

# Bank Pay Caps, Bank Risk, and Macroprudential Regulation

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## Abstract

This paper studies the consequences of a regulatory pay cap in proportion to assets on bank risk, bank value, and bank asset allocations. The cap is shown to lower banks' risk and raise banks' values by acting against a competitive externality in the labour market. The risk reduction is achieved without the possibility of reduced lending from a Tier 1 increase. The cap encourages diversification and reduces the need a bank has to focus on a limited number of asset classes. The cap can be used for Macroprudential Regulation to encourage banks to move resources away from wholesale banking to the retail banking sector. Such an intervention would be targeted: in 2009 a 20% reduction in remuneration would have been equivalent to more than 150 basis points of extra Tier 1 for UBS, for example.

**Keywords:** Bank regulation; financial stability; bankers' pay; bonus caps; Capital Conservation Buffer.

**JEL Classification:** G01, G21, G38.

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# 1 Introduction

The remuneration of bankers and executives in the financial sector is the focus of significant regulatory attention in the UK, EU and globally. Many are concerned that the level and structure of pay contributes to the riskiness of banks. This concern has inspired the Financial Stability Board's *Principles for Sound Compensation Practices*; the adoption by the European Union of the *1-to-1 Bonus Rule*; and the adoption in Basel III of a *Capital Conservation Buffer* which prevents banks making some remuneration payments if their Tier 1 capital should fall below a specified level.<sup>1</sup> The level of pay is indeed a significant cost for banks. Thanassoulis (2012, Figures 1, 3, and IA.1) documents that for a substantial minority of financial institutions remuneration exceeds 30% of shareholder equity; while non-financial firms rarely pay this much. For some financial institutions pay as a proportion of shareholder equity is much higher – and sometimes in excess of 80% of shareholder equity.

This paper studies the impact of a cap on total remuneration for bankers in proportion to the risk weighted assets they control. Such a cap could be targeted, affecting some sectors, such as the wholesale side, and not others, such as the retail side. Thus the cap can work with existing regulatory attempts to treat wholesale and retail banking separately (the *Independent Commission on Banking* ring-fence in the UK for example).

The analysis demonstrates that a variable cap in proportion to assets leans against the competitive externality which drives pay up. Such a cap acts to lower aggregate remuneration. Hence banks will have increased resilience to shocks on the value of their assets due to their reduced cost based. This reduction in bank risk is achieved whilst increasing bank values.

In principle banks can always be made less risky by increasing their capital adequacy ratio. But by encouraging banks to meet such requirements by either avoiding lending risk or reducing lending, such a direct intervention has a cost. The intervention in the labour market for banks increases bank values and does not compromise lending. Further, to the extent that there is a broader desire to intervene in the labour market for bankers, it would be desirable if any such intervention did have the effect of improving financial stability.

To determine the scale of the relevance of remuneration to financial stability let us suppose the remuneration bill could be reduced by some percentage. One can calculate how much of an increase in the Tier 1 capital ratio this reduction in remuneration would represent by comparing funds saved to total risk weighted assets. As remuneration falls during crisis periods I focus on crisis years to avoid misleading estimates of the importance of remuneration. Figure 1 considers the remuneration paid in 2008 and 2009, during the

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<sup>1</sup>For discussions of these interventions please see FSB (2009), Thanassoulis (2013b) and BCBS (2010).

last financial crisis, by the top 100 global banks ranked by asset value in 2011.<sup>2</sup>

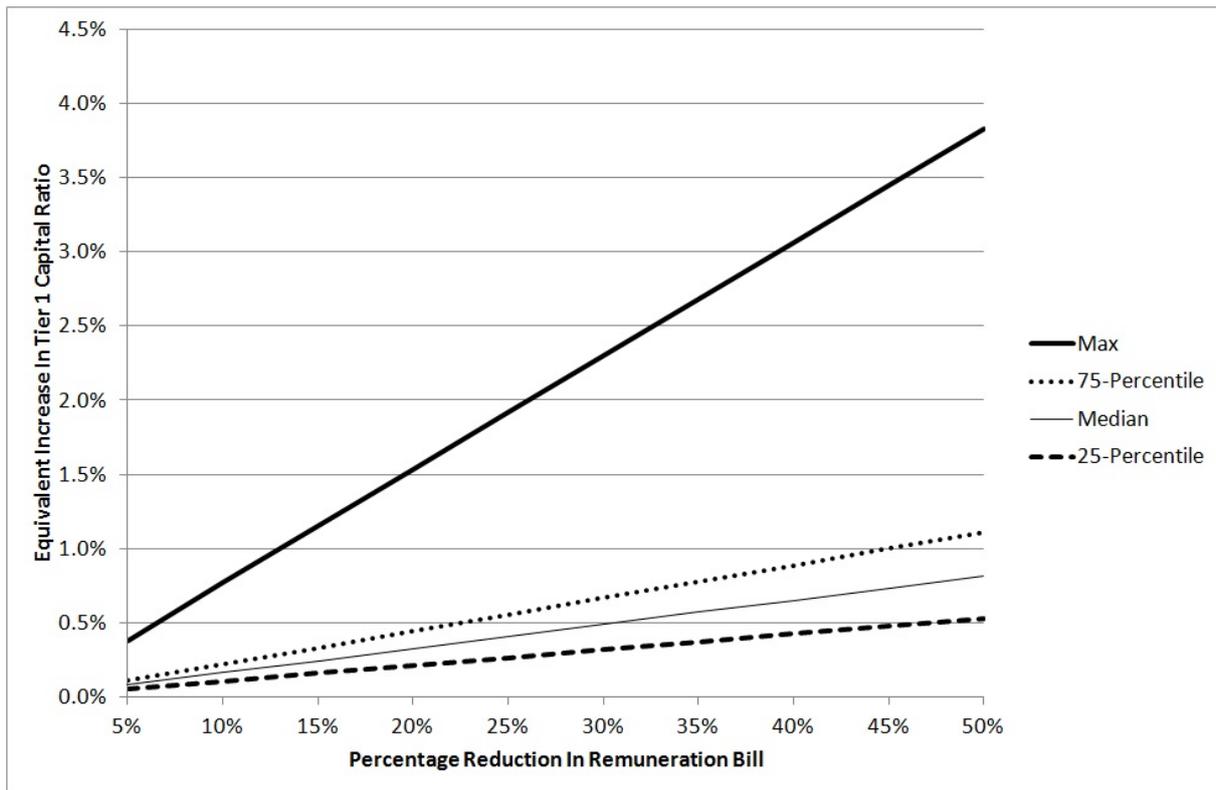


Figure 1: Remuneration Reduction Expressed As A Gain In Tier 1 Ratio

Notes: The graph considers the remuneration paid by the top 100 global banks by asset size during the financial crisis, captured as years 2008 and 2009. The figure expresses the money saved by a reduction in the costs of remuneration as the equivalent increase in the Tier 1 ratio which would have been achieved. This is the ratio of the remuneration saving against the risk weighted assets. The graph demonstrates that for a quarter of the top 100 banks, a remuneration reduction of 20% could increase resilience by the equivalent of between 50 and 150 basis points on the Tier 1 ratios. Data from Bloomberg, see footnote 2.

Figure 1 demonstrates that a 20% reduction in the remuneration bill would be equivalent to an increase in the Tier 1 capital ratio for the average bank in the sample of about 30 basis points (0.3%). However, the intervention is targeted. For large banks for which remuneration is substantial, a 20% reduction in remuneration would have bestowed an extra Tier 1 cushion of up to 150 basis points or 1.5%. This is significant in the context of the Tier 1 requirements of Basel III.

The analysis captured in Figure 1 demonstrates that, during crisis periods, remuneration is a substantial bill for some, but not all, banks. Figure 2 displays the identity of the 20 banks (in the top 100) who would have been helped most by a 20% reduction in remuneration costs on their 2009 remuneration bill. Figure 2 demonstrates that an

<sup>2</sup>The data sample is the top 100 listed institutions in Bloomberg by total assets in 2011 for which relevant data exists and whose activities include banking. Only group entities were included; public institutions such as central banks and development banks were excluded. Of the 100, a sample of 80 banks remain. The list includes the 31 Globally Systemically Important Financial Institutions defined by FSB (2011).

intervention in the level of remuneration would have helped some major household names which were the focus of considerable regulatory attention during the crisis. For example, a 20% reduction in the remuneration bill in 2009 would have been equivalent to a Tier 1 increase at UBS of 1.5%, 1.3% for Credit Suisse, and over 0.8% for Deutsche Bank. Finally note that, in future crisis times, extra earnings secured by any reduction in pay would likely be retained on the balance sheet due to the introduction of the *Capital Conservation Buffer* in the Basel III framework. Thus an intervention which lowered market remuneration levels and increased bank values would have an arguably significant and targeted effect of lowering risk in the financial system.

