Bankers' Pay Structure And Risk

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Abstract

This study outlines a new theory linking industrial structure to optimal employment contracts and excessive risk taking. Banks hire their bankers using optimal contracts derived within a competitive labour market. To motivate effort banks must use some variable remuneration. Such remuneration introduces a risk-shifting problem; a banker would wish to inflate early earnings at the cost of increased risk in the tails. To manage this some bonus pay is optimally deferred. As consolidation in the financial sector rises it becomes more expensive to manage the risk-shifting problem than the moral hazard problem. Eventually the optimal contract jumps from one achieving zero risk-shifting to one permitting some risk-shifting; even though the banks have no corporate governance problems. The insights apply more widely across industries; this paper demonstrates that US financial services have evolved in a manner consistent with this mechanism.

Keywords: risk-shifting; moral hazard; incentives; bonuses; banks; bankers' pay; organizational culture; risk taking.

JEL Classification: G21, G34.

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"*This economic crisis began as a financial crisis, when banks and financial institutions took huge, reckless risks in pursuit of quick profits and massive bonuses.*"
President Obama, January 2010.

"*You [Wall Street] don't have to wait for a law to overhaul your pay system so that folks are rewarded for long-term performance instead of short-term gains.*"
President Obama, September 2009.

1 Introduction

Competition between banks and investment houses for bankers and traders is intense. A compelling narrative of the recent financial crisis is that the labour market for bankers has resulted in bankers receiving pay focused too much on short-term revenues. As a result the most senior policy makers in the US, EU and G20 have, with hindsight, decried the huge risks which built up in the financial system. These observations have been met with pleas for banks to reform their pay practices. Globally, financial regulators are rushing to introduce new rules which explicitly intervene in the allowable structure of bankers' pay.

The hypothesis that those who ran banks did not care about risks and were happy to be reckless is poorly supported by the evidence. All the major banks were regulated prior to the crisis with a view to managing their overall risk. Analysis of banks' returns delivers no evidence that those run by CEOs whose interests were better aligned with shareholders were less reckless or made smaller losses – in fact there is weak evidence to the contrary (Fahlenbrach and Stulz 2010). It therefore remains crucial to understand why banks and financial institutions would, in good faith, enter into the remuneration contracts whose outcomes have been so damaging. Failure to do so runs the risk that the regulations on pay now being introduced will quickly outlive their usefulness and become constricting once regulatory monitoring improves.

I offer a model which studies the rich contracting problem between properly governed banks and their bankers. I study this problem embedded in a competitive market for banker talent. Only such a model which combines the economics of incentives with the impact of competition between banks for bankers can explore whether a market failure in the labour market for bankers exists, could lead to excessive risk building up, and could warrant regulatory intervention.

The model I offer has three key parts. First I consider the banker labour market for any given activity undertaken by banks and/or shadow banks.[1] Banks and shadow banks active in this activity differ by the size of the balance sheet or fund they will allow to support it. These banks compete with each other to hire a suitably qualified banker to undertake and manage this activity with the fund available. Second the bankers are subject to two standard contracting frictions: moral hazard and risk-shifting. Bankers must be motivated to exert effort; they must also be motivated to avoid risky projects which grow short term profits but at the cost of long term risks. This latter risk-shifting worry is at the centre of the financial crisis. The bankers differ in their investing and banking skill, they are not all identical. A banker has more information as to her ability to generate profits in the current climate with the currently available tools than the banks have. Finally banks compete to hire the bankers and can use sophisticated remuneration

[1] See Pozsar et al. (2010) for a full discussion of the shadow banking sector. It includes, for example, hedge funds and investment banks.

contracts which tally with those available in reality. They can use fixed wages; or they can use a bonus based on the expected net present value (npv) of the revenue stream (equivalent to stock options for the CEO); or they can offer deferred, also known as vested, pay whose value depends on the realised outcome of future performance; or they can use all of these in any combination. The choice of structure and level of remuneration is endogenous and will be the outcome of the competitive market for banker talent.

Competition between banks for bankers determines a market rate of surplus which each banker must secure. The market rate is determined by the amount of surplus which the marginal competing bank is willing to offer to hire that banker instead of the one they will be hiring in equilibrium. Competition between banks does not force one particular remuneration structure on a bank rather than another, it purely sets the surplus which must be delivered. A bank which solely rewarded using fixed wages would not provide incentives for the banker to exert effort. To prevent this, and so manage the moral hazard problem, sufficient variable pay needs to be provided. The variable pay can be payable early and so reflect the npv of expected revenues, or it could be deferred and reflect actually generated revenues.

