on  $w_{N-1,N}$  :

$$(1 - Q) \frac{dw_{N-1,N}}{dQ} - \alpha_{N-1} (S_{N-1} - S_N) + D_{N-1} + w_{N-1,N} < 0 \quad (18)$$

We now seek a bound on  $dw_{N-1,N}/dQ$ . Taking differentials in (14)

$$\begin{aligned} 0 &= -\alpha_{N-1} S_N dQ - dw_{N-1,N} \\ &\quad - \lambda S_N G \gamma \left[ \frac{w_{N-1,N} + D_N}{\alpha_{N-1} S_N (1 - Q)} \right]^{\gamma-1} \left\{ \frac{dw_{N-1,N}}{\alpha_{N-1} S_N (1 - Q)} + \frac{w_{N-1,N} + D_N}{\alpha_{N-1} S_N (1 - Q)^2} dQ \right\} \end{aligned}$$

So collecting terms

$$\frac{dw_{N-1,N}}{dQ} = - \frac{\left\{ \alpha_{N-1} S_N + \lambda G \gamma \left[ \frac{w_{N-1,N} + D_N}{\alpha_{N-1} S_N (1 - Q)} \right]^{\gamma-1} \frac{w_{N-1,N} + D_N}{\alpha_{N-1} (1 - Q)^2} \right\}}{\left\{ 1 + \frac{\lambda G \gamma}{\alpha_{N-1} (1 - Q)} \left[ \frac{w_{N-1,N} + D_N}{\alpha_{N-1} S_N (1 - Q)} \right]^{\gamma-1} \right\}} \quad (19)$$

Equation (16) and (14) together imply that

$$\frac{w_{N-1,N} + D_N}{\alpha_{N-1} S_N (1 - Q)} > \frac{D_N}{\alpha_N S_N} \text{ and } w_{N-1,N} < [\alpha_{N-1} (1 - Q) - \alpha_N] S_N \quad (20)$$

Regular algebra allows one to confirm that  $dw_{N-1,N}/dQ$  is increasing in the square bracketed term  $\left[ \frac{w_{N-1,N} + D_N}{\alpha_{N-1} S_N (1 - Q)} \right]^{\gamma-1}$  which let us label  $B$ . It follows that

$$(1 - Q) \frac{dw_{N-1,N}}{dQ} < \lim_{B \rightarrow \infty} (1 - Q) \frac{dw_{N-1,N}}{dQ} = -[w_{N-1,N} + D_N]$$

Substituting this into (18) confirms the inequality as  $S_n - D_n > S_{n+1} - D_{n+1}$ . Hence we have part 2a, namely that the default risk which bank  $N - 1$  incurs declines as  $Q$  is raised.

*Proof of part 2b.*

We now seek conditions under which the value of bank  $N - 1$  increases with  $Q$ . This happens if

$$\frac{d}{dQ} \left\{ \alpha_{N-1} S_{N-1} (1 - Q) - w_{N-1} - \lambda S_{N-1} G \left[ \frac{w_{N-1} + D_{N-1}}{\alpha_{N-1} S_{N-1} (1 - Q)} \right]^{\gamma} \right\} > 0$$

Taking differentials and restricting to  $\gamma = 1$  yields the condition:

$$\begin{aligned} -\alpha_{N-1}S_{N-1}dQ - dw_{N-1} - \lambda G \left\{ \frac{dw_{N-1}}{\alpha_{N-1}(1-Q)} + \frac{w_{N-1} + D_{N-1}}{\alpha_{N-1}(1-Q)^2} dQ \right\} &> 0 \\ \frac{dw_{N-1}}{dQ} &< - \left\{ \alpha_{N-1}S_{N-1} + \lambda G \frac{w_{N-1} + D_{N-1}}{\alpha_{N-1}(1-Q)^2} \right\} / \left\{ 1 + \frac{\lambda G}{\alpha_{N-1}(1-Q)} \right\} \end{aligned} \quad (21)$$

Using (17), and substituting in for  $dw_{N-1,N}/dQ$  using (19), condition (21) can be written

$$-\frac{\left\{ \alpha_{N-1}S_N + \lambda G \frac{w_{N-1,N} + D_N}{\alpha_{N-1}(1-Q)^2} \right\}}{\left\{ 1 + \frac{\lambda G}{\alpha_{N-1}(1-Q)} \right\}} - \alpha_{N-1}(S_{N-1} - S_N) < -\frac{\left\{ \alpha_{N-1}S_{N-1} + \lambda G \frac{w_{N-1} + D_{N-1}}{\alpha_{N-1}(1-Q)^2} \right\}}{\left\{ 1 + \frac{\lambda G}{\alpha_{N-1}(1-Q)} \right\}}$$