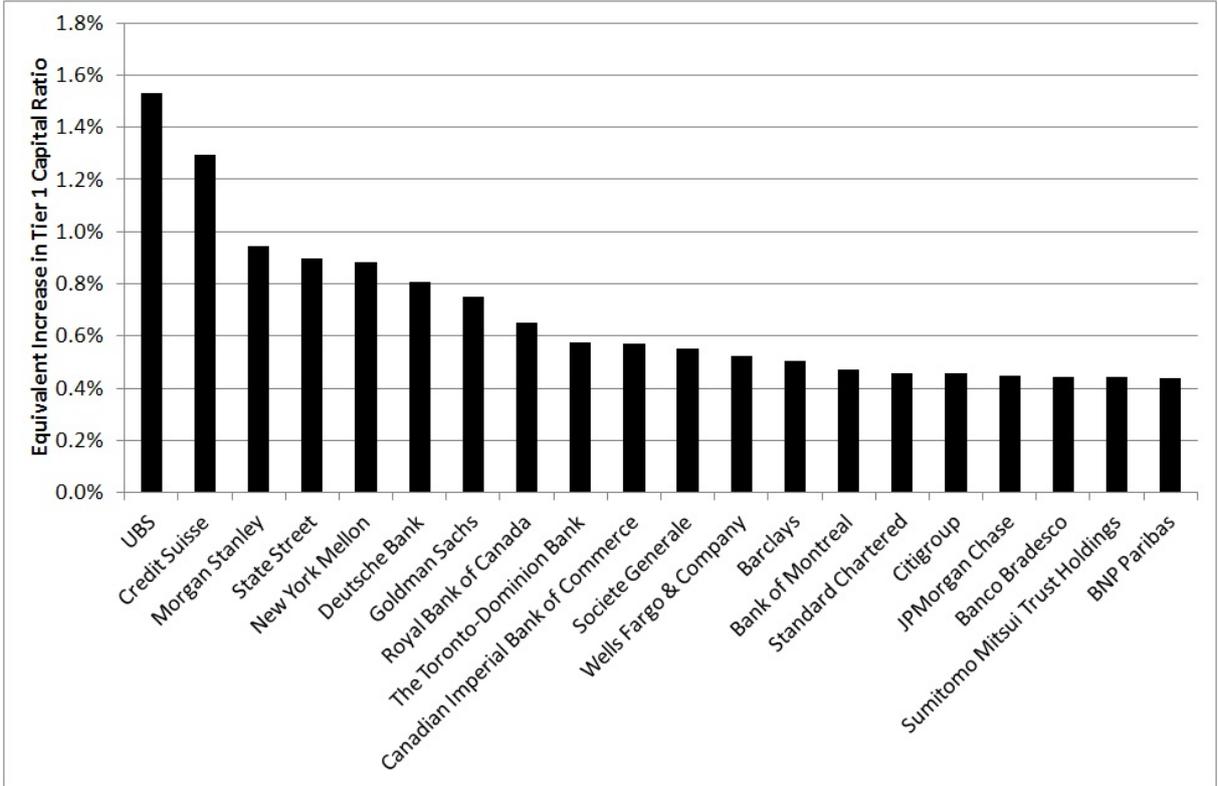


Figure 2: Equivalent Gain In Tier 1 Ratio For The 20 Most Affected Banks

Notes: The graph documents the impact of a 20% reduction in remuneration in the crisis year 2009. The reduction in the remuneration bill can be measured in terms of an increase in the Tier 1 ratio. The graph documents the impact of such a reduction in remuneration on the 20 most affected banks in the sample of the top 100 banks used in Figure 1. These are are banks which would gain most resilience if the remuneration level of bankers could have been reduced. Data from Bloomberg, see footnote 2.

In a market, such as the labour market for bankers’ services, competition to hire scarce talent leads to an externality. The remuneration level will be determined by the institution which is the marginal bidder for the banker. By bidding to hire a banker unsuccessfully, the marginal bidding bank drives up the market rate of pay in the financial sector. The bidding is a pecuniary externality: the banker gains, the employing bank loses. However, in addition the employing bank’s fragility to market stress is increased by increases in

its cost base. This lowers the value of the employing bank further. This competitive externality represents a market failure. A bank failure makes other bank failures more likely, and in addition can have negative consequences for both savers and borrowers. These further externalities magnify the importance of the market failure.

A cap on pay in proportion to assets impacts on the marginal bidding bank more than the employing bank. As pay in a given business line rises in proportion to the resources or assets being managed, in equilibrium the marginal bidding bank does not have a sufficiently large pot of assets to attract the banker, and so is unwilling to offer a large enough expected payment. The bank which succeeds in hiring the banker will be able to do so at a lower bonus rate as it adjusts the rate for the fact that it has a larger pot of assets, and/or is an otherwise more desirable place to work. A cap on the size of remuneration in relation to assets impacts the ability of the marginal bidder to drive up pay. Hence the level of pay in the whole market is reduced.

As the proposed cap is on total remuneration, the measure allows the bank to structure pay in the manner it considers optimal. Risk sharing features, such as bonuses, can be fully preserved (Thanassoulis (2012)), as there is no requirement to force fixed wages up within the cap.

A cap on pay in proportion to assets will alter a bank's asset allocation decisions. Within an individual business unit the manager would like to be assigned as large a fraction of the bank's assets as possible as this would likely translate into the largest pay. This effect exists whether or not there is a cap, and forces banks to become focused on asset classes considered to be core so as to secure the talent they desire. A cap in proportion to assets is more binding on the marginal bidder than on the employing bank. Hence each bank will find that in its core business lines it is able to hire its staff more cheaply as the marginal bidders are impeded in their bidding. This allows the banks to row back on the specialization that had been necessary with unconstrained bidding, and so benefit from increased diversification.

The cap could naturally also be a tool for macroprudential regulation as it can be used to encourage the re-targeting of banks from some business lines to others. Suppose that a cap is imposed on bankers managing wholesale assets, and not for those managing assets on the retail side. In this case regulated banks would be at a disadvantage in hiring traders, for example, compared to financial institutions, such as hedge funds, which operate without a banking license. The expected return banks would have from these wholesale activities would decline as the banks would be unable to hire the most sought-after traders. Hence banks will be incentivised to reassign assets at the margin from wholesale towards retail banking.

## 2 Literature Review

The objective of this paper is to investigate the consequences of a regulatory pay cap on bank risk, bank value and bank asset allocation decisions. This work builds on Thanassoulis (2012) who demonstrates the competitive externality operating through the labour market which drives up pay and so increases bank risk. In this study I extend the Thanassoulis (2012) framework to study the effects of a regulatory cap on total pay in proportion to assets. Further I extend the study to consider multiple asset classes, asset allocation, and macroprudential regulation. The model of a competitive labour market used here builds on the seminal contributions of Gabaix and Landier (2008) and of Edmans, Gabaix and Landier (2009). Relative to these works I explicitly model the possibility of bank failure arising from poor asset realisations, and so am in a position to discuss bankers and their impact on financial stability.

As in Wagner (2009), if the size of the pool of assets should fall below some level, a default event occurs which results in extra costs for 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.

There is little empirical evidence on the level of bankers' pay and on bank risk. Cheng, Hong, and Schienkman (2010) is a notable exception which demonstrates that financial institutions which have a high level of aggregate pay, controlling for their size, are riskier on a suite of measures. A complementary finding is offered by Fahlenbrach and Stulz (2011) who demonstrate that bank CEO's with the largest equity compensation were more likely to lead their banks to losses in the financial crisis. Other empirical research has in general focused on CEO pay and incentives whereas our focus here is on remuneration more widely.<sup>3</sup>

This analysis focuses on the aggregate level of risk which a bank would knowingly allow their bankers to take on rather than the risk choices of individual bankers. Other studies have focused on how competition between banks affects individual bankers' incentives to moral hazard in a parallel stream in the literature. For example Thanassoulis (2013a) argues that competition for bankers drives pay up and can lead an industry to using contracts which tolerate short-termism. This work provides a rationale for forced deferral of pay conditional on results. By contrast, Foster and Young (2010) argue that any variable pay can be gamed and can lead to risk being pushed into the tails.

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<sup>3</sup>See for example Llense (2010) on CEO pay for performance, and Edmans and Gabaix (2011) on the relative value of contract design versus hiring the optimal individual to be CEO.

