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# 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 pay 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 had the effect of improving financial stability.

Basel III has determined, through the *Capital Conservation Buffer*, that banks' incentives to pay out rather than retain earnings needs to be managed. Leading scholars have argued that the amount banks paid out in share buybacks and dividends was so large as to materially inhibit real economy lending through the last financial crisis (Acharya, Gujral and Shin (2009)). Thanassoulis (2012) documents that the banks in this study typically paid out double the amount in remuneration than they did on share buybacks and dividends, and the shareholder payments only grew to be comparable to remuneration during the last crisis. Thus if payments to shareholders became high enough to be

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

a concern to the well functioning of the banking system, the aggregate wage bill is at this elevated level of note permanently. To determine more quantitatively the scale of the relevance of remuneration to financial stability let us suppose the total 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. Table 1 considers the remuneration paid in 2008 and 2009, during the last financial crisis, by the top 100 global banks ranked by asset value in 2011.<sup>2</sup> If the total remuneration bill was cut by only 5%, then this would be equivalent to an average increase in Tier 1 equity levels of 9 basis points. If the remuneration bill could be cut by 20% then the equivalent increase in the Tier 1 ratio would be 37 basis points.

Table 1: Remuneration Reduction Expressed As A Gain in Tier 1 Ratio

Notes: The table expresses the money saved by a hypothetical reduction in the aggregate pay bill expressed as the equivalent increase in Tier 1 equity. This is calculated by determining the dollar saving from a given percentage reduction in the total pay bill and dividing by the total risk wighted assets. Data from Bloomberg, see footnote 2.

Reduction in aggregate bank remuneration	5%	10%	15%	20%	25%	30%
Average equivalent increase in Tier 1 levels (basis points)	9	19	28	37	47	56

Table 1 demonstrates that lowering pay has only a modest effect on an average bank's resilience. The average however hides wide variation amongst individual banks. Thus an intervention on pay would be targeted. It would make the banks with the most unsafe pay levels, safer. Figure 1 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 1 demonstrates that an 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% (150 basis points), 1.3% for Credit Suisse, and over 0.8% for Deutsche Bank. These are significant figures in the context of the Tier 1 requirements of Basel III. 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.

<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).

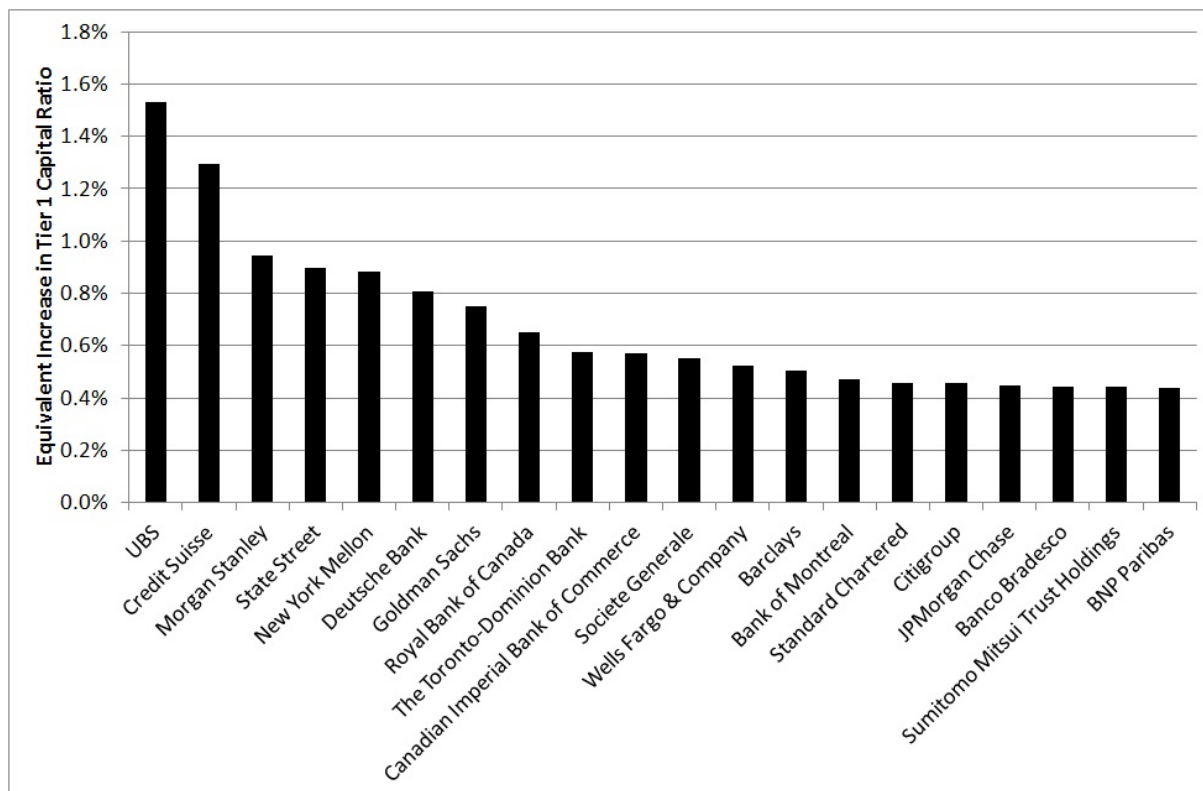


Figure 1: Equivalent Gain In Tier 1 Ratio For The 20 Most Affected Banks

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 Table 1. These 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 market level of remuneration 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 latter 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 therefore 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. Those banks which were the runners-up to employ the best wholesale bankers become less aggressive bidders due to the pay cap. This lowers the remuneration level of wholesale bankers and allows the banks which specialised in wholesale banking to devote more of their assets to retail banking so as to benefit from diversification. Secondly some universal banks will be competing against other non-bank financial institutions which may be regulated under different rules. The presence of these institutions outside the regulatory net strengthens the macroprudential tool. Regulated banks would be at a disadvantage in hiring the best traders or wholesale bankers. Hence 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. Thus banks would be even more 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 Thanas-

soulis (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 the shape of the remuneration contracts offered, and so individual bankers' incentives to take risks. For example Thanassoulis (2013a) argues that competition for bankers drives pay up and can lead to an industry 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. Raith (2003) considers firms competing, rather than banks, and endogenises the level of bonus to incentivise effort. He shows that firms with larger market shares increase the bonus incentives they offer. Benabou and Tirole (2013) consider competing firms using contracts to screen workers by ability: the high ability workers are given incentives to take excessive risks. Acharya, Pagano and Volpin (2013) study the incentives a banker has to move institution to avoid their employer learning whether their performance was due to skill or luck. The insights in these works are complementary to the analysis here as none of these analyses explore the impact of pay caps on the labour market equilibrium.