Paying bonuses early in the life-cycle of the banker's investments has the benefit that nothing is lost to discounting, and it ensures effort is provided. However such pay introduces the risk-shifting problem. If pay depends on the estimated npv of future returns then a banker will be incentivised to select risks which increase her immediate revenues enough to emulate a higher ability banker, whilst creating a risk of some larger loss in the future. Some authors have alleged that much hedge fund investing is exactly of this form (Foster and Young 2008). I purely note that such investing to hide true ability and inflate early returns is possible. To mitigate the risk-shifting problem some of the pay must be deferred. The pay will have to be vested over the duration of the bankers' investments with the amount of pay depending on the future realised returns. It follows that a bank has reason to use all the three kinds of remuneration outlined above, as is observed in reality. Using deferred pay comes at a cost however: the banker discounts the future.

Competition between banks for bankers creates a negative externality between the banks which increases the cost of managing the risk-shifting problem more rapidly than managing the moral-hazard problem. In particular as consolidation in the banking sector increases the more each bank will value the bankers expected to be of higher ability. This pushes their remuneration up. To deliver the required surplus and ensure no risk-shifting the employing bank will need to increase the surplus faster still as the deferred portion is partly discounted by the banker. However to not increase the deferred pay will result in the banker facing a contract which would make it optimal for her to risk-shift with some probability. The cost of employing the banker therefore grows with industry consolidation, but the benefit to the bank of avoiding her banker risk-shifting is independent of such consolidation. If consolidation should become sufficient then the balance of costs and benefits swings: the employing bank, properly run and motivated to maximise value, endogenously chooses to jump to a contract form which permits some risk-shifting.

This paper therefore demonstrates how changes in industry structure can lead to a firm choosing to move from a no risk-shifting equilibrium to one in which some risk-shifting is tolerated. This mechanism applies to industries beyond banking. However risk-shifting in banking can result in huge externalities for society which therefore provides a rationale for intervention. A sufficient, condition to trigger this mechanism is if there is convergence in the size of the funds chasing the bankers. I show that this is exactly true of US banking in the last 40 years (Section 6); and the effect reached unprecedented highs in the early years of this millennium, peaking just prior to the financial crisis.

Related Literature

To study the link between optimal contracting and industrial structure I offer a model of a competitive labour market between banks for bankers. This endeavour builds upon the work of Gabaix and Landier (2008) and Edmans, Gabaix and Landier (2008). In this series of papers the authors offer a model of a competitive labour market for CEOs. My contribution has been to reformulate these models to allow for both risk-shifting and moral hazard in a dynamic setting. This extension is key. Without extending the activities of the agent across multiple periods the incentives for pushing risk into the future tails and so the rationale for deferred pay cannot be studied. This extension results in multiple equilibria: some without firms allowing risk-shifting and others where it is tolerated; thus, unlike the Gabaix et al. papers I am able to link the jump from one equilibrium to another to the prevailing industry structure.

The focus on the interplay between risk-shifting and moral hazard is a feature this paper has in common with Acharya, Mehran and Thakor (2010). Acharya et al. study how a bank can be motivated to avoid both problems via their capital adequacy requirement – they do not consider industry structure or competition between the banks. These authors show that some leverage is needed as this creates variable returns for uninsured creditors and so manages their moral hazard; while enough equity is required which will absorb losses so that the bank has something to lose and so avoids risk-shifting. However for some parameters both moral hazard and risk-shifting cannot be simultaneously managed. The study I offer is at the individual banker level and so the tools of control are the remuneration structure which Acharya et al. do not study. The optimal use of variable remuneration can be understood as paralleling the need for leverage at an institutional level; and the use of deferred pay matches the equity requirement in Acharya et al.. The study I offer demonstrates how industry structure can move the bank to a point where it cannot manage both risk-shifting and moral hazard; and by studying individual contracts this paper can demonstrate how the bank will respond to these conflicting pressures.

Thanassoulis (2011) considers the impact of competition between banks for bankers on the level of bankers' remuneration and not its structure. Thanassoulis (2011) argues that bonuses play an important insurance role for banks: they allow the remuneration bill to shrink when bankers' investments perform poorly which is when the risk of a default event is present. However that study is silent on whether the variable remuneration should be deferred, and is also silent on risk-shifting and moral hazard problems. Here we explicitly consider the moral hazard and risk-shifting problems; variable remuneration does play an incentive role and the relationship between pay structure and competition is studied. Acharya and Volpin (2010) allow the level of corporate governance, that is of CEO monitoring, to be endogenous.[2] Their study does not explore risk-shifting concerns and is silent on the optimal remuneration structure. By explicitly

[2] For a discussion of corporate governance failures in banking see Thanassoulis (2009).

studying the contract form in the context of the industrial structure we can make predictions as to when an organizational structure which allows for some risk-shifting becomes optimal.