### 3 The Model

Suppose there are  $N$  banks who have assets in a given asset class of  $S_1 > S_2 > \dots > S_N$ . Banks seek a banker who will maximise the expected returns from their assets. If the bank's assets in this class should however shrink to be less than  $\eta S$ , for some  $\eta < 1$ , then the bank incurs some extra costs. The parameter  $\eta$  measures a required preservation rate on assets below which the bank, or its creditors, take actions which generate a cost to the bank. This captures, for example, the costs of forced asset sales to reimburse creditors, or increased costs of capital. I refer to the case in which assets fall below this critical level as a default event. I assume the bank's costs in the case of a default event are proportional to the initial level of assets:  $\lambda S$ . The functional form is chosen for tractability, but it is not a key assumption. The key assumption is that costs of default can arise if a banker shrinks the assets they are given to manage sufficiently.

There are  $N$  bankers who can run this asset. Their expected returns are  $\alpha_1 > \alpha_2 > \dots > \alpha_N$  per dollar of assets managed. Thus if banker  $i$  is employed by bank  $j$  then the expected assets of bank  $j$  will be  $\alpha_i \cdot S_j$ . I assume that bankers' returns' distributions are all translations of each other so that bankers differ only in their skill. Hence the return density of banker  $n$  can be written as  $f_n(x) = (1/\alpha_n) f(x/\alpha_n)$ . Where  $f(\cdot)$  is a density of returns with unit expectation. Integrating we have the cumulative returns distribution given by  $F_n(v) = F(v/\alpha_n)$ . The outside option in the labour market for bankers will be determined endogenously to this model. In addition the bankers have the option of leaving this labour market and, for example, moving to another industry or location. I normalise this outside option to zero. Finally bankers are assumed to be risk neutral. There is considerable evidence that bankers may actually be risk loving (see the evidence contained in Thanassoulis (2012)). However all that is required for the following analysis is that bankers are not too risk averse.

As the bank is an expected profit maximiser, the shape of the distribution of investment returns generated by the banker will only be important if a default event is triggered, leading to the extra costs of the premature liquidation of assets. 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  $F_n$ . I now follow Gabaix and Landier (2008) and Thanassoulis (2012) and use Extreme Value Theory to characterise the shape of a general returns distribution in its left tail. I assume that the returns are bounded below by zero so that the bank enjoys limited liability on its investments. In this case the left hand tail of the returns distribution can be approximated by

$$F_n(v) \sim G \cdot (v/\alpha_n)^\gamma \tag{1}$$

where  $\alpha$  is the expected return of the banker. I further restrict to  $G > 0$  being a constant and not a function which varies more slowly than any polynomial and I require  $\gamma \geq 1$  so

that the distribution function takes a convex shape.

I restrict bankers to be paid in bonuses which are proportional to the assets controlled. Thanassoulis (2012, Proposition 1) demonstrates that banks, as modeled here, would prefer to pay fully in bonuses rather than using fixed wages as well as bonuses. Bonus pay allows banks to share some of the risk of poor asset realizations with the bankers. This lowers the banks' expected costs from the possibility of realizations which trigger a default event. Table 1 presents evidence from the UK corroborating that this all bonus restriction is a reasonable assumption, particularly for those earning the largest amounts. More recent regulatory interventions have limited bonuses and required banks to pay staff using higher fixed wages.<sup>4</sup> Table 1 shows that if banks are given the flexibility they would elect to pay staff overwhelmingly in the form of variable bonuses.

Table 1: Proportion of Remuneration Received As Bonus

Notes: Data reproduced from Financial Services Authority (2010, Table 1, Annex A3.8). The FSA required this information of UK staff for seven major international banking groups, and six major UK banking groups. The sample consists of 2,800 staff comprising, the FSA estimate, 70% of 'Code Staff' in banks operating in the UK. That is staff whose activities can have a material impact on their employing bank. The table demonstrates that, given the flexibility, banks would choose to deliver the vast majority of pay in the form of bonuses.

Total compensation bands	2008		2009	
	% base salary	% bonus	% base salary	% bonus
£500K to £1mn	19%	81%	24%	76%
> £1mn	9%	91%	11%	89%

This is not an explicit model of moral hazard, though the outcome of such models is compatible with these assumptions. As pay is delivered in the form of variable pay conditional on performance, managers are fully incentivised. The shape of the tail risk of the manager is fixed in this model, it is not a function of the pay arrangements. Thus remuneration structure is assumed not to impact on the tail risk of the bank directly. This assumption is satisfied in the case of well functioning corporate governance. In this case the tail risk of a bank is decided by the Board to maximise bank value, and they have sufficient levers to control it.<sup>5</sup> If corporate governance is poor, the forces identified in this study are joined by the moral hazard effect of bonus pay on tail risk. The variable cap on pay explored in this paper would reduce these moral hazard effects, and so has further beneficial effects in the setting of poor corporate governance.

Suppressing the subscripts momentarily, if a bank with assets  $S$  hires a banker of type  $\alpha$  on bonus rate  $q$  then the banker expects to receive remuneration of  $q \cdot \alpha S$ . The expected

<sup>4</sup>See Thanassoulis (2013b) for a discussion of the European 1-to-1 bonus regulation.

<sup>5</sup>The risk a banker or trader exposes his/her institution to is a matter for internal risk controls. It is managed, for example, by restrictions on the required Value at Risk (which can take the form of minimum as well as maximum VaR requirements), by asset allocation decisions, and by hedging decisions.

returns to the bank, gross of costs of any default event are  $\alpha(1-q)S$ . Suppose the realisation of the returns is  $a$ . There is a default event if the realisation,  $a(1-q)S < \eta S$ . Using (1), the probability of this is  $F(\eta/(1-q)) = G \cdot (\eta/\alpha(1-q))^\gamma$ . Hence the expected value of the bank is  $E(V)$  where

$$E(V) = \alpha(1-q)S - \lambda SG \left( \frac{\eta}{\alpha(1-q)} \right)^\gamma \quad (2)$$

Each bank will seek to maximise this expected value. A cap on the remuneration in proportion to assets is equivalent to setting a maximum value for the bonus rate,  $q$ .

There is a competitive labour market for bankers. Banks bid against each other to hire a banker to run their assets. Each bank can offer a given banker a targeted bonus rate  $q$  which will be applied to the realized returns on the assets the banker manages. The offers are banker specific so that more able bankers can be offered more generous terms. The market is assumed to result in a Walrasian equilibrium where an individual's pay is set by the marginal bidder for their services. This can be modeled as the banks bidding for the bankers in a simultaneous ascending auction (see Thanassoulis (2012, 2013a)).

Finally I assume that the total size of each bank's balance sheet is exogenous. The analysis which follows will however fully endogenise the asset allocation decision between different asset classes. The assumption that balance sheets are exogenous is equivalent to an assumption that the Board of a Bank would not decide to change their aggregate size and debt-to-equity ratio to allow an individual to be hired. Banks may well decide to alter their asset allocation decisions within the envelope of their chosen balance sheet size. We will explore this in detail below.<sup>6</sup>

## 4 The No Intervention Benchmark

The level of pay a banker enjoys in the market is set by the marginal bidder for their services. A bank, in deciding how much to bid for a banker, trades off the cost of employing the banker as against the increase in value the banker generates as compared to the next best hire. This section will determine the market rate of pay as a function of fundamentals.

**Lemma 1** *The bank with the  $n^{\text{th}}$  largest assets to be managed will hire the banker of the same rank  $n$ . Thus there will be positive assortative matching.*

The lemma follows by showing that a bank recruiting a manager to manage a large pot of assets would be willing to outbid a bank which is recruiting a manager to oversee a smaller pot of assets. This is not immediate as we are in a setting of non-transferable

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<sup>6</sup>It would in principle be possible for a bank to stay within its regulatory Tier 1 ratios, and yet grow assets, to increase pay, by leveraging up with safe assets. This more general weakness in the regulatory regime is already being addressed through the *Leverage Ratio* requirement in the Basel III framework.

utility. Greater pay for a banker increases the expected costs of default. This loss of value to the bank is not a gain to the banker. The bank recruiting for the smaller set of assets will bid for their first choice of banker up to the point where the extra value generated on their assets as compared to the next best banker is just outweighed by the extra costs incurred in remuneration to the banker. A bank recruiting for a larger set of assets would have the skill of the better banker applied to a larger pot of assets. In addition, increases in banker skill raise the expected return of the banker and so lower the probability of a default. As default costs are increasing in the size of the assets managed, the reduction in the expected costs from default is more substantial for the bank recruiting for a large pot of assets. Hence, for both reasons, the larger bank would value the better banker more, and so the bank recruiting for the larger pot of assets would win in bidding for a given banker. It follows, by induction, that there will be positive assortative matching with bankers being assigned in equilibrium to banks according to their rank.