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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 a default event can arise if a banker shrinks the assets they are given to manage sufficiently.

There are  $N$  bankers who can run this asset. They expect to grow the assets they manage by a factor of  $\alpha_1 > \alpha_2 > \dots > \alpha_N$ . Thus if banker  $i$  is employed by bank  $j$  then the expected assets of bank  $j$  at the end of the period will be  $\alpha_i \cdot S_j$ . An expected asset growth factor of  $\alpha_i = 1$  would imply that that banker  $i$  is only expected to maintain the dollar value of the assets he or she manages. I assume that each banker's distribution of realised asset growth factors are translations of each other so that bankers differ only in their skill. Hence the density of asset growth factors delivered by banker  $n$  can be written as  $f_n(x) = (1/\alpha_n) f(x/\alpha_n)$ , where  $f(\cdot)$  is a density with unit expectation implying that the expectation of  $f_n(\cdot)$  is  $\alpha_n$ . Integrating we have the cumulative distribution of the asset growth factor 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 asset growth outcomes generated by the banker will only be important if the resultant asset levels are low enough to trigger a default event, leading to the extra costs described above. 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 distribution in its left tail. I assume that the asset growth factor generated by the bankers is bounded below by zero so that banks enjoy limited liability on their investments. In this case the left hand tail of the distribution of asset growth



factors can be approximated by

$$F_n(v) \sim G \cdot (v/\alpha_n)^\gamma \quad (1)$$

Extreme Value Theory would require  $G$  to be a slowly varying function.<sup>4</sup> I restrict to  $G > 0$  being a constant. 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 they control. 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 2 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>5</sup> Table 2 shows that if banks are given the flexibility they would elect to pay staff overwhelmingly in the form of variable bonuses.

Table 2: 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.

	2008		2009	
Total compensation bands	% 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 bonus rates delivered by this model would be in excess of any bonus rates required by an explicit model of incentives and moral hazard. 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 dollar remuneration of  $q \cdot \alpha S$ . The expected asset level of the bank at the end of the period, gross of the cost of any default event, is  $\alpha(1 - q)S$ . Suppose the realisation of the asset

<sup>4</sup>See Resnick (1987). A function  $G(v)$  is defined as being slowly varying at zero if  $\lim_{v \rightarrow 0} G(tv)/G(v) = 1$  for any  $t > 0$ .

<sup>5</sup>See Thanassoulis (2013b) for a discussion of the European 1-to-1 bonus regulation.

growth factor 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 at the end of the period 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 level of 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 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>

### 3.1 Discussion of Key Assumptions

This model of banks competing for bankers is designed to be tractable and to allow the key competitive forces which determine pay levels to be clearly explained. Underlying the model are two key assumptions. The first is that the risk profile of the bank is decided by the Board and not the banker, thus bonus rates do not alter the tail risk of the institution. The second is that the bank pays out remuneration to the banker, even if the banker delivers a loss on the assets managed. This section will discuss each of these assumptions in turn.

The Board of any bank will determine a desired risk profile for their institution depending upon the return on equity they believe their investors demand. The Board will seek to impose this risk profile on the bank by using the corporate governance levers at their disposal. These levers include the ability to manage the Value at Risk (VaR) of individual bankers, often on a daily basis, and broader asset allocation and hedging de-

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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 can be managed here by appropriate risk weighting (Section 5.1). Further this more general weakness in the regulatory regime is already being addressed through the *Leverage Ratio* requirement in the Basel III framework.

cisions. This study assumes that these levers are sufficient to restrict the bankers to the desired risk profile. Banker skill is therefore solely expressed as the expected return given this shape of (tail) risk. If this risk control assumption is violated then payment levels and bonus rates are related to the risk profile of the institution. That is the tail risk  $F_n$  would be a function either of the bonus rate  $q$ , or of the expected dollar remuneration.<sup>7</sup> The dependence of tail risk on the remuneration would complicate the analysis offered here. When bidding to hire a banker a large bank would be able to offer a low bonus rate which, in the case of poor risk control, would lower the riskiness of the bank. However larger banks will secure the services of more talented bankers who have to be paid more, and this might raise the riskiness of the institutions. The effect of poor risk control would therefore be ambiguous for the solution of the model, even absent any bonus caps. However the externalities described in this paper would remain: the marginal bidder for a banker would increase the fragility of the employing bank by raising her costs. This effect would be exacerbated for larger banks if tail risk grows in remuneration levels, or may be mitigated if tail risk responds to bonus rates.

This study considers the impact of a cap on pay in proportion to the assets a banker manages, and this cap is expressed as a cap on the bonus rate payable. The intervention of a bonus rate cap studied here lowers bonus rates *and* overall pay levels. If banks cannot fully control their tail risk then such an intervention would mitigate the adverse effects of the poor risk control (see footnote 7). The lower bonus rates would reduce the incentive to take excessive risk, to conduct fraud, to be myopic and to churn across employers. Hence the analysis here understates the benefits of a bonus cap along all these avenues.