There has long been a concern that inappropriately designed incentive pay can lead executives to chase short term stock prices and so take value reducing actions. This literature has in general not considered competition for managers, nor optimal contracting. A seminal work here is Stein (1989). The manager in Stein's model inflates early earnings in a value reducing way to try to fool the market. However the market correctly infers that this will happen and so assigns the correct value to the firm. The manager is caught in a prisoners' dilemma: she must manipulate to avoid investors thinking her business is worse that it is. Many have built on Stein's insight (see for example Goldman and Slezak 2006) and used the signal jamming models of, for example, Fudenberg and Tirole (1986) and later of Holmstrom (1999).[3] These models assume that the manager knows no more about her true ability than the market, and so in the end the market can infer accurately the managers' actions. I allow the bankers to know more about their ability than the banks do. Therefore if contracts should be selected which permit some risk-shifting then the market will not know how much, or even whether, risk is being shifted at all.

There is a parallel research endeavour which considers incentive provision for CEOs and bankers, but in the absence of competition for the bankers/managers. Bolton, Scheinkman and Xiong (2006) argue that stock prices include an option element which is increased by short term firm actions. Current shareholders seeking to maximise their gains from sales to overconfident investors might then use short term contracts for their CEOs. Froot, Perold and Stein (1992) make a similar argument. Inderst and Pfeil (2009) argue that bankers have both a deal origination role and subsequently a deal vetting role. If a bank will undertake any deal, regardless of quality – perhaps because of the ability to securitise – then it becomes optimal to focus just on deal origination and so high powered short term incentives result.[4]

2 The Model

The model has three parts. First it is a competitive model of banks and investment firms competing to hire bankers and investors, thus the banks and bankers must be modelled. Secondly bankers/investors make investments and in so doing suffer from both moral hazard and the possibility of risk-shifting, thus bankers' possible investments need to be modelled. Finally the model is designed to allow us to address the effect on risk taking of the remuneration contracts the industry selects, thus a rich family of remuneration structures need to be modelled and their interactions understood. These parts will be combined into a dynamic stage game in which first banks hire bankers with endogenously chosen remuneration contracts; then bankers make their investments and risks are taken depending on the contracts endogenously selected.

[3] See Rotemberg and Scharfstein (1990) for a case with competition on the product side, but not competition for managers or labour.

[4] There is a longer literature which considers short-termism in incentives for entrepreneurs due to the need to manage the twin tasks of monitoring, and shutting down poor performers. See von Thadden (1995), Guembel (2005), Biais and Casamatta (1999).

2.1 The Competitive Market For Bankers

We consider the market for any one of the services offered by commercial banks, investment banks, or shadow banks in the financial intermediation industry. Examples include foreign exchange, equities investing, securitisation, structured finance products, the provision of loans and so on. In this sector we suppose there are N different active such firms. I refer to these as banks for short. Bank i has a fund devoted to this sector of size S_i. The banks are ordered so that $S_1 > S_2 > \cdots > S_N$. Banks are risk neutral, discount profits at the risk free rate which is normalised to zero, and look to maximise the profits generated from their funds. Each bank seeks an individual banker to run their fund in this sector.

There are N bankers who the banks are competing to hire. The bankers differ in their ability. Each banker is of high ability at conducting the specific investment/trade/action required with probability $\mu_i \in (0, 1)$. The bankers are ordered so that $\mu_1 > \mu_2 > \cdots > \mu_N$. Each individual banker learns her actual ability in investing this particular asset class in the current market conditions after contracting, but before making her investment and effort choices. The bankers are risk neutral and have an outside option normalised to 0.

The assumption of risk neutrality on the part of bankers is not a key assumption. If the bankers were risk averse then the results would be strengthened. Nevertheless risk neutrality is a compelling assumption for bankers for at least three reasons (Thanassoulis 2011). Firstly there is evidence that traders show an enhanced bias towards loss aversion, and are therefore risk loving over losses, as compared with normal members of the population (Haigh and List 2005, Liu et al. 2010). Secondly there is medical evidence that successful traders and bankers, and those who select into the finance profession, show greater levels of testosterone which is known to be associated with risk taking (Coates and Herbert 2008, Sapienza, Zingales and Maestripieri 2009). Finally there is direct econometric evidence from markets that estimated risk aversion parameters are small, and indeed often negative (Jackwerth 2000, Rosenberg and Engle 2002).