In this benchmark case bankers are indifferent to the identity of their employing bank and select their employer based on their expected pay. The analysis offered here is essentially unchanged if banks differ in non-financial ways. For example banks may not all offer an equally pleasant work environment, or banks may not all offer equally compelling long term career prospects. Suppose that if a banker works at bank  $i$ , then bank specific differences raise the utility generated for the banker by a factor of  $\tau_i$ . Thus if the bonus rate were  $q$  then the banker's expected utility at bank  $i$  would be  $(1 + \tau_i) q \alpha S_i$ . In this case it is as if the banker were managing utility adjusted assets of  $\Sigma_i = (1 + \tau_i) S_i$ . The banks could be re-ordered according to  $\{\Sigma_i\}$ . We would then have positive assortative matching by utility adjusted asset size. The results in this paper would be unaffected by this change.

It follows that the marginal bidder for a banker of rank  $n$  is the bank of rank  $n + 1$ . We are therefore in a position to solve for the market rate of remuneration for all of the bankers:

**Proposition 2** *The banker of rank  $i$  will be employed by bank  $i$  and will receive an expected payment of  $q_i \cdot \alpha_i S_i$  where the bonus rate  $q_i$  is given by:*

$$q_i = \sum_{j=i+1}^N \frac{S_j (\alpha_{j-1} - \alpha_j)}{S_i \alpha_i}$$

Proposition 2 follows by an inductive argument. The amount bank  $i$  needs to pay to secure the banker of rank  $i$  depends upon how much bank  $i + 1$ , one down in the size league table, is willing to bid. This is the marginal bid which needs to be matched. The amount bank  $i + 1$  is willing to bid depends upon how much bank  $i + 1$  must pay for its banker, which in turn depends upon the bidding of bank  $i + 2$ . Hence the market rate can be established by induction.

Having established the market rates of pay through Proposition 2 we can now interrogate the impact of regulatory interventions on the entire market.

## 5 Effect Of Pay Cap In Proportion to (Risk Weighted) Assets

Let us now consider a policy intervention which caps the pay of the individual running this asset class to no more than a proportion  $\chi$  of assets. As I have assumed good corporate governance of bank risk, the optimal bank risk profile which maximises returns is unchanged. So the Extreme Value approximation (1) continues to hold. Analysis of the new market equilibrium yields that such a regulatory intervention would have the following effects.

**Proposition 3** *Consider a mandatory cap on the remuneration of the banker equal to at most a bonus rate  $\chi$  as a proportion of assets.*

- 1. The intervention lowers bank risk and raises bank values for all except the smallest banks.*
- 2. The lower the remuneration cap as a proportion of assets, the greater the positive impact: higher bank values and lower bank risk.*
- 3. The equilibrium allocation of bankers to banks is not affected, preserving allocative efficiency.*

In the labour market, banks compete with each other to hire scarce talent. The market rate of pay for a banker will be determined by the institution which is the marginal bidder for the banker's services. By bidding to hire a banker unsuccessfully, poaching banks drive up the market rate. The bidding is a pecuniary externality: the banker gains while the employing bank loses. However, there is also an increase to the employing bank's fragility to stress, due to increases in its cost base. The larger cost base due to pay increases the probability of a destruction of assets beyond the required preservation level, and so increases the expected cost of this event. This lowers the value of the employing bank further and is a competitive externality. The cap works by leaning against this competitive externality.

The cap impacts the marginal bidder for any given banker more than the equilibrium employer. The remuneration enjoyed by a banker is set by the amount the marginal bidding bank is prepared to offer. Lemma 1 demonstrated that a larger bank would be willing to bid most, yielding positive assortative matching. It follows that the bank which succeeded in hiring a banker in equilibrium will have been able to do so at a lower rate

as a proportion of the assets the banker will run. The preferred bank adjusts the rate it offers down for the fact that it offers the banker more resources and opportunities to make profits, and/or is a more desirable place to work.

A cap on pay in proportion to assets impacts the ability of the marginal bidder to drive up pay. This lowers the marginal bid and so allows the employing bank to hire the banker they would do absent the cap, but at a lower level of remuneration. Hence the market rate of pay is reduced. This reduction in pay increases the value of the bank directly as they secure their equilibrium employee more cheaply. In addition the reduction in the remuneration payable lowers the bank's fragility as less remuneration must be paid out when the banker's realized results are poor. This reduction in risk also raises the value of the bank.

As the employing bank now secures greater value from the banker they hire, in equilibrium, to run their business unit, the surplus the bank is willing to bid to hire marginally better bankers is reduced. The reduction in the competitive externality, and the corresponding reduction in bank risk therefore propagates upwards through the labour market.

It follows from the logic of the intervention that the more stringent the cap, the greater the impact on the marginal bidder, and so the greater is the gain for bank values, and the greater the reduction in bank risk.

It also follows from the above logic that the cap will inhibit some types of bank growth. In particular a bank with a small balance sheet will be unable to offer out-sized proportions of their assets as remuneration to hire the best bankers. Such growth would leave the bank very fragile to negative shocks to its assets. A small bank can however grow by retaining earnings, and so growing the balance sheet, alongside offering large remuneration to attract the best bankers. Thus growth which preserves the robustness of the growing bank is not inhibited.

As the cap applies to all banks in proportion to assets, it does not alter the matching of bankers to banks. No allocative inefficiency is introduced into the system. However, the benefit requires macro not micro prudential regulation. No single entity can secure the risk reduction and value increasing benefits alone, as these arise from altering the value of the marginal bidding banks for any given banker.

The remuneration cap will lower market rates of pay for bankers. In principle one might therefore be concerned that this will lead to a departure of workers from finance to other industries. However education-adjusted wages enjoyed by workers in finance have out-stripped other industries since 1990 by a premium of between 50% and 250% for the highest paid employees (Philippon and Reshef (2012)). Thus I conclude that wages in finance could fall by some margin before the general equilibrium labour re-allocation effect would become a problem.

## 5.1 Assets To Be Valued On A Risk Weighted Basis

The analysis has explored the case of good corporate governance under which the risk profile of the bank is set to maximise the bank's value. To ensure the robustness of the regulatory pay cap, I here consider the case of poor corporate governance such that the banker, and not the Board, selects the shape of the tail risk.

Let us consider a banker who is subject to the pay cap  $\chi$ , and who for the analysis of this section, has authority to invest in  $m$  securities with the returns on security  $j \in \{1, \dots, m\}$  denoted  $\{\tilde{r}_j\}$ . If the banker selects allocations  $\{x_j\}$  then next period's assets will be  $\tilde{S} = \sum_j x_j \tilde{r}_j$ . These returns are assumed jointly normally distributed with vector of expected returns  $\underline{\rho}$  and the variance-covariance matrix  $\mathbf{V}$ . As is often proposed in the literature which models banks as portfolio maximisers,<sup>7</sup> let us suppose that the banker is directed by the Board to maximise a mean-variance objective function

$$E(\tilde{S}) - (\varphi/2) \text{var}(\tilde{S}) \text{ for some } \varphi > 0. \quad (3)$$

Suppose the banker is required to deliver a value of the objective (3) of at least  $R$ .

I now assume that before these investments the banker needs to be paid an amount  $W$  for past performance. The banker wishes to maximise his pay  $W$ . This timing captures that a banker may seek to alter the allocation of assets at the moment of reporting to achieve regulatory benefits, such as enhanced pay. Suppose that any cap on remuneration applies to the weighted sum of security values  $\langle \underline{\beta}, \underline{x} \rangle$  with vector of weights  $\underline{\beta}$ . Thus the pay cap regulation implies

$$W \leq \chi \cdot \langle \underline{\beta}, \underline{x} \rangle$$

As the banker wishes to maximise his pay, his optimisation problem becomes

$$\max_{\{x_1, \dots, x_m\}} \chi \cdot \langle \underline{\beta}, \underline{x} \rangle \text{ subject to } R = \langle \underline{x}, \underline{\rho} \rangle - (\varphi/2) \langle \underline{x}, \mathbf{V} \underline{x} \rangle \quad (4)$$

**Proposition 4** *The ratio of allocations to individual securities is unaffected by a pay cap if the cap weights securities proportionally to their expected returns ( $\underline{\beta}$  parallel to the vector of expected returns  $\underline{\rho}$ ).*

The banker will be tempted to alter the investment profile he targets if doing so can allow more to be paid under the cap whilst preserving the expected returns net of risk. Proposition 4 shows that this is not possible if the weights used to measure the quantity of assets are proportional to the returns on those assets. Hence if assets are weighted proportionally to expected returns, the assumptions of this analysis remain robust, even if the banker selects his investment strategy so as to maximise pay.