The second key assumption is that even if a bank should see its assets shrink enough to trigger the costs of a default event through, for example, forced asset sales, then the bank incurs a remuneration payment nonetheless. It might seem more realistic that a banker who returns a lower level of assets than she began with would not only not receive a bonus, but most likely lose her job. If so then one might conclude that remuneration payments would not add to a bank's fragility, as when assets shrunk remuneration payments would automatically be suspended until the threat of a default event had passed. This reasoning is incomplete for a number of reasons. Firstly, it may be that a banker who shrinks assets loses her job, however consider the following thought experiment. A banker running assets of 100 makes a 20% loss in the first two quarters and so is dismissed. The bank will need an alternative banker to run these assets, suppose this replacement banker delivers 10% growth in the remaining two quarters. This second banker would expect

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<sup>7</sup>This may be because high bonuses are used to separate high ability from low ability bankers with the former incentivised to take excessive risks (Benabou and Tirole (2012), Bannier, Feess, and Packham (2012)); or it may be because bankers game bonus schemes through legitimate and illegitimate schemes (Foster and Young (2010)); or it may be because bonuses provide an incentive for bankers to take early risks and then jump to a new employer before their ability is revealed (Acharya, Pagano and Volpin (2013)); or it may be because bonuses encourage bankers to push risks into the future so inducing myopia (Thanassoulis (2013a)).

to be paid, and yet over the year assets have shrunk from 100 down to  $100 \times 80\% \times 110\% = 88$ , a reduction of 12%. Thus remuneration is payable even if one believes that in banking no failure is tolerated. Secondly, in reality a reduction in asset levels may well be due to bad luck and wider economic forces, rather than poor banker skill. Indeed bankers would invariably argue this to be the case. Thanassoulis (2012, Figure 2) demonstrates that bankers were paid very large sums on average in the recent past, even after delivering negative returns on equity. Finally, unless the bank formally enters bankruptcy protection, remuneration contracts have to be honoured. A bank may also wish to honour implicit rather than explicit commitments as any failure to do so would alter all employees' expectations of their pay and lead either to demands to make implicit commitments explicit in contract terms, or lead to the departure of staff. Thus I conclude that the assumption that remuneration is payable even if a bank incurs the costs of a default event is appropriate.

## 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, net of any changes to the expected costs of a default event, 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 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 asset growth and so lower the probability of a default event. 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:*

$$q_i = \sum_{j=i+1}^N \frac{S_j (\alpha_{j-1} - \alpha_j)}{S_i \alpha_i} \quad (3)$$

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 A 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 severe 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.

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 competing remuneration offers 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.

Salary caps have been a feature of sports remuneration in the US. However these are different to the proposal outlined here. Sports salary caps are the same across all teams<sup>8</sup>, while the intervention studied here links pay caps to the size of the assets managed. This link to bank size is critical in ensuring the cap targets the negative externality created by the marginal bidder, and ensuring that the cap does not create a distortion in the allocation of talented bankers to banks.

Finally, it has been noted that the financial sector has undergone a period of sustained consolidation and merger activity dating back to before the 1990s.<sup>9</sup> This consolidation in the banking sector has been accompanied by a sharp increase in the size of the balance sheets of the largest banks (Morrison and Wilhelm (2008)). The model of the banking labour market we study here captures one reason bank mergers create value: the desire to grow the balance sheet to allow more talented bankers to be hired. The pay cap studied here does not necessarily strengthen this merger incentive. Whether it does so depends

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<sup>8</sup>See for example “2013 NFL salary cap breakdown by team,” *USA Today*, available at <http://www.usatoday.com/picture-gallery/sports/nfl/2013/09/13/2013-nfl-salary-cap-breakdown-by-team/2808245/>

<sup>9</sup>For example, Bank for International Settlements (2001 Table 1.1, p34) document that in 1990 there were 8 M&A deals involving banks in one of the 13 countries studied with a value in excess of \$1bn, and the average value of these deals was \$26.5bn. Over the decade this activity grew, and by 1998 there were 58 M&A deals in that year with a value in excess of \$1bn, and the average value of these deals had risen to \$431bn.

on the particular parameter values.<sup>10</sup>

## 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 now consider how a banker would seek to distort the value maximising risk profile of a bank if their objective was to maximise the money available for remuneration.

In this section I will use the Pyle-Hart-Jaffee approach to modelling the bank as a portfolio manager.<sup>11</sup> Formally suppose a bank wishes to maximise the value generated from  $m$  securities with the returns on security  $j \in \{1, \dots, m\}$  denoted  $\{\tilde{r}_j\}$ . If the bank selects allocations in dollars of  $\{x_j\}$  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  $\mathbf{V}$ . Hence

$$\begin{aligned}\mu &= E(\tilde{S}) = \sum_j x_j \rho_j \\ \sigma^2 &= \text{var}(\tilde{S}) = \langle \underline{x}, \mathbf{V} \underline{x} \rangle\end{aligned}$$

The Pyle-Hart-Jaffee approach assumes that the value function of the bank can be decomposed into a function of only the first two moments of the returns distribution:  $U(\mu, \sigma^2)$ . If the bank selects the riskiness of her portfolio, as assumed here, then the first order condition of the bank's optimisation problem would yield

$$\frac{\partial U}{\partial \mu} \frac{\partial \mu}{\partial x_i} + \frac{\partial U}{\partial \sigma^2} \frac{\partial \sigma^2}{\partial x_i} = 0$$

This can be written in matrix notation as  $-\lambda \underline{\rho} + \mathbf{V} \underline{x} = 0$  where  $\lambda = -(\partial U / \partial \mu) / 2(\partial U / \partial \sigma^2)$ . Hence the bank would select an allocation of assets for the banker to manage proportional to  $\mathbf{V}^{-1} \underline{\rho}$ .

I now assume that the banker managing these assets must be paid an amount  $W$  for past performance. 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

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

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<sup>10</sup>For an example of merger becoming less profitable with a bonus cap consider a duopoly of banks. Merger (to monopoly) will have the merged bank hiring the best banker and offering a bonus at the normalised rate of 0. This is unaffected by a bonus cap. Pre-merger a bonus cap can increase the value of the larger bank, hence lowering the incentive to merge.

<sup>11</sup>The Pyle-Hart-Jaffee approach was proposed in Pyle (1971) and Hart and Jaffee (1974). The version used here is derived from Freixas and Rochet (2008, section 8.4).