2.2 Bankers' Possible Investments

The bankers make their investments at the start of time period $t = 1$. These trades generate returns at the end of period $t = 1$ and again at the end of period $t = 2$.

Suppose a banker of skill μ is hired by a bank to manage a fund of size S. If the banker discovers she is of high ability and exerts effort then in each period the trade generates a profit, with certainty, of $S(\rho + a)$. ρ is the return net of the cost of capital and a is an additional boost to the return of the trade which arises because the the banker is of high ability. As the risk free rate is normalised to 0, a high ability banker will generate profits over the two periods with an npv of $2S(\rho + a)$.

If the banker discovers she is not of high ability then she is of lesser ability. In this case the lesser ability banker, despite exerting effort, does not receive the additional boost (a) to the profit each period. Hence the npv of profits generated by a lesser ability banker is $2S\rho$. However a lesser ability banker could decide to risk-shift and so pump up her $t = 1$ profits at some risk to the $t = 2$ returns. In reality this could be done by manipulation (Stein 1989); by use of innovative financial products (Foster and Young 2008); or by relaxing quality control (Landier, Sraer and Thesmar 2010). The exact method is irrelevant to this argument. If the lesser ability banker does decide to risk-shift then at $t = 1$ she will generate profit of $\rho + a$ per dollar managed with certainty. However at $t = 2$ she will only generate the profit $\rho + a$ with probability $1 - \eta$. With probability η the trade will blow up.[5] In this case the banker will have a recovery rate of less than 1 and so deliver a negative profit in period 2 of $-Sz$. z measures the shortfall between the recovery rate and the cost of capital. A banker of lesser ability may decide to risk-shift or not with certainty, or to play some mixed strategy – the choice is endogenous.

If the banker (of lesser or high ability) does not put in effort then profits in period 1 are reduced to $\varepsilon\rho S$ where $\varepsilon < 1$, and further a loss of $Z \cdot S$ is registered at $t = 2$. I assume that this loss is sufficiently great that a banker who puts in 0 effort will generate a negative total npv for the bank: thus banks wish to secure effort from their employed banker. By setting $\varepsilon < 1$ I capture that a lack of effort on the part of a banker is sufficiently observable that it can affect the expected npv of the bankers' investments and so can influence pay. By focusing on standard remuneration contracts, presented next, I maintain the realistic assumption that a perceived lack of effort cannot be taken as a breach of contract and so used to confiscate any fixed wage. For convenience the profits which the banker can generate for the bank are captured in Table 1.

Table 1: Banker's Investment Opportunities. Notes: All bankers can exert effort or not. If they fail to exert effort then after high initial returns, bank profits turn negative. Bankers who exert effort differ in their ability. A banker of lesser ability can risk-shift to disguise her true ability. This introduces a tail risk for the bank. The bank seeks an optimal contract to manage the twin problems of moral hazard and risk-shifting.

	Profit at $t = 1$	Profit at $t = 2$
High ability banker	$(\rho + a) S$	$(\rho + a) S$
Lesser ability banker – no risk-shifting	ρS	ρS
Lesser ability banker – risk-shifting to disguise	$(\rho + a) S$	$\begin{cases} (\rho + a) S & \text{with prob } 1 - \eta \\ -zS & \text{with prob } \eta \end{cases}$
Banker, either ability, exerts 0 effort	$\varepsilon\rho S$,$(\varepsilon < 1)$	$-Z \cdot S$

2.3 Banker Remuneration

It is important that the model is rich enough to allow us to study the actual structure of remuneration in investing and banking. Here I allow banks to compete to hire bankers using three separate remuneration instruments captured by the triple $\{f, \beta, v\}$:

Fixed Wage. f is the fixed wage the bank agrees to pay its banker. It is independent of the realised revenues in either $t = 1$ or $t = 2$. I assume it is paid out at the end of $t = 1$.

Non Deferred Bonus on Expected NPV of Investments. β is the bonus rate applied at the end of $t = 1$ to the principal's estimated npv of total profits which the banker will generate, given her $t = 1$ profits. This is therefore a bonus based on a forward looking

[5] One could add in active risk control so that any risk-shifting is identified by the principal and neutralised with some probability. The results of this analysis would continue to apply as long as the technology used to identify risk-shifting was not both perfect and costless.

performance measure as others have noted would be desirable (Dikolli 2001). It pays out at the end of period 1. For the CEO the npv of the profits is captured by the share-price and so β could be exactly proxied by stock rewards and the principal would be the shareholders. For other workers the npv of the profits from the trade can be computed from the available information by the principal who would, for example, be the senior bank executives.