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<sup>7</sup>This approach is described fully in the text book Freixas and Rochet (2008). A detailed formulation is offered in Rochet (1992).

This analysis parallels that underlying the derivation of optimal risk weights in capital adequacy regulation (Freixas and Rochet (2008)). As these authors argue, in the standard CAPM framework, the expected return on a security rewards the investor for the security's idiosyncratic risk. Hence Proposition 4 captures that the weight accorded to a security should grow in that security's idiosyncratic risk. The Basel risk weights are a convenient approximation to this rule.

## 6 Asset Allocation Responses To A Pay Cap

Banks invest in many assets classes. The banker managing an asset class can make greater profits from a larger pots of assets. Hence, even absent pay regulation, there exists an incentive to try to manage as many assets as possible. This implies that in the absence of any remuneration cap, banks are under pressure to raise asset allocations to areas where they seek to hire the best bankers/traders. This increased asset allocation has a cost however in terms of reduced diversification and excessive concentration.

This section will demonstrate that a remuneration cap weakens this excessive concentration effect and so creates an incentive for banks to re-assign assets so as to better diversify. The cap impacts the marginal bidder more than the equilibrium employer. It therefore hampers the extent to which a rival bank can drive up remuneration in any given asset class. This reduces the need to focus assets on a limited number of core areas, and so allows for greater gains from diversification.

We demonstrate these results through an extension of our model to allow for multiple asset classes.

### 6.1 Extension To A Model Of Multiple Assets

To demonstrate excessive specialization most clearly, I consider two symmetric banks each with total balance sheet size of  $T$ . There are two available asset classes, and within each there are two bankers who could run either bank's investments in this class. The most able manager can generate expected returns of  $\alpha$ , the next best hire makes expected returns of  $\beta < \alpha$ . The bankers' outside options continue to be normalised to zero.

Each bank must decide on the quantity of assets to devote to each of the asset classes. The banks each face costs of  $\frac{1}{2}cS^2$  of putting assets  $S$  into any given asset class. This assumption is equivalent to capturing decreasing returns to scale in each asset, and proxies for the costs of reduced diversification and increased specialisation. It therefore captures, for example, that the marginal loan quality declines as more and more of the balance sheet is used for loans. The returns on the two assets are assumed to be independent.

## 6.2 Optimal Asset Allocation

Because of the symmetry of the problem I consider a symmetric allocation. Proposition 5 below will demonstrate that the banks would not split their balance sheet equally between the two assets as such an allocation would maximise the pay competition for each banker. I therefore consider a symmetric allocation of assets in which each bank targets the best banker in a different asset class by putting  $S > T/2$  into the targeted asset class, and  $T - S$  into the remainder. The expected value of a bank which secures the  $\alpha$ -banker in its targeted class for a bonus of  $q_\alpha$ , and the  $\beta$ -banker in the other business line for a bonus of  $q_\beta$  is given by

$$\begin{aligned}
 V(S; T - S) = & \alpha(1 - q_\alpha)S - \frac{c}{2}S^2 - \lambda SG \left( \frac{\eta}{\alpha(1 - q_\alpha)} \right)^\gamma \\
 & + \beta(1 - q_\beta)(T - S) - \frac{c}{2}(T - S)^2 - \lambda(T - S)G \left( \frac{\eta}{\beta(1 - q_\beta)} \right)^\gamma
 \end{aligned} \tag{5}$$

Equation (5) captures the costs of a default event in any asset class. Such an event occurs if the assets under management in the class shrink to be less than  $\eta$  of their initial level. Under a pay cap we require  $q_\alpha, q_\beta < \chi$ .

**Proposition 5** *As the cap on pay becomes stricter ( $\chi$  declines), banks re-balance their asset allocation in the direction of making their exposure more diversified and less asymmetric.*

The asset allocation an institution makes is a trade off between giving the most assets to managers who can produce the highest return, set against the effects of diminishing returns to scale and the costs of over specialisation. To understand the result it is perhaps easiest to consider the reverse, and suppose that a remuneration cap becomes less binding. As the remuneration cap is removed, the bank finds itself subject to more aggressive bidding for the best banker from the bank which is under-weight in that asset class. To continue to employ the  $\alpha$ -banker the bank must match the more aggressive bidding. This lowers the profits available from the asset class, and it increases the risk of a default event as well. If the bank now increases its asset allocation to its targeted area then it can lower the proportion of returns used for remuneration. This increases the bank's value from this asset class because its risk of a default event is reduced. The cost to the bank of over-specializing has not been altered by the rival's bidding. Hence the dominant effect is that the bank responds to a relaxation of the cap by focusing more on its target asset class in defence against a more aggressive rival bank.

Running the process in reverse we see that as the remuneration cap becomes more strict, it is the institutions which are already most devoted to the class that are least handicapped. The cap is more binding on the marginal bidder than on the equilibrium employer. It therefore follows that the leading institutions in the class are in a position

to reduce their asset allocation as they can continue to employ the best staff with fewer assets, and stand to gain the diversification benefits by re-balancing towards other asset classes.

Hence an effect of the pay cap intervention is that it reduces the pressure to excessively focus on the core areas, as would be necessary with unconstrained bidding. The cap instead creates a force for diversification amongst the banks. It does not lead to the opposite of banks increasing their exposure to narrow asset classes.

## 7 Pay Regulation As A Macroprudential Tool

A cap on remuneration in proportion to assets can be applied to some business lines and not to others. For example, it could apply only to those within banks managing assets which reside in the wholesale banking book, and not apply to those managing assets in the retail banking book. Further banks are in competition with hedge funds to secure bankers/traders, and hedge funds who do not possess a banking license are regulated under different rules.

This section demonstrates how the remuneration regulation can be used to re-target banks' activities by applying the pay regulation asymmetrically. The section considers a cap which applies only to bank managers of assets in the wholesale banking book. I will demonstrate that this partial application of the regulation incentivizes the bank to refocus assets from their wholesale activities towards their retail banking activities.

### 7.1 A Model Of Asymmetrically Applied Pay Cap Regulation

Consider a bank with balance sheet  $T_b$ . There are two available asset classes, and the bank must decide how to allocate its assets between them. The asset classes are the wholesale banking book and the retail banking book. Denote the size of the wholesale banking book by  $S_b$ , and so the retail banking book is of size  $T_b - S_b$ .

The bank is regulated as to the remuneration it can pay to bankers who manage assets within its wholesale banking book. It is not regulated on payments to those managing the retail banking assets. Thus the pay cap regulation is asymmetrically applied.

There is a hedge fund with assets  $S_h$  which conducts activities on the wholesale market, but does not have a retail banking license. This model simply captures that banks have multiple business units, and in some of the business units they will face rivals who come under a different regulatory regime.

As in Section 6, for each institution I suppose that there is a cost to assigning capital,  $S$ , to any given use. Here I model this cost as equal to  $c^{\text{bnk}} \cdot S^2/2$  for retail banking, and  $c^{\text{w}} \cdot S^2/2$  in the case of wholesale banking. As noted, this assumption is equivalent to capturing decreasing returns to scale in each asset and proxies for the costs of under

diversification. I assume that the returns on the two assets are independent.

The banker who runs the retail banking book has an expected return of  $\beta$ . There are two possible bankers who can manage wholesale banking activities. The best executive has expected return  $\alpha$  while the next best hire has a lower expected return. For parsimony I suppose the next best manager of assets in the wholesale banking book generates a return equal to that from retail banking:  $\beta$  with  $\beta < \alpha$ . Once the bank has determined the assets in its wholesale banking book, there is competition to hire the bankers. All bankers' outside options are normalised to zero.

The case of interest is where, absent any cap, the bank would secure the better executive to run its wholesale business unit. Such a bank is one which is vulnerable to the introduction of a remuneration cap which applies to it, but not its rival. To this end I restrict attention to the case in which

$$S_h < T_b \cdot c^{\text{bnk}} / (c^{\text{bnk}} + c^w) \quad (6)$$

This parameter restriction ensures that, absent any cap, the bank would secure the  $\alpha$ -banker for its wholesale banking book.

## 7.2 Asset Allocation with Asymmetric Pay Cap Regulation

First I determine an upper bound on the size of the retail banking book in the absence of any regulation capping pay.