To analyse the scope for banker induced distortion, suppose that the banker can distort the risk profile of the bank, as long as he delivers a value of the objective  $U(\mu, \sigma^2)$  of at least  $R$ . As the banker wishes to maximise his pay, his optimisation problem becomes

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

**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 expected 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.

This analysis parallels that underlying the derivation of optimal risk weights in capital adequacy regulation (Rochet (1992)). In the standard CAPM framework, the expected return on a security rewards the investor for the security's undiversifiable risk. Hence Proposition 4 captures that the weight accorded to a security in the pay cap should grow in that security's systematic risk. Rochet (1992) argues that risk weights in capital adequacy requirements should be proportional to the expected returns to ensure that the bank will invest in an efficient portfolio of assets given the limited liability constraint. To the extent that the Basel risk weights capture systematic risk, they are a convenient approximation to this rule.<sup>12</sup>

## 6 Asset Allocation Responses To A Pay Cap

Banks invest in many asset classes. The banker managing an asset class can make greater profits from a larger pot 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 does not strengthen this effect, but rather weakens this excessive concentration effect amongst evenly matched banks,

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<sup>12</sup>However the risk weights offered in banking regulation are not a pure estimation of systematic risk (Iannotta and Pennacchi (2012)). The Basel rules allow national regulators some flexibility in selecting risk weights, and where analysis is conducted the risk weights are calculated to reflect the overall expected loss conditional on a default. The Basel risk weights will therefore be a good proxy for systematic risk only to the extent that systematic risk is correlated with overall risk.

and so creates an incentive for banks to re-assign assets so as to better diversify. The cap impacts the marginal bidder in any asset-class 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.

I demonstrate these results through an extension of the model to allow for multiple asset classes.

## 6.1 Extension To A Model Of Multiple Assets

The diversification effect of bonus caps is at its strongest when the competing banks are close in size. Later in this section I will discuss the case of banks of very different size. To demonstrate this positive effect of bonus caps most simply, consider initially two banks each with equal total balance sheet size of  $T$ . Consider a model of two available asset classes, and within each asset class there are two bankers who could run either bank's allocation to the asset class. The most able manager in each class has an expected growth factor of  $\alpha$ , the next best hire has an expected growth factor of  $\beta < \alpha$ . The bankers' outside options continue to be normalised to zero. The asset level realisations in each asset class are assumed to be independent.

Each bank must decide how to split its balance sheet between the available asset classes, assigning  $S$  dollars to one asset class and  $T - S$  dollars to the other. To proxy for the benefits of diversification parsimoniously I suppose that the banks gain value  $c \cdot S(T - S)$  on top of the assets realised within each asset class, with the parameter  $c$  a constant greater than zero. The specific functional form of diversification benefit is for convenience, the economic assumption is that diversification confers some benefits to the bank, and these benefits fall away if the bank withdraws from a given asset class. This assumption captures, for example, that the volatility of returns in the normal course of business are reduced which provides value for employee stock holders and any other investors who are not fully diversified; alternatively the assumption captures the effect of diminishing marginal returns to any given asset class as more and more of the balance sheet is used for that asset class. I model the banks as first simultaneously deciding their asset class allocations, and then competing to hire the bankers as in the benchmark model given above.

## 6.2 Optimal Asset Allocation

Because of the symmetry of this initial problem I consider a symmetric allocation. I therefore consider an 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

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

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 more severe ( $\chi$  declines), banks re-balance their asset allocation in the direction of making their exposure more diversified and less asymmetric.*

The asset allocation a bank makes is a trade off between giving the most assets to managers who can produce the highest return, set against 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, each 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 in its targeted asset class, each 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 the realised assets used for remuneration. This increases the bank's value from this asset class because its risk of a default event is reduced. Hence each bank responds to a relaxation of the pay cap by focusing more on its target asset class in defence against the now more aggressive rival bank.

Running the process in reverse we see that as the remuneration cap becomes more severe, 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 in each asset class 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 for similarly matched banks to excessively focus on their core areas, as would be necessary with unconstrained bidding. The cap instead creates a force for diversification amongst the banks. This beneficial effect becomes weaker as the banks become more asymmetric in size. To see this suppose that the two banks studied in this section become sufficiently asymmetric in size that the large bank can secure the  $\alpha$ -banker in both asset classes. In

this case one can show that the optimal asset allocation will be unaffected by the presence, or otherwise, of a bonus cap.<sup>13</sup> The analysis in this case exactly parallels the single asset class analysis in Section 5. A bonus cap impacts the ability of the marginal bidder to drive up remuneration in both asset classes, allowing the larger bank to lower its risk and increase its value with no asset allocation distortion.

## 7 Pay Regulation For Macroprudential Objectives

A cap on remuneration in proportion to assets can be applied to some business lines and not to others. This section demonstrates how such partial application of pay regulation can be used to re-target banks' activities to certain asset classes. Suppose, as an example, that for reasons outside of this model a regulator decided that there was insufficient lending to the real economy via banks.<sup>14</sup> In this case a pay cap in proportion to assets applied to bankers working in wholesale banking, but not in retail banking, would alter the equilibrium asset allocation decisions so that all banks refocus assets away from wholesale and towards retail banking. Though a pay cap is an instance of microprudential regulation, the effect would be a macroprudential one as the resilience of all banks across the system is improved.

Further banks are in competition with other Financial Institutions, such as hedge funds, to secure bankers/traders, and these financial institutions who do not possess a banking license are often regulated under different rules. I will study the case of incomplete regulatory coverage in Section 7.2. The existence of financial institutions outside the regulatory net, rather than being a problem, can be used to further enhance the efficacy of pay-caps as a macroprudential tool.

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

Once again consider the model of Section 6 of two asset classes and two bankers in each asset class with expected asset growth factors  $\alpha > \beta$ . For expositional purposes, and in keeping with the motivating example, I will label the two asset classes  $r$  for retail and  $w$  for wholesale banking. However the analysis applies to any subdivision of banks' activities. Generalising from Section 6, I move away from symmetry and consider two banks with balance sheets  $T_r, T_w$ . I restrict attention to the interesting case in which each bank

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<sup>13</sup>Both banks would split their balance sheets equally between the asset classes to maximise the diversification benefits. If the bonus cap is binding, then the smaller bank will bid at most a bonus rate of  $\chi$ . The larger bank would secure the  $\alpha$ -banker in each asset class at a bonus rate of  $\chi T_2/T_1$  where  $T_1 > T_2$  denotes the size of the total balance sheet. The equilibrium bonus falls in the bonus cap as per Proposition 3.