Deferred Pay Subject to Performance. v is the deferred (or vested) component of pay. It is a share option like instrument which vests until the final period, $t = 2$. The vested component of remuneration pays out a proportion v of the observed end of period 2 profits. Bankers have a discount rate of $r > 0$. Hence, in end of period 1 dollars, the vested component of pay is worth $v/(1+r)$ multiplied by period 2 profits.

As is standard in dynamic models of financial contracting, the individual's impatience exceeds the risk free rate at which the business discounts the future (DeMarzo and Sannikov 2006, DeMarzo and Fishman 2007, Biais et al. 2010). The presence of a discount rate for an individual may be motivated by a standard preference for earlier consumption. If the deferred pay is in the form of stock options then a further reinforcing reason exists as employees value such pay less than the firm does as the individual cannot be fully diversified (Hall and Murphy 2002, Meulbroek 2001). The available experimental evidence suggests that the difference between an individual's discount rate and the risk free rate of return which a firm can access may be very different indeed (Harrison, Lau and Williams 2002).

To maintain realism I assume that bankers are protected by limited liability. Hence $\{f, \beta, v\} \geq 0$. The three remuneration structures I study are designed to be close approximations to the main types of remuneration used in the Finance Industry. In particular, the current Financial Stability Board guidance (Financial Stability Board 2009) requires that bankers' compensation should be variable, a substantial part of which should reflect performance (β); and further much of this compensation should be deferred (v), with guidance of 40% to 60% given. For rank and file bankers in risk taking positions variable remuneration is the dominant method of remuneration (evidence from the UK's Financial Services Authority reproduced here as Table 2). Nevertheless remuneration does include some fixed wages validating their presence in this analysis.

As is standard in the macroeconomics literature and in much of the contracting literature I assume that the agent's utility function has the income effect (see, for example, Cooley and Prescott 1995, Sannikov 2008, Edmans, Gabaix and Landier 2008). This means that as the agent's income increases it becomes costlier to compensate him for effort. I opt for the formulation offered by Edmans, Gabaix and Landier 2008. A banker who is paid total remuneration W receives a utility given by $W \cdot g(e)$. If effort is exerted then $e = \bar{e}$ and $g(\bar{e}) := 1$. However if a banker does not put in effort then $e = 0$ and $g(0) := 1/(1-\Lambda)$. Hence $\Lambda < 1$ is a parameter capturing the cost of effort: if $\Lambda = 0$ then effort would be costless.

Table 2: The weighted average of the breakdown between bonus pay and fixed wages for major UK investment banks. Notes: Data from Financial Services Authority 2010, Table 1. The figures reported confirm that though the vast majority of pay for bankers comes from bonuses and so are variable rewards, some fixed wages remain for rank and file staff. This validates the modelling choice used in this analysis. During 2008 and 2009 bank profits remained under pressure, and bankers' bonuses were the subject of very public discussion and policy attention (FSA 2010, FSB 2009). As a result the proportion of pay in bonuses in the run up to the financial crisis is liable to be higher than these figures report.

	2008		2009	
Total compensation bands	% base salary	% bonus	% base salary	% bonus
Greater than £1m	9%	91%	11%	89%
£500k to £1m	19%	81%	24%	76%

2.4 The Hiring and then Investment Game

The N banks each have a fund and are in competition to hire one of the N bankers to run their fund. This competition and subsequent investment is modelled by the following game:

1. **Hiring Stage – occurs at** $t = 0$. Each bank can offer a given banker a targeted remuneration package of the form $\{f, \beta, v\}$. These offers are banker specific – bankers with a higher probability of being high ability (higher μ_i), can be offered more generous packages. The matching and market remuneration is decided as the outcome of a standard simultaneous ascending auction for the bankers. As each banker is a substitute for another, such auctions deliver the competitive equilibrium assignment (Milgrom 2000).[6]

2. **Investing Stage – occurs over** $t = 1$ **and** $t = 2$ **.** Once each of the N banks has hired its banker, then the employed bankers learn their actual types and make their investment choices using the available balance sheet S_n. The returns generated by investing are given by Table 1. The banker receives the remuneration mandated by his contract. At the end of $t = 1$ the bank will use realised profits to Bayesian update her beliefs as to the expected returns at $t = 2$.