Multiplying through this inequality follows if

$$\begin{aligned} \alpha_{N-1}(S_{N-1} - S_N)(1-Q) &> w_{N-1} + D_{N-1} - w_{N-1,N} - D_N \\ \alpha_{N-1}(S_{N-1} - S_N) &> D_{N-1} - D_N \text{ using (17)} \end{aligned}$$

This is true as  $S_n - D_n > S_{n+1} - D_{n+1}$ .

Now we are in a position to use induction. We have shown that relaxing  $Q$  will lower bank  $N-1$ 's default risk and, for  $\gamma$  close to 1, raise bank  $N-1$ 's value. Hence, following the inductive step of part 1, bank  $N-1$  is willing to bid less aggressively for the  $A_{N-2}$ -team and so bank  $N-2$  sees its default risk fall and its value rise. Part 2b now follows by induction. ■

**Proof of Proposition 5.** Consider the  $A_n$ -team and the  $A_{n+1}$ -team. Bank  $n+1$  is willing to bid for the  $A_n$ -team up to a bonus of  $q_{n,n+1}$  where, similar to (11):

$$\begin{aligned} &\alpha_n \left( 1 - q_{n,n+1} (1 + t^b) \right) S_{n+1} - \lambda S_{n+1} G \left[ \frac{D_{n+1}}{\alpha_n S_{n+1} (1 - q_{n,n+1} (1 + t^b))} \right]^\gamma \\ = &\alpha_{n+1} \left( 1 - q_{n+1,n+1} (1 + t^b) \right) S_{n+1} - \lambda S_{n+1} G \left[ \frac{D_{n+1}}{\alpha_{n+1} S_{n+1} (1 - q_{n+1,n+1} (1 + t^b))} \right]^\gamma \end{aligned}$$

This delivers a solution for  $q_{n,n+1}$  of

$$\begin{aligned} \alpha_n \left( 1 - q_{n,n+1} (1 + t^b) \right) &= \alpha_{n+1} \left( 1 - q_{n+1} (1 + t^b) \right) \\ \Rightarrow q_{n,n+1} (1 + t^b) &= 1 - \frac{\alpha_{n+1}}{\alpha_n} \left( 1 - q_{n+1} (1 + t^b) \right) \end{aligned}$$

Given  $q_{n+1}$  bank  $n$  will therefore offer a bonus just sufficient to attract the  $A_n$ -team. Hence we have

$$\begin{aligned}
\alpha_n S_n q_n (1 + t^b) &= \alpha_n S_{n+1} q_{n,n+1} (1 + t^b) = \alpha_n S_{n+1} \left[ 1 - \frac{\alpha_{n+1}}{\alpha_n} (1 - q_{n+1} (1 + t^b)) \right] \\
&= S_{n+1} [\alpha_n - \alpha_{n+1}] + \alpha_{n+1} S_{n+1} q_{n+1} (1 + t^b) \\
&= \dots = \sum_{j=n}^{N-1} S_{j+1} [\alpha_j - \alpha_{j+1}] \text{ as } u_N := 0
\end{aligned}$$

Hence we have

$$q_n^{\text{bank-tax}} = \frac{1}{1 + t^b} q_n^{eqm}$$

This delivers that the bonuses paid to bankers are reduced.

The default risk of bank  $n$ , and its value, under the bonus tax regime is given by (3). Now substitute in the fact that a bonus of  $q$  costs the bank  $q(1 + t^b)$ . As we have shown that  $q_n^{\text{bank-tax}}(1 + t^b) = q_n^{eqm}$  for all  $n$ , the result follows. ■