<sup>14</sup>Insufficient lending in the UK to Small and Medium sized Enterprises (SMEs) has been a notable recent regulatory concern. See for example "Funding for Lending failure dismays BoE," *Financial Times*, March 11, 2013.

secures just one of the  $\alpha$ -bankers. Bank  $T_r$  will specialize in the  $r$  asset class (e.g. retail banking). It devotes  $S_r$  dollars to retail banking, and  $T_r - S_r$  dollars to the alternative asset-class: wholesale banking. Similarly bank  $T_w$  specialises in the  $w$  asset-class (e.g. wholesale banking), and so devotes  $S_w$  dollars to its asset class specialism (the  $w$  asset class). Bank  $T_r$  assigns more dollars to the  $r$  asset class than the rival bank, and in this sense specialises in the  $r$  asset class (retail banking).

Each bank secures gains from diversification (as in Section 6) proxied by  $c \cdot S_w (T_w - S_w)$  for the wholesale focused bank, and similarly for the retail focused bank.

The regulatory intervention I analyse here is a bonus rate cap  $\chi$  applied to remuneration on the  $w$ -asset class only. If this bonus cap is binding then it will affect the marginal bidding bank in the  $w$ -asset class. Hence the cap implies that bank  $r$  is restricted in the bonus rate it can offer to try and attract the  $\alpha$ -wholesale banker. Bank  $r$  can offer the  $\alpha$ -wholesale banker at most expected pay of  $\chi \cdot \alpha (T_r - S_r)$  given its asset allocation choice. The bonus rate paid by bank  $w$  for the wholesale banker will be below the cap (13). There is no cap on bonuses offered to bankers in the retail banking asset class.

I again model the banks as first simultaneously deciding their asset class allocations, and then competing to hire the bankers as in the benchmark model given above. I restrict attention to the benefits of diversification large enough that

$$c > \max \left( \frac{1}{S_w}, \frac{1}{S_r} \right) \cdot \frac{\lambda}{2} G \left( \frac{\eta}{\alpha} \right)^\gamma \frac{\gamma(\gamma+1)\chi^2}{(1-\chi)^{\gamma+2}} \quad (6)$$

This assumption delivers stability of the equilibrium allocation of assets between classes. The assumption is trivially satisfied if the banks are large enough.

We are now in a position to study the effect a partially applied pay cap has on the asset allocation decisions of the two banks. I denote the best asset allocation response of bank  $w$  to bank  $r$  as  $S_w(S_r)$  and vice-versa. Thus if bank  $r$  assigns assets  $S_r$  to its specialism (the  $r$  asset-class, retail banking), and by implication assets  $T_r - S_r$  to wholesale banking, then bank  $w$ 's best response is to assign  $S_w(S_r)$  to its asset-class specialism (the  $w$  asset class, wholesale banking).

**Lemma 6** *The best asset allocation responses of each bank are strategic substitutes. Thus  $dS_w(S_r)/dS_r < 0$ .*

The result builds on the logic of Section 6 and demonstrates the strategic interaction between asset class allocation decisions. If bank  $r$  should increase its allocation to its asset-class specialism ( $r$  asset-class, retail banking), then by definition it is moving assets away from the other asset class: wholesale banking. The rival bank now faces a less aggressive bidder for the  $\alpha$ -wholesale banker. As explained in Section 6 the wholesale focused bank can now benefit from increased diversification and so reduces its focus to wholesale banking. The wholesale focused bank therefore increases its allocation to retail

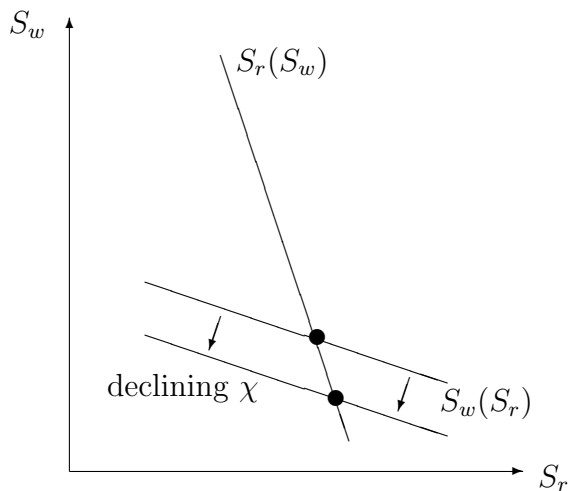


Figure 2: Best Response Asset Allocation Functions.

Notes: The curve  $S_w(S_r)$  captures the best asset allocation response of the  $w$  focused bank on asset class  $w$  (wholesale banking), in response to the allocation  $S_r$  of the  $r$  focused bank to the  $r$  asset class (retail banking). The best response functions are strategic substitutes as the curves slope down. As the bonus rate cap  $\chi$  on wholesale banker remuneration is made more severe ( $\chi$  declines), the best response curve of the  $w$  bank is pulled down. The best response curve of the  $r$  bank is not affected as there is no cap on retail banker remuneration. Hence the equilibrium asset allocation to retail banking rises for both banks.

banking. As there is no bonus rate cap on remuneration to retail bankers, there is now a second round effect making bank  $w$  a more aggressive bidder for the  $\alpha$ -retail banker. Therefore, to protect its profitability bank  $r$  optimally responds by further increasing its asset allocation to retail banking also.