As is standard in contracting models with asymmetric information I assume that behaviour is captured by a Perfect Bayesian Equilibrium. This implies that banks use Bayes' rule to update their beliefs as to the npv the employed banker is expected to generate. For ease of reference the time line of the entire game is given in Figure 1:

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

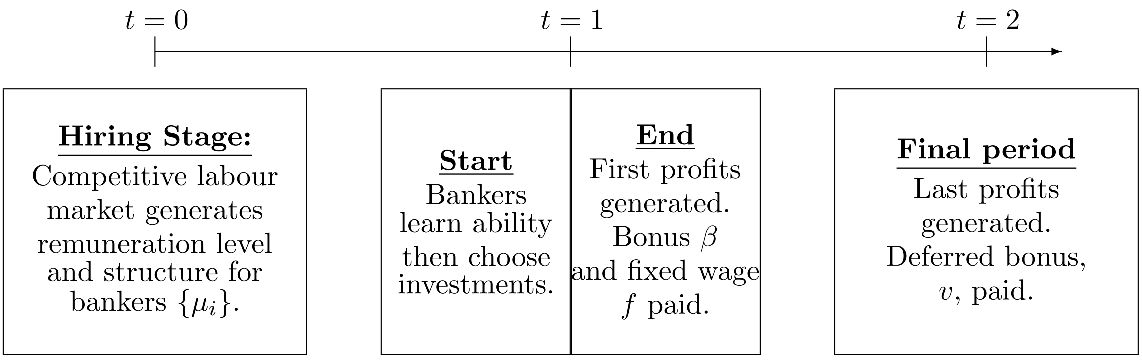

Figure 1: The time line for the model of competition for bankers followed by banker investments.

To complete the model I make two further restrictions on the parameters studied. The first is that the losses incurred in the event of risk-shifting are not trivial. In particular the losses from risk-shifting exceed the profits which can be generated by a high ability banker.

$$z > \rho + a \tag{1}$$

The second restriction is that the possibility of loss when risk-shifting is such that the vested part of pay is reduced in expectation by risk-shifting. This is equivalent to saying that η, the probability of a bad outcome if risk-shifting, cannot be vanishingly small. If this did not hold then a lesser ability banker could not be persuaded not to risk-shift under any circumstances using the remuneration tools here. Thus, recalling the banker's limited liability, this is equivalent to:

$$[(1-\eta)(\rho + a) + \eta \cdot 0] \cdot v < \rho \cdot v \Leftrightarrow \rho\eta > a(1-\eta) \tag{2}$$

One can imagine more complicated models by for example allowing for renegotiation; adding more uncertainty to the returns of the bankers; seeking the fully optimal dynamic contract; allowing the higher ability banker to risk-shift also. I have sought the simplest model which allows me to develop the results transparently and describe the economic forces at work; these forces are robust to extensions such as these. All technical proofs are contained in Appendix A.

3 Solving For Bankers' Investment Decisions

We solve the model using backward induction. Thus let us first consider what investments a banker will select if she has been employed under the remuneration contract $\{f, \beta, v\}$, sufficiently generous to induce effort, and if the banker runs a fund of size S. This work will allow us to determine what contracts will induce a banker of lesser ability to risk-shift. By understanding this the banks, in the hiring stage, will be able to avoid (should they wish to) competing with contracts which might lead to risk-shifting behaviour.

Whether a banker of lesser ability decides to risk-shift or not will depend upon the weighted value of vested pay, V, where :

$$V := v \cdot \left[\frac{\rho\eta - a(1-\eta)}{1+r}\right]$$

V measures the change in the effective bonus provided by deferred (vested) pay if the banker changes from risk-shifting to not risk-shifting. If a banker of lesser ability avoids risk-shifting then their period 2 profit rate will be ρ. If instead a lesser ability banker had decided to risk-shift, then their period 2 profit rate would be higher by a as long as the fund does not blow up; this case applies with probability $1-\eta$. However with probability η the fund would turn a loss; and so limited liability will result in the banker's payoff dropping to 0. Thus with probability η the profit ρ generated by not risk-shifting would have been lost. Combining, $\rho\eta - a(1-\eta)$ measures the extra period 2 profit which a banker can expect by not risk-shifting. It is positive by the assumption that the probability of a loss, η is not trivial, (2). Discounting back to period 1 gives V.