**Lemma 6** *In the absence of a remuneration cap the bank will secure the  $\alpha$ -banker to run the wholesale banking book. The bank will set its retail banking book strictly smaller than  $T_b \cdot c^w / (c^{\text{bnk}} + c^w)$ .*

The economics of Lemma 6 are readily explained. Suppose, for a contradiction, that the bank only succeeds in hiring the  $\beta$ -banker to run the wholesale banking book. Under this assumption the value of the bank can be determined by adapting (5) as:

$$\begin{aligned} V_b(S_b) &= \beta S_b - \frac{c^w}{2} S_b^2 - \lambda S_b G\left(\frac{\eta}{\beta}\right)^\gamma + \beta (T_b - S_b) - \frac{c^{\text{bnk}}}{2} (T_b - S_b)^2 - \lambda (T_b - S_b) G\left(\frac{\eta}{\beta}\right)^\gamma \\ &= \beta T_b - \frac{c^w}{2} S_b^2 - \frac{c^{\text{bnk}}}{2} (T_b - S_b)^2 - \lambda T_b G\left(\frac{\eta}{\beta}\right)^\gamma \end{aligned} \quad (7)$$

Equation (7) follows as both bankers will receive a normalised bonus rate of zero. This value function is concave in the allocation of assets to the wholesale banking book,  $S_b$ . This follows due to the assumption on the diminishing returns to scale. Hence there is an optimal allocation. The first order condition can be found and the optimal asset allocation determined under the assumption that the bank secures the  $\beta$ -banker. This

asset allocation is sufficiently large that the bank would have more assets in its wholesale banking book than the hedge fund, given assumption (6). This delivers the desired contradiction as the bank will outbid the hedge fund and so secure the  $\alpha$ -banker for its wholesale activities (Lemma 1).

It follows that, absent pay cap regulation, the bank will outbid the hedge fund and hire the  $\alpha$ -banker. The next step in the logic is to note that as the returns from wholesale banking are greater than a  $\beta$ -banker would generate, the bank would decide to move more of its assets to the wholesale banking book. This is not straightforward to show as the bank's risk is a function of both the size of the wholesale banking book and the pay to the  $\alpha$ -banker. As the bank increases the asset allocation for the wholesale banking book, the risk of assets shrinking so as to trigger a default event become smaller. However greater specialization comes with costs from the diminishing marginal returns. The proof demonstrates that the problem remains concave so that there is a clear optimal asset allocation for the bank, and it must have the retail banking book smaller, and the wholesale banking book larger, than the level which would be chosen if the  $\alpha$ -banker were unavailable. Hence we have an upper bound on the retail banking book in the absence of pay cap regulation, and this upper bound is given in Lemma 6.

**Proposition 7** *If the bank is subject to a sufficiently stringent cap on remuneration for the wholesale banking book then the bank will re-allocate more assets to retail banking and reduce the size of the wholesale banking book. The bank would choose*

$$\begin{aligned} \text{Banking book, } T_b - S_b &= T_b \cdot c^w / (c^{bnk} + c^w) \\ \text{Trading book, } S_b &= T_b \cdot c^{bnk} / (c^{bnk} + c^w) \end{aligned} \tag{8}$$

Proposition 7 considers a regulation which is sufficiently strict that the bank loses the best banker to the hedge fund. In this setting the bank can secure bankers, but they are not the very best ones. As a result the returns available from the wholesale banking book fall slightly, to the lower level  $\beta$ . The bank would now conduct its asset allocation decision exactly as in the proof of Lemma 6 under the assumption that it will secure the  $\beta$ -bankers for both books, and the optimal asset allocation can be found. At the asset allocation stage the bank will choose, at the margin, to divert funds away from the wholesale banking book and towards the retail banking book as the returns from wholesale banking have diminished as a result of the asymmetrically applied pay cap regulation. Proposition 7 captures that the partial coverage of remuneration regulation can be turned to the regulator's advantage. The ability to use pay cap regulation to incentivise greater retail banking activity can therefore be used as a macroprudential regulatory tool.

## 8 Conclusion

A variable cap on remuneration in proportion to assets lowers bank risk and raises bank values. Such a cap impacts on the marginal bidder for a banker more than on the employing bank. The implication is that the market rate of pay for bankers declines.

Such a cap could be implemented as proportional to the risk weighted assets of an institution. Doing so would make the cap robust to gaming even in the absence of good corporate governance. As a benchmark calculation let us suppose that remuneration in banks adhered to a commonly experienced 80:20 rule (Sanders 1988) so that the 20% best paid bankers secure 80% of the remuneration. If the pay of these best paid executives could be lowered by a quarter then this would equate to a 20% reduction in the overall remuneration bill, the effect of which was graphed in Figure 2. Such a reduction in 2009 would have been equivalent, in safety terms, to an increase in the Tier 1 ratio of over 150 basis points for the most affected institution (UBS).

A cap applied at the easier to implement bank level will likely be implemented by senior management as a top down rule. This is because the numbers of employees involved would make micro-managing deviations from a general rule impractical (see Table 2). Hence a cap at the bank level tackles the externality described at the individual banker level.

	<b>20% of employees in 2009</b>
UBS	13,047
Credit Suisse	9,520
Morgan Stanley	12,278
Deutsche Bank	15,411
Goldman Sachs	6,500
Citigroup	53,060

Table 2: Numbers of Employees Targeted By Intervention

Notes: The table documents the numbers of employees which would have to be captured by an intervention if it were targeted at the top 20% of earners in the named banks in 2009. The data is drawn from Bloomberg and the dataset is that used in Figures 1 and 2. The banks displayed are a selection of household names drawn from the top 20 banks documented in Figure 2.

Bankers would, *ceteris paribus*, rather manage more assets as profits and pay can be greater as a result. The pay cap policy intervention impacts poaching banks more than the equilibrium employers and so dampens the pressure banks are under to focus resources on given asset classes so as to secure better bankers. This allows banks to reduce the extent to which they are over-weight in asset classes which are their focus and re-assign some assets to increase their diversification.

The pay cap intervention forms a macroprudential tool as it can be structured to encourage banks to refocus towards the retail banking book. Though this intervention raises bank values, no bank can secure the benefits unilaterally as the competitive externality

cannot be tackled by just one firm.

The logic, described in this analysis, of the negative externality banks exert on each other through the labour market exists in all industries. Thus one might wonder if a similar pay cap regulation would be advisable in other industries beyond finance. I do not seek to take a stand on this question. However I note that the rationale for intervening beyond finance is weaker for at least two reasons. Firstly the financial sector is special as compared to other areas of business due to the substantial negative externalities it exposes society to when financial firms fail. These costs to society create the impetus to increase banks' resilience, which a pay cap can help to achieve. Secondly, the financial sector has a larger remuneration bill as a proportion of shareholder equity than other sectors. It therefore follows that the gain from a pay cap in terms of bank risk reduction is correspondingly greater than it would be in other sectors.

## A Omitted Proofs

**Proof of Lemma 1.** Consider banks  $i$  and  $i - 1$  and bankers  $j$  and  $j - 1$ . We wish to show that the bank with the larger pot of assets in this business unit will secure the better banker. Suppose the outside option of banker  $j$  is  $u$ . If bank  $i$  hires banker  $j$  at a bonus rate  $q_{i,j}$  then the bonus must satisfy  $\alpha_j q_{i,j} S_i = u$ . Hence bank  $i$ 's expected utility would be, from (2):

$$V_{ij} = \alpha_j (1 - q_{i,j}) S_i - \lambda S_i G \left( \frac{\eta}{\alpha_j (1 - q_{i,j})} \right)^\gamma \quad (9)$$

Hence bank  $i$  is willing to bid up to a bonus of  $q_{i,j-1}$  for banker  $j - 1$  where:

$$V_{ij} = \alpha_{j-1} (1 - q_{i,j-1}) S_i - \lambda S_i G \left( \frac{\eta}{\alpha_{j-1} (1 - q_{i,j-1})} \right)^\gamma \quad (10)$$

Setting (9) equal to (10), this has solution  $\alpha_{j-1} (1 - q_{i,j-1}) = \alpha_j (1 - q_{i,j})$ . The maximum bid that bank  $i$  will make for banker  $j - 1$  is therefore

$$q_{i,j-1} = 1 - (\alpha_j / \alpha_{j-1}) (1 - q_{i,j}) \quad (11)$$

The same working determines the maximum that bank  $i - 1$  is willing to bid for banker  $j - 1$  as  $q_{i-1,j-1} = 1 - (\alpha_j / \alpha_{j-1}) (1 - u / (\alpha_j S_{i-1}))$ . The lemma follows by demonstrating that bank  $i - 1$  is willing to bid to higher levels of utility for banker  $j - 1$ :

$$\begin{aligned} \alpha_{j-1} S_{i-1} q_{i-1,j-1} - \alpha_{j-1} S_i q_{i,j-1} &= [\alpha_{j-1} S_{i-1} - \alpha_j S_{i-1} + u] - [\alpha_{j-1} S_i - \alpha_j S_i + u] \\ &= (\alpha_{j-1} - \alpha_j) (S_{i-1} - S_i) > 0 \end{aligned}$$