Bonus caps applied to wholesale banking can kick-start this re-allocation process by inhibiting bank  $r$  from bidding up wholesale banker bonuses:

**Proposition 7** *If a bonus cap applying only to one asset class is made more severe, all banks increase their asset allocation to the alternative asset class. Hence if a bonus rate cap  $\chi$  applying only to wholesale banker remuneration is reduced, all banks increase their asset allocation to retail banking.*

A bonus rate cap applied to one asset-class affects the marginal bidder's ability to drive up pay in this asset class. The retail-focused bank is the smaller bank in the wholesale banking asset class, and so it is the marginal bidder setting the remuneration level which the wholesale-focused bank needs to match. A bonus rate cap for bankers working in wholesale banking impedes the retail focused bank from bidding up the remuneration of wholesale bankers. This sets off the logic of Lemma 6. Namely the wholesale focused bank, facing less intense competition to hire the  $\alpha$ -wholesale banker, is able to profit from diversification. Thus bank  $w$ , at the margin, moves some assets away from wholesale and towards retail banking. This makes competition for the  $\alpha$ -retail banker more intense, and as there is no bonus cap to protect it, this leads to the retail focused bank also repatriating some of its assets away from wholesale and towards retail banking. This effect is depicted graphically in Figure 2. Thus partially applied pay caps can be used to alter banks' asset allocation decisions through the economic cycle.

## 7.2 Macprudential Effects With Incomplete Regulatory Coverage

In this section I expand the analysis above to demonstrate why, even with incomplete regulatory coverage, pay caps in proportion to assets applied partially across asset classes, can be used effectively to alter the equilibrium allocation of banks' assets. Consider therefore just one universal bank  $r$  active in both the  $r$  asset class (e.g. retail banking) and the  $w$  asset class (e.g. wholesale banking). The bank is once again 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 retail banking assets. Thus the pay cap regulation continues to be partially applied.

Now replace the universal bank  $w$  analysed in the section above with a competing financial institution active only in the  $w$  asset class. I will refer to this institution, for the purposes of this example, as a hedge fund and label its assets in the class  $S_h$ . I assume this  $h$  institution sits outside of the regulatory net and so is exempt from the pay cap. (Otherwise the analysis above is trivially extended). 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. The benefits of diversification for bank  $r$  are again proxied by  $c \cdot S_r (T_r - S_r)$  if bank  $r$  assigns  $S_r$  dollars to the retail banking book. In both asset classes there continue to be two bankers with expected growth factors  $\alpha > \beta$ . (Only one retail banker will be required – hence the  $\alpha$ -retail banker will be secured by bank  $r$ ).

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

$$S_h < \frac{T_r}{2} - \frac{1}{2c} \left( \alpha - \beta + \lambda G \left[ \left( \frac{\eta}{\beta} \right)^\gamma - \left( \frac{\eta}{\alpha} \right)^\gamma \right] \right) \quad (7)$$

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

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

**Lemma 8** *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  $S_r^\dagger$  where*

$$S_r^\dagger = \frac{T_r}{2} + \frac{1}{2c} \left( \alpha - \beta + \lambda G \left[ \left( \frac{\eta}{\beta} \right)^\gamma - \left( \frac{\eta}{\alpha} \right)^\gamma \right] \right)$$

The economics of Lemma 8 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:

$$W_r(S_r) = \underbrace{\alpha S_r - \lambda S_r G\left(\frac{\eta}{\alpha}\right)^\gamma}_{\text{from retail book}} + \beta(T_r - S_r) - \lambda(T_r - S_r) G\left(\frac{\eta}{\beta}\right)^\gamma + c \cdot S_r(T_r - S_r) \quad (8)$$

Equation (8) follows as both bankers will receive a normalised bonus rate of zero. This value function is concave in the allocation of assets to the retail banking book,  $S_r$ . Hence there is an optimal allocation given by the first order condition. This asset allocation is sufficiently large that the bank would have more assets in its wholesale banking book than the hedge fund, given assumption (7). 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, bank  $r$  will outbid the hedge fund and hire the  $\alpha$ -wholesale banker. As bank  $r$  must compete with the hedge fund to secure the wholesale banker, the  $\alpha$ -wholesale banker receives higher remuneration than the  $\alpha$ -retail banker does. Thus, to protect its profitability the retail bank diverts assets to wholesale banking, shrinking its retail banking book. This is not straightforward to show as the interaction between pay levels and bank default risk is not linear. Nevertheless it can be demonstrated that 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 8.

**Proposition 9** *If the bank is subject to a sufficiently severe cap on remuneration for the wholesale banking book then the bank will re-allocate more assets to retail banking and reduce the size of its wholesale banking book.*

Proposition 9 considers a regulation which is sufficiently severe that the bank loses the best wholesale banker to the hedge fund. In this setting the bank can secure bankers, but in wholesale banking they are not the very best ones. As a result the expected growth factor available from wholesale banking assets falls slightly, to the lower level of  $\beta$ . The bank would now conduct its asset allocation decision as in the proof of Lemma 8 under the assumption that it will secure the  $\beta$ -bankers for the wholesale banking book, and so 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 partially applied pay cap regulation. Proposition 9 captures that the incomplete regulatory coverage of remuneration regulation can be turned to the regulator's advantage. The ability to use pay cap regulation as a macroprudential tool survives in the presence of a porous regulatory net.



## 8 Conclusion

A variable cap on remuneration in proportion to risk weighted 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, and so banks become less fragile as their cost base is pulled down. By addressing a negative externality in the labour market for bankers, the intervention also has the effect of dampening the pressure banks are under to focus resources on given asset classes so as to secure better bankers. And the pay cap can be used to achieve macroprudential objectives through the cycle as it can be structured to encourage banks to refocus towards a subset of asset classes (e.g. retail banking) if desired by a regulator. Finally, by using appropriate risk weights, bankers' incentives to abuse any weakness in corporate governance failings to grow pay is mitigated.

Consider therefore a regulatory intervention which capped total bank remuneration summed over wholesale bankers proportional to each bank's risk-weighted wholesale banking assets. Regulation at the aggregate level is easier and less costly to implement than per person caps. And yet such a cap will likely be implemented by senior management on rank-and-file hiring decisions 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 3). Hence a cap at the bank level tackles the externality described at the individual banker level, and likely generates the consequences for bank values and bank risk studied here.