Proposition 1 *Suppose the contract $\{f, \beta, v\}$ is sufficiently generous so as to induce effort. There exists corporate governance constants $\{CG_*, CG^*\}$ such that:*

1. *If $V \geq CG^*$ then no risk-shifting will occur.*
2. *If $V \leq CG_*$ then lesser ability bankers always risk-shift.*
3. *If $CG_* < V < CG^*$ then bankers of lesser ability risk-shift with positive probability.*

The corporate governance constants are given by

$$CG^* = 2a\beta \quad (3)$$

$$CG_* = \beta \max\left(-2\rho, 2a - \eta(1-\mu)(\rho + a + z)\right) \quad (4)$$

To understand the economics of the result, note first that a no risk-shifting equilibrium is a separating equilibrium as lesser ability bankers are discovered promptly at the end of $t = 1$. If remuneration includes any bonus pay, $\beta > 0$, then a banker of lesser ability might consider risk-shifting and so hiding her true skill level. Such a deviation would raise period $t = 1$ profits by aS. In addition, by mistakenly convincing the bank (the principal) she was high ability, the deviation would also raise the expected profits at $t = 2$. Hence by risk-shifting the banker could raise the perceived npv of the fund as far as the bank is concerned by $2aS$. This would raise pay by $2\beta aS$. The lesser ability banker would only be deterred from augmenting her pay in this way if the expected losses incurred in period $t = 2$ from her reduced vested pay are large enough. This yields the first result.

If the weight of vested pay should fall below CG^* then the above reasoning fails. The banker of lesser ability would still like to pump up expectations of future profits at $t = 1$ by risk-shifting. However the bank, the principal here, is a rational Bayesian and correctly identifies this temptation. Thus when the bank sees high profits in period $t = 1$ it no longer sees it as certain proof the banker is of high ability. We therefore initially move into a mixed-strategy equilibrium region (result 3). Here a lesser ability banker will risk-shift with some probability (labelled λ in the proof). Seeing high profits the bank reduces the expected npv of the investments to reflect λ.

If however the vested component of pay drops too far, then we move to case 2. Here the banker is rewarded predominantly on returns from $t = 1$ profits. If a banker allows her employer to see she is of lesser ability then her pay falls with little gain arising from the increased $t = 2$

profits. As a result risk-shifting is guaranteed. A bank can avoid this behaviour by structuring the contracts she offers appropriately. Whether or not she would choose to will be explored next.

4 Optimising Variable Remuneration For Individual Banks

Competition between banks to hire bankers will result in the banks competing in the expected utility they are willing to offer each banker. Thus the contracting problem can be separated into two parts. First the amount of utility which needs to be offered will be the result of the competitive equilibrium. Secondly, given a level of utility which a bank needs to deliver, the bank then needs to determine the most profitable contract it can offer to its banker.

Let us therefore assume that a bank wishes to hire a banker with ability μ to run a fund of size S. Recall we assume that the loss from no effort, Z, is sufficiently large that hiring a banker on a contract which results in them not exerting effort is loss making. Let us suppose that the banker has an outside option which would award her a utility of $u \geq 0$.

Proposition 2 *If the bank wishes to ensure a banker who discovers they are of lesser ability does not risk-shift then the optimal contract satisfies:*

1. *A positive bonus based on the net present value of returns calculated at $t = 1$ (β) is required iff $u > 0$.*
2. *Vested pay is reduced to the point at which the no risk-shifting condition becomes binding. Vested pay is strictly positive iff $u > 0$ and is given in terms of fundamentals by*

$$\frac{v}{1+r}\frac{\rho+a}{a}\eta\left(\frac{\rho}{\Lambda}+a\mu\right)=\frac{u}{S} \tag{5}$$

Proposition 2 is an important step to solving the full competition model. The economics of the result can be understood as follows. The bank wishes to ensure that her banker exerts effort. The bank therefore needs to offer some variable remuneration. If the bank did not then shirking would be more profitable for the banker as her remuneration would be separated from her results. A lack of effort from the banker results in some early modest profits followed by large subsequent losses. Thus to incentivise effort and deal with the banker's moral hazard requires the bank to use forward looking variable pay. This is a combination of early bonuses based on the expected npv of the investment (β), and deferred bonuses based on realised returns (v).

Deferred bonuses are discounted by the banker as she is impatient to some extent. Therefore it is more expensive for a bank to deliver a given level of utility to a banker using deferred as opposed to immediate bonuses. The total deferred payment would have to increase to counter the banker's impatience. As a result the bank would like to use immediate bonuses rather than deferred bonuses.