The inequality follows as, by assumption,  $S_{i-1} > S_i$  and  $\alpha_{j-1} > \alpha_j$ . It follows that we have positive assortative matching. ■

**Proof of Proposition 2.** Bank  $i + 1$  will be willing to bid for the banker of rank  $i$  a bonus  $q_{i+1,i}$  given by (11) as  $q_{i+1,i} = 1 - (\alpha_{i+1}/\alpha_i)(1 - q_{i+1})$ . This is the marginal bid for banker  $i$ . Hence bank  $i$  will match the marginal bidder:

$$\begin{aligned}\alpha_i q_i S_i &= \alpha_i q_{i+1,i} S_{i+1} \\ &= (\alpha_i - \alpha_{i+1}) S_{i+1} + \alpha_{i+1} q_{i+1} S_{i+1}\end{aligned}\tag{12}$$

It follows, by induction that  $\alpha_i S_i q_i = \sum_{j=i+1}^N S_j (\alpha_{j-1} - \alpha_j) + S_N \alpha_N q_N$ . The ultimate outside option of leaving the industry for all the bankers is normalised to 0 which yields  $q_N = 0$ . The result follows. ■

**Proof of Proposition 3.** We first show that a bank will pay a lower bonus rate to the banker they hire than they would bid for a better banker. This follows from (11) as  $q_{i,i-1} - q_i = (1 - q_i)(1 - \alpha_i/\alpha_{i-1}) > 0$ . Hence a cap will be binding on a bank's bidding for better staff.

Suppose that the cap affects the bidding of bank  $j$  for the better banker  $j - 1$  for the subset of banks  $j \in M$ . If bank  $j \in M$  then the bid for banker  $j - 1$  is a bonus  $q_{j,j-1} = \chi$  as the cap is binding. Hence bank  $j - 1$  will secure banker  $j - 1$  at a bonus such that it matches the utility offered by bank  $j$ :  $\alpha_{j-1} S_j \chi = \alpha_{j-1} S_{j-1} q_{j-1}$ , yielding

$$q_{j-1} = \chi (S_j / S_{j-1}) < \chi\tag{13}$$

If instead a bank ranked  $j$  were competing against a bank unaffected by the cap, then the required bonus will also be unaffected by the cap, and is given by (12).

We can now determine the equilibrium bonus paid by any bank  $i$ . Let bank  $m$  be the bank with the greatest assets, conditional on being smaller than bank  $i$ 's, which is affected by the cap. Thus  $m \in M$  and  $m > i$ . From (12) we have

$$\begin{aligned}\alpha_i S_i q_i &= \sum_{j=i+1}^{m-1} S_j (\alpha_{j-1} - \alpha_j) + \alpha_{m-1} q_{m-1} S_{m-1} \\ &= \sum_{j=i+1}^{m-1} S_j (\alpha_{j-1} - \alpha_j) + \alpha_{m-1} \chi S_m \text{ by (13)}\end{aligned}\tag{14}$$

As the cap is binding on bank  $m$  by assumption, we have  $\chi < q_{m-1}^{\text{uncapped}}$ . Hence the bonus paid by bank  $i$  declines as a result of the cap. The risk of a bank incurring a default event is  $G(\eta/\alpha(1-q))^\gamma$ . As the bonus  $q$  declines this probability also declines. The value of the bank rises by inspection of (2). Hence we have the first result.

We now turn to the second result. We wish to show that the bonus payable by bank

$i$  declines as the cap,  $\chi$ , falls. Suppose first that a reduction in the cap  $\chi$  does not alter the identify of the the highest rank bank, with assets in this business line smaller than  $i$ , which is affected by the cap. If so the bonus bank  $i$  pays is given by (14). This moves monotonically with  $\chi$  delivering the result. Suppose now the cap is so stringent that it affects more banks. Thus suppose the identity of the highest rank bank, with assets smaller than  $i$ , which is affected by the cap becomes bank  $\tilde{m}$  where  $i < \tilde{m} < m$ . The bonus payable by bank  $i$  can therefore be written, from (12) as

$$\alpha_i S_i q_i = \sum_{j=i+1}^{\tilde{m}-1} S_j (\alpha_{j-1} - \alpha_j) + \alpha_{\tilde{m}-1} q_{\tilde{m}-1} S_{\tilde{m}-1}$$

The proof now follows by observing that the bonus bank  $\tilde{m} - 1$  pays declines as a result of the cap now affecting bank  $\tilde{m}$ . This follows as the bid of bank  $\tilde{m}$  for banker  $\tilde{m} - 1$  is reduced by the cap. Hence the bonus paid by  $i$  again moves monotonically in  $\chi$ . This delivers the result.

Finally, as the cap applies to all banks, the positive assortative matching result of Lemma 1 is unaffected. There is no re-ranking of the banks and so the allocation of banks to bankers is unaffected. ■

**Proof of Proposition 4.** Given the maximisation problem (4) formulate the Lagrangian  $\mathcal{L} = \chi \cdot \langle \underline{\beta}, \underline{x} \rangle + \lambda (\langle \underline{x}, \underline{\rho} \rangle - \frac{\varphi}{2} \langle \underline{x}, \mathbf{V} \underline{x} \rangle - R)$  with Lagrange multiplier  $\lambda$ . The first order condition then yields an expression for the optimal allocation  $\underline{x}^*$  :

$$\chi \underline{\beta} + \lambda \underline{\rho} - \lambda \varphi \mathbf{V} \underline{x}^* = 0$$

Hence we have

$$\underline{x}^* = \frac{1}{\varphi} \mathbf{V}^{-1} \left( \underline{\rho} + \frac{\chi}{\lambda} \underline{\beta} \right)$$

The direction of the vector  $\underline{x}^*$  varies in the cap  $\chi$  unless  $\underline{\beta}$  is proportional to  $\underline{\rho}$  yielding the result. ■

**Proof of Proposition 5.** First we note that both banks choosing exactly the same allocation in all asset classes so that they set  $S = T/2$  is not an equilibrium. As the banks are equal in size, competition for the  $\alpha$ -banker would push their expected pay up to the point where both banks were indifferent between the  $\alpha$  and  $\beta$  banker. Thus it would be as if both hired  $\beta$ -bankers. This is dominated by one bank moving  $\varepsilon$  of their balance sheet to one of the business lines. They would then secure some benefit from an  $\alpha$ -banker which increases their profit.

In the absence of a cap, the bank with the smaller asset allocation in any given class will be willing to bid for the  $\alpha$ -banker up to a bonus of  $1 - \beta/\alpha$ . This follows from (11). The bank with the smaller asset allocation will have  $T - S$  in the asset class, so this bonus would deliver an expected utility to the  $\alpha$ -banker of  $(\alpha - \beta)(T - S)$ . If the cap

on remuneration is binding ( $\chi < 1 - \beta/\alpha$ ) then the bonus is limited and so the bid is capped at expected remuneration of  $\alpha\chi(T - S)$ . Hence the bank with the larger pot of assets secures the  $\alpha$ -banker by offering a bonus rate of  $q = \chi(T - S)/S$ . The bank with a smaller pot of assets in any given class will recruit the  $\beta$ -banker for a bonus of 0 as the outside option is normalised to 0.