	<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 3: Numbers of Employees Targeted By Intervention On Top 20% Of Earners  
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 Table 1 and Figure 1. The banks displayed are a selection of household names drawn from the top 20 banks documented in Figure 1.

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 1. 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).

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 finance industry is special as compared to other areas of business due to the negative externalities it exposes society to when financial firms fail. These impacts on society are not formally part of this model and so this study does not offer a justification that pay caps in banking are worthwhile. I purely note that the case for pay caps in proportion to assets is likely to be relatively stronger in banking than in other industries. Secondly, the financial sector has a larger remuneration bill as a proportion of shareholder equity than other industries. 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 industries.

## 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  $j - 1$  :

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

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:

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

It follows, by induction that  $\alpha_iS_iq_i = \sum_{j=i+1}^N S_j(\alpha_{j-1} - \alpha_j) + S_N\alpha_Nq_N$ . 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

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

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  $\mathcal{L} = \chi \cdot \langle \underline{\beta}, \underline{x} \rangle + \eta [U(\langle \underline{x}, \underline{\rho} \rangle, \langle \underline{x}, \mathbf{V}\underline{x} \rangle) - R]$  with Lagrange multiplier  $\eta$ . The first order condition then yields an expression for the optimal allocation  $\underline{x}^*$  :

$$\chi \underline{\beta} + \eta \left[ \frac{\partial U}{\partial \mu} \underline{\rho} + 2 \frac{\partial U}{\partial \sigma^2} \mathbf{V} \underline{x}^* \right] = 0$$

Hence we have

$$\underline{x}^* = \frac{-1}{2\eta (\partial U / \partial \sigma^2)} \mathbf{V}^{-1} \left( \eta \frac{\partial U}{\partial \mu} \underline{\rho} + \chi \underline{\beta} \right)$$

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.

The bank with the smaller asset allocation in any given class will have  $T - S$  in the asset class. 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):

$$V(\tilde{S}; T - S) = \alpha \left[ 1 - \chi \frac{T - S}{\tilde{S}} \right] \tilde{S} - \underbrace{\lambda \tilde{S} G \left( \frac{\eta}{\alpha \left[ 1 - \chi \frac{T - S}{\tilde{S}} \right]} \right)}_{(i)} + c \tilde{S} (T - \tilde{S}) \quad (15)$$

$$+ \beta (T - \tilde{S}) - \lambda (T - \tilde{S}) G \left( \frac{\eta}{\beta} \right)^\gamma$$

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 in  $\tilde{S}$ . Consider the arm in which  $\tilde{S} > \chi(T - S)$  which is the relevant one as  $\tilde{S} > T - S$ . This curve is positive, 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

$$0 < 2h'(\tilde{S}) + \tilde{S}h''(\tilde{S}) = \frac{-2\eta\chi(T - S)}{\alpha(\tilde{S} - \chi(T - S))^2} + \tilde{S} \frac{2\eta\chi(T - S)}{\alpha(\tilde{S} - \chi(T - S))^3}$$

$$\Leftrightarrow 0 < 2\eta[\chi(T - S)]^2 \text{ which is true.}$$

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:

$$\frac{\partial V}{\partial \tilde{S}}(S, T - S) = 0 = \alpha + c(T - 2S) - \beta + \lambda G \left( \frac{\eta}{\beta} \right)^\gamma \quad (16)$$

$$- \lambda G \left( \frac{\eta}{\alpha \left[ 1 - \chi \frac{T - S}{S} \right]} \right)^\gamma \left\{ 1 - \gamma \frac{\chi \frac{T - S}{S}}{\left[ 1 - \chi \frac{T - S}{S} \right]} \right\}$$

This defines the equilibrium 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 algebraic manipulation of (16),  $\partial^2 V / \partial \tilde{S} \partial \chi > 0$ .<sup>15</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  $\partial^2 V / \partial \tilde{S} \partial \chi$  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.** I will prove the result for bank  $w$ , the result for bank  $r$  follows analogously. Bank  $r$  is subject to a bonus cap of  $\chi$  in its bidding for the  $\alpha$ -wholesale banker. This yields expected remuneration of  $\alpha\chi(T_r - S_r)$ . Hence bank  $w$  secures the  $\alpha$ -wholesale banker by offering a bonus rate of  $q = \chi(T_r - S_r) / S_w$ . Hence from (5) the value of bank  $w$  is:

$$\begin{aligned} V_w(S_w; T_r - S_r) = & \alpha \left[ 1 - \chi \frac{T_r - S_r}{S_w} \right] S_w - \underbrace{\lambda S_w G \left( \frac{\eta}{\alpha \left[ 1 - \chi \frac{T_r - S_r}{S_w} \right]} \right)}_{(i)} \\ & + \beta (T_w - S_w) - \lambda (T_w - S_w) G \left( \frac{\eta}{\beta} \right)^\gamma + c S_w (T_w - S_w) \end{aligned} \quad (17)$$

By the proof of Proposition 5 the value function  $V_w(S_w; T_r - S_r)$  is concave in the asset allocation  $S_w$ . Hence the best response of bank  $w$  is given by the first order condition,  $\partial V_w / \partial S_w = 0$ . Analogously to (16):

$$0 = \alpha - \beta + c(T_w - 2S_w) + \lambda G \left( \frac{\eta}{\beta} \right)^\gamma - \lambda G \left( \frac{\eta}{\alpha} \right)^\gamma \left( \frac{1}{\left[ 1 - \chi \frac{T_r - S_r}{S_w} \right]} \right)^{\gamma+1} \left\{ 1 - (\gamma + 1) \chi \frac{T_r - S_r}{S_w} \right\} \quad (18)$$

I now show that the best response curve,  $S_w(S_r)$  is downwards sloping to yield the required

<sup>15</sup>The result follows if  $\left( \frac{\eta}{\alpha(1-\chi)} \right)^\gamma \left\{ 1 - \gamma \frac{\chi}{1-\chi} \right\}$  is decreasing in  $\chi$ . Differentiating with respect to  $\chi$  yields