**Proof of Proposition 6.** Bank  $n + 1$  will be willing to bid up to a bonus rate of  $q_{n,n+1}$  to attract the  $A_n$ -team where, following (11):

$$\begin{aligned}
&(1 - \rho) S_{n+1} + \alpha_n (1 - q_{n,n+1}) \rho S_{n+1} - \lambda S_{n+1} G \left[ \frac{D_{n+1} - (1 - \rho) S_{n+1}}{\alpha_n \rho S_{n+1} (1 - q_{n,n+1})} \right]^\gamma \\
&= (1 - \rho) S_{n+1} + \alpha_{n+1} (1 - q_{n+1}) \rho S_{n+1} - \lambda S_{n+1} G \left[ \frac{D_{n+1} - (1 - \rho) S_{n+1}}{\alpha_{n+1} \rho S_{n+1} (1 - q_{n+1})} \right]^\gamma
\end{aligned} \tag{22}$$

This is solved by the relationship

$$\alpha_n (1 - q_{n,n+1}) = \alpha_{n+1} (1 - q_{n+1}) \Rightarrow q_{n,n+1} \text{ is given by (12)}$$

Hence we have that bank  $n$  will deliver a bonus of  $q_n^{eqm}$ .

Bank  $n$ 's default risk is

$$\Pr(\text{default}) = G \cdot \left[ \frac{D_n - (1 - \rho) S_n}{\alpha_n \rho S_n (1 - q_n^{eqm})} \right]^\gamma$$

Recalling that  $\rho$  is the proportion of assets which *can* be invested:

$$\frac{d}{d\rho} \Pr(\text{default}) =_{\text{sign}} \frac{d}{d\rho} \left[ \frac{D_n}{\rho} - \frac{(1-\rho) S_n}{\rho} \right] = -\frac{D_n}{\rho^2} - S_n \left( -\frac{1}{\rho^2} \right) > 0$$

Which gives the desired result. ■

**Proof of Proposition 7.** Once a cap at  $\bar{S}$  is introduced the top  $k$  banks are all equal in size at this level and so offer perfectly symmetric Bertrand competition in their quest to hire one of the  $k$  best teams of bankers. The remuneration of the worst of these, the  $A_k$ -team, will be determined by the competitive pressure from the smaller bank  $k+1$ . Hence the standard analysis yielding (4) applies to the bank which hires the  $A_k$ -team

$$q_k = \frac{1}{\alpha_k \bar{S}} \sum_{j=k}^{N-1} [\alpha_j - \alpha_{j+1}] S_{j+1} \quad (23)$$

The top  $k$  banks would be in active competition to hire one of the best  $k-1$  banking teams. Following (12) in hiring a banker of rank  $i \leq k$  each of the  $k$  joint largest banks would be willing to bid up to bonus  $\bar{q}_i$  which leaves her indifferent between the  $A_i$ -team and the  $A_k$ -team. That is

$$\alpha_i (1 - \bar{q}_i) = \alpha_k (1 - q_k) \Rightarrow \bar{q}_i = 1 - (1 - q_k) \frac{\alpha_k}{\alpha_i}$$

As there is more than one bank of equal size seeking to hire the  $A_i$ -team when  $i < k$  competitive bidding will push the bonuses paid up to  $\bar{q}_i$ . Hence the default risk run by the top  $k$  banks is equal to that run by the bank hiring the  $A_k$ -team. To see this use (3) to yield:

$$\Pr(\text{default}_i) = G \cdot \left[ \frac{(1-\kappa) \bar{S}}{\bar{S} \alpha_i (1 - \bar{q}_i)} \right]^\gamma = G \cdot \left[ \frac{(1-\kappa) \bar{S}}{\bar{S} \alpha_k (1 - q_k)} \right]^\gamma = \Pr(\text{default}_k)$$

We are now in a position to prove the proposition. First note that the default risk run by bank  $k$  has increased compared to before the policy intervention as

$$\begin{aligned} \Pr(\text{default}_k) &\geq \Pr(\text{default before intervention}_k) \\ \Leftrightarrow \frac{(1-\kappa) \bar{S}}{\bar{S} \alpha_k (1 - q_k)} &\geq \frac{(1-\kappa) S_k}{S_k \alpha_k (1 - q_k^{eqm})} \\ \Leftrightarrow q_k &\geq q_k^{eqm} \end{aligned}$$

This is immediate from (23) as  $\bar{S} \leq S_k$ . Next before the intervention banks of rank 1 to  $k - 1$  had a lower default risk than bank  $k$  (Proposition 3). After the intervention all the  $k$  banks have the same default risk at the level of bank  $k$  which itself is higher than bank  $k$  had before the intervention. Thus risk is increased for the top  $k$  banks. ■

## References

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