To identify the optimal asset allocation  $S$  we must ensure there is no incentive to unilaterally deviate to a different allocation  $\tilde{S}$ . Denote the value from such a deviation by  $V(\tilde{S}; T - S)$  where the second argument captures the rival's weight in the asset class. From (5):

$$\begin{aligned}
V(\tilde{S}; T - S) &= \alpha \left[ 1 - \chi \frac{T - S}{\tilde{S}} \right] \tilde{S} - \frac{c}{2} \tilde{S}^2 - \underbrace{\lambda \tilde{S} G \left( \frac{\eta}{\alpha \left[ 1 - \chi \frac{T - S}{\tilde{S}} \right]} \right)}_{(i)}^\gamma \\
&\quad + \beta (T - \tilde{S}) - \frac{c}{2} (T - \tilde{S})^2 - \lambda (T - \tilde{S}) G \left( \frac{\eta}{\beta} \right)^\gamma
\end{aligned} \tag{15}$$

We first establish that the value function, (15) is concave in the asset allocation  $\tilde{S}$ . This follows if the term (i) is convex in  $\tilde{S}$ . To test this define  $h(\tilde{S})$  by

$$h(\tilde{S}) := \frac{\eta}{\alpha - \alpha\chi \frac{T - S}{\tilde{S}}}$$

This is a hyperbola. Consider the arm in which  $\tilde{S} > \chi(T - S)$  which is the relevant one as  $\tilde{S} > T - S$ . This curve is downwards sloping and convex. Now consider  $f(\tilde{S}) = \tilde{S} [h(\tilde{S})]^\gamma$ . As  $\gamma \geq 1$  a sufficient condition for this curve to be convex is if

$$\begin{aligned}
0 &< 2h'(\tilde{S}) + \tilde{S}h''(\tilde{S}) = \frac{-2\eta\chi(T - S)}{\alpha(\tilde{S} - \chi(T - S))^2} + \tilde{S} \frac{2\eta\chi(T - S)}{\alpha(\tilde{S} - \chi(T - S))^3} \\
&\Leftrightarrow 0 < 2\eta[\chi(T - S)]^2 \text{ which is true.}
\end{aligned}$$

Thus the objective function of the bank is concave and so has a unique maximand given by the first order condition. Hence an equilibrium is achieved when  $\partial V/\partial \tilde{S}$  evaluated at  $\tilde{S} = S$  equals zero. This gives:

$$\begin{aligned}
\frac{\partial V}{\partial \tilde{S}}(S, T - S) &= 0 = \alpha - cS - \beta + c(T - S) + \lambda G \left( \frac{\eta}{\beta} \right)^\gamma \\
&\quad - \lambda G \left( \frac{\eta}{\alpha \left[ 1 - \chi \frac{T - S}{S} \right]} \right)^\gamma \left\{ 1 - \gamma \frac{\chi \frac{T - S}{S}}{\left[ 1 - \chi \frac{T - S}{S} \right]} \right\}
\end{aligned} \tag{16}$$

This defines the optimal level of assets in the two business units,  $S$  and  $T - S$ , implicitly

as a function of  $\chi$ .

We wish to determine the change in the asset allocation to the over-weight asset in equilibrium. We have  $\partial V(S(\chi), T - S(\chi)) / \partial \tilde{S} \equiv 0$  which defines  $S$  as a function of  $\chi$ . We therefore have

$$0 = \frac{\partial^2 V}{\partial \tilde{S} \partial \chi} + \frac{dS}{d\chi} \left\{ \frac{\partial^2 V(S, T - S)}{\partial \tilde{S} \partial \tilde{S}} - \frac{\partial^2 V(S, T - S)}{\partial \tilde{S} \partial (T - S)} \right\}$$

By inspection of (16),  $\partial^2 V / \partial \tilde{S} \partial \chi > 0$  by algebraic manipulation.<sup>8</sup> Due to the concavity of the value function with respect to  $\tilde{S}$ , we have that  $\partial^2 V / \partial \tilde{S} \partial \tilde{S} < 0$ . By the same logic as for  $\chi$  we have  $\partial^2 V / \partial \tilde{S} \partial (T - S) > 0$ . Combining we have determined that  $dS/d\chi > 0$ , so the result is proved. ■

**Proof of Lemma 6.** First we demonstrate that the bank would secure the better wholesale banker. Suppose, for a contradiction, that the bank selects  $S_b < S_h$  assets for its wholesale banking book. In this case the bank secures bankers for both books with expected returns of  $\beta$ . The value of the bank is given by (7). This is concave in  $S_b$ . The first order condition for this expression would set  $S_b = T_b \cdot c^{\text{bnk}} / (c^{\text{bnk}} + c^w)$ . This is however a contradiction to  $S_b < S_h$  by the assumption in (6). Hence the bank would always prefer an asset allocation to wholesale banking which was sufficient to secure the better banker.

For the bank to hire the better executive to run its wholesale banking book, we must have (by the positive assortative matching of Lemma 1) that the bank has more assets for the executive to run than the hedge fund. That is  $S_b > S_h$ . With no remuneration caps the banker would be paid a bonus rate of  $(1 - \beta/\alpha)(S_h/S_b)$ , which follows from (12). The bank's expected value from selecting  $S_b > S_h$  is then, adapting (5):

$$\begin{aligned} V_b(S_b) = & \alpha \left( 1 - [1 - \beta/\alpha] \frac{S_h}{S_b} \right) S_b - \frac{c^w}{2} S_b^2 - \lambda S_b G \underbrace{\left( \frac{\eta}{\alpha \left( 1 - [1 - \beta/\alpha] \frac{S_h}{S_b} \right)} \right)^\gamma}_{(i)} \\ & + \beta (T_b - S_b) - \frac{c^{\text{bnk}}}{2} (T_b - S_b)^2 - \lambda (T_b - S_b) G \left( \frac{\eta}{\beta} \right)^\gamma \end{aligned} \quad (17)$$

This is concave in  $S_b$  if (i) is convex. Expression (i) is convex in  $S_b$  by the method of proof of Proposition 5. Hence the objective function of the bank is concave and so has a unique

<sup>8</sup>The result follows if, for example,  $\left( \frac{\eta}{\alpha(1-\chi)} \right)^\gamma \left\{ 1 - \gamma \frac{\chi}{1-\chi} \right\}$  is decreasing in  $\chi$ . Differentiating with respect to  $\chi$  yields

$$\gamma \left( \frac{\eta}{\alpha(1-\chi)} \right)^\gamma \left[ \frac{1}{1-\chi} - \frac{1}{(1-\chi)^2} \right]$$

And multiplying through by  $(1-\chi)^2$  confirms that the derivative is negative.

maximand given by the first order condition. The first order condition with respect to  $S_b$  delivers

$$\begin{aligned} \frac{dV_b}{dS_b} = & \alpha - c^w S_b - \lambda G \left( \frac{\eta}{\alpha \left( 1 - [1 - \beta/\alpha] \frac{S_h}{S_b} \right)} \right)^\gamma \left( 1 - \gamma \frac{[1 - \beta/\alpha] S_h}{(S_b - [1 - \beta/\alpha] S_h)} \right) \\ & - \beta + c^{\text{bnk}} (T_b - S_b) + \lambda G \left( \frac{\eta}{\beta} \right)^\gamma \end{aligned}$$

To demonstrate that the optimal size of the wholesale banking book, conditional on being larger than the hedge fund, is greater than  $T_b \cdot c^{\text{bnk}} / (c^{\text{bnk}} + c^w)$  we have

$$V'_b \left( T_b \frac{c^{\text{bnk}}}{c^{\text{bnk}} + c^w} \right) = \alpha - \beta + \lambda G \left\{ \left( \frac{\eta}{\beta} \right)^\gamma - \left( \frac{\eta}{\alpha - [1 - \beta/\alpha] \frac{S_h}{S_b}} \right)^\gamma \right\} \Bigg|_{S_b = T_b \frac{c^{\text{bnk}}}{c^{\text{bnk}} + c^w}} + \lambda G \left( \frac{\eta}{\alpha - [1 - \beta/\alpha] \frac{S_h}{S_b}} \right)^\gamma \gamma \frac{[1 - \beta/\alpha] S_h}{(S_b - [1 - \beta/\alpha] S_h)}$$

This is positive by the assumption in (6). ■

**Proof of Proposition 7.** The hedge fund is willing to bid up to a bonus given by (11) as  $q_{h,1} = 1 - \beta/\alpha$ . Hence the hedge fund would be willing to offer the  $\alpha$ -banker an expected utility of up to  $\alpha q_{h,1} S_h = (\alpha - \beta) S_h$ . To hire the better executive the bank needs to match this remuneration. This occurs if  $\alpha q_b S_b \geq (\alpha - \beta) S_h$ . If the remuneration cap is binding on the bank then the better executive can only be hired if  $S_b \geq (1 - \beta/\alpha) (S_h/\chi)$ . Suppose the cap is sufficiently stringent that the wholesale banking book is optimally below this level.<sup>9</sup> In this case the bank cannot outbid the hedge fund. The bank will therefore secure the  $\beta$ -banker to run its banking book. In this case the bank's value is given by (7). Optimising this value over the asset allocation, the optimal wholesale banking book size is then given as  $S_b = T_b \cdot c^{\text{bnk}} / (c^{\text{bnk}} + c^w)$ , yielding (8). The wholesale banking book has shrunk and the banking book grown by comparison with the bound in Lemma 6. ■

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<sup>9</sup>This is true in the limit as  $\chi$  tends to 0. Therefore there is a range of bonus caps for which it is true by continuity.

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