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

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

result. Taking differentials we have

$$\frac{\partial}{\partial^2 S_w^2} V_w(S_w, T_r - S_r) \frac{dS_w}{dS_r} - \frac{\partial}{\partial S_w \partial (T_r - S_r)} V_w(S_w, T_r - S_r) = 0$$

Due to the concavity of the value function with respect to  $S_w$ ,  $\partial^2 V / \partial^2 S_w < 0$ . By algebraic manipulation one can confirm that  $\partial^2 V_w / \partial S_w \partial (T_r - S_r) > 0$  which implies that  $dS_w(S_r) / dS_r < 0$  as required. ■

**Proof of Proposition 7.** Lemma 6 shows that the asset allocation decisions are strategic substitutes. We first show that decreasing the bonus cap  $\chi$  pushes the reaction function of bank  $w$  down. Taking differentials,  $\frac{\partial}{\partial^2 S_w^2} V_w \frac{dS_w}{d\chi} + \frac{\partial^2}{\partial S_w \partial \chi} V_w = 0$ . By concavity  $\frac{\partial}{\partial^2 S_w^2} V_w < 0$ , and  $\frac{\partial^2}{\partial S_w \partial \chi} V_w > 0$  from the proof of Proposition 5 (using footnote 15). Hence  $dS_w / d\chi > 0$  as required. As the bonus cap does not apply to retail banking, the reaction function of bank  $r$ ,  $S_r(S_w)$  is unaffected by  $\chi$ .

Reducing  $\chi$  will push the intersection of the reaction curves towards greater retail banking assets if the equilibrium is stable (Tirole (1988)) so that  $-1 < dS_i(S_j) / dS_i < 0$  for all  $i \neq j$ . This can be confirmed by explicit differentiation of (18):

$$\begin{aligned} 0 = & -2c \frac{dS_w(S_r)}{dS_r} - \lambda G \left( \frac{\eta}{\alpha} \right)^\gamma \gamma (\gamma + 1) \frac{1}{\left[ 1 - \chi \frac{T_r - S_r}{S_w} \right]^{\gamma+2}} \chi^2 \frac{(T_r - S_r)^2}{S_w^3} \frac{dS_w(S_r)}{dS_r} \\ & - \lambda G \left( \frac{\eta}{\alpha} \right)^\gamma \gamma (\gamma + 1) \frac{1}{\left[ 1 - \chi \frac{T_r - S_r}{S_w} \right]^{\gamma+2}} \chi^2 \frac{T_r - S_r}{S_w^2} \end{aligned}$$

Simplifying, for  $c$  large enough we guarantee that  $dS_w(S_r) / dS_r > -1$ . In particular a sufficient condition for the result to hold is (6) using the fact that  $T_i - S_i < S_j$  for  $i \neq j$  by construction. The proof that  $dS_r(S_w) / dS_w > -1$  is analogous. Hence we have the desired result. ■

**Proof of Lemma 8.** First we demonstrate that the bank would secure the better wholesale banker. Suppose, for a contradiction, that the bank selects  $T_r - S_r < S_h$  assets for its wholesale banking book. In this case the value of the bank is given by (8). This is concave in  $S_r$ . The first order condition for this expression would set  $S_r = S_r^\dagger$ . Hence bank  $r$  would have assets  $T_r - S_r^\dagger$  in its wholesale banking bank. But this is in excess of the hedge fund's assets,  $S_h$  by (7). Hence we have a contradiction and so the bank must prefer an asset allocation to wholesale banking which was sufficient to secure the better banker.

With no remuneration caps the banker would be paid a bonus rate of  $(1 - \beta/\alpha) (S_h / (T_r - S_r))$ ,

which follows from (12). Bank  $r$ 's expected value is then, adapting (17):

$$\begin{aligned}
V_r(S_r; S_h) &= \alpha \left( 1 - [1 - \beta/\alpha] \frac{S_h}{T_r - S_r} \right) (T_r - S_r) - \underbrace{\lambda (T_r - S_r) G \left( \frac{\eta}{\alpha \left( 1 - [1 - \beta/\alpha] \frac{S_h}{T_r - S_r} \right)} \right)}_{(i)}^\gamma \\
&\quad + \alpha S_r - \lambda S_r G \left( \frac{\eta}{\alpha} \right)^\gamma + c \cdot S_r (T_r - S_r)
\end{aligned} \tag{19}$$

This is concave in  $S_r$  if (i) is convex, which is true by the method of proof of Proposition 5. Hence the objective function of the bank is concave and so has a unique maximand given by the first order condition. The first order condition with respect to  $S_r$  delivers

$$\begin{aligned}
\frac{d}{dS_r} V_r(S_r; S_h) &= \lambda G \left( \frac{\eta}{\alpha \left( 1 - [1 - \beta/\alpha] \frac{S_h}{T_r - S_r} \right)} \right)^\gamma \left[ 1 - \gamma \frac{1}{\left( 1 - [1 - \beta/\alpha] \frac{S_h}{T_r - S_r} \right)} [1 - \beta/\alpha] \frac{S_h}{T_r - S_r} \right] \\
&\quad - \lambda G \left( \frac{\eta}{\alpha} \right)^\gamma + c \cdot (T_r - 2S_r)
\end{aligned}$$

Algebraic manipulations deliver that  $\frac{d}{dS_r} V_r(S_r^\dagger; S_h) < 0$  using (7). Hence the optimal size of the wholesale banking book is greater than  $T_r - S_r^\dagger$ , and so the assets devoted to retail are below  $S_r^\dagger$ , yielding the result. ■

**Proof of Proposition 9.** 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  $\alpha q_r (T_r - S_r) \geq (\alpha - \beta) S_h$ . If the remuneration cap is binding on the bank then the better executive can only be hired if  $T_r - S_r \geq (1 - \beta/\alpha) (S_h/\chi)$ . Suppose the cap is sufficiently severe that the wholesale banking book is optimally below this level.<sup>16</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 (8). Optimising this value over the asset allocation, the optimal wholesale banking book size is then given as  $S_r^\dagger$ . The wholesale banking book has shrunk and the banking book grown by comparison with the bound in Lemma 8. ■

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<sup>16</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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