The only constraint on using immediate bonuses is the risk-shifting problem (Proposition 1). If deferred pay is lowered too much then a banker of lesser ability will find it optimal to risk-shift. If this is to be avoided deferred pay can only drop to the point at which the risk-shifting constraint becomes binding. Hence we have the result.

By contrast we now explore what contracts a bank would use if she were happy to allow bankers of lesser ability to risk-shift. Let us again suppose that the bank wishes to hire a banker with ability μ to run a fund of size S, and that the banker has an outside option which would award her a utility of u.

Proposition 3 *If a bank is happy to allow a banker who discovers they are of lesser ability to always risk-shift then:*

1. *If the npv of the fund under risk-shifting is positive,*[7] *then optimality requires vested pay, v, to be set to zero.*

2. *Otherwise, some positive vested pay is required when the outside option of the banker, u, is greater than* 0*.*

Following the logic described above, a bank which is happy to see risk-shifting by less able bankers would like to avoid using vested pay. Such pay is expensive as the banker discounts the future and so total payments must be increased to deliver a given level of utility to the banker. Hence if risk-shifting is tolerated then the bank would first consider just using immediately delivered bonuses: β.

However, the contract must ensure that the banker, even one of lesser ability, would exert effort. To achieve this a bonus based on the npv of future profits (β) can be used, as long as this npv is positive. If not limited liability makes this bonus irrelevant. Therefore in the case where the npv of the fund under risk-shifting is negative, the bank must use some vested bonus pay to ensure effort is exerted.

4.1 High Banker Outside Options And Bank Tolerance Of Risk-Shifting

Propositions 2 and 3 took as given the objective of either tolerating risk-shifting, or insisting on its absence. However in a competitive equilibrium of the market for bankers the only requirement is that a bank offer a contract which delivers the required level of utility to her targeted banker. Whether it is optimal for the bank to deliver this utility via a contract which rules risk-shifting out, or not, will be endogenously decided. Here we show that if the outside option, u, which must be delivered to the targeted banker grows high enough, then the bank will find it preferable to allow some risk-shifting. Hence if bankers are to get very high levels of utility, then banks will optimally (considering themselves, not society) deliver this while condoning risk-shifting.

For simplicity of exposition I from now on restrict attention to the case where the npv of invested funds are positive even under risk-shifting. This was the condition of part 1 of Proposition 3.

Proposition 4 *If the banker's outside option (u) is sufficiently high then the bank will find it optimal to offer remuneration contracts structured so that risk-shifting occurs with positive probability.*

[7]That is $\Pi_1^{\text{risk-shift}} > 0$. See (8) in the proof of Proposition 1.

This result has at least two implications. The first is that, should the bankers' required rents become large enough, then the market, and similarly the bank, will be unable to determine the risk that is being shifted, nor indeed if any actually is. This will depend on the skill of the banker as regards investing in the current climate with the currently available tools (and possibly also on their randomised choice), both of which are private information to the banker. This contrasts with an influential stream of research (Stein 1989, Goldman and Slezak 2006), in which executives try to pump up their share price at the cost of future profits. That literature assumes the executives have no private information. As a result the executives' behaviour can be accurately inferred (they are in a prisoners' dilemma) and the market can completely correct for the distortion. Here bankers do have private information: hence the level of risk cannot be accurately inferred; and so neither can it be fully corrected for.

The second implication is that one might expect a more concentrated industrial structure, appropriately defined, to drive up bankers' outside options and so result in risk-shifting. This is indeed so and will be formalised in the section which follows. First however it is important to understand the economics behind the result in Proposition 4.

Let us consider a bank which employs its banker using a contract which delivers no risk-shifting. From Proposition 1 a banker will only avoid risk-shifting if the quantity of vested pay is sufficient to give the banker a large enough stake in her investments doing well for their whole life and not just at the very beginning. However bankers are impatient, and so the amount of vested, or deferred, pay is kept to a minimum (Proposition 2).

Now suppose that the banker's outside option were to rise. In this case the utility which is awarded to the banker must rise at the same rate. Part of this extra utility can be delivered via the fixed wage. However to maintain incentives to exert effort the amount of variable remuneration must also rise. In the same way, to prevent risk-shifting the amount of utility delivered via vested pay must rise sufficiently to keep the constraint on no risk-shifting binding. (Part 1 of Proposition 1). Note however that as the banker is impatient, the amount of vested pay must rise faster than u grows by a multiple of $(1+r)$, where r is the bankers' discount rate (equation 5). Hence as the bankers' outside option rises, the cost to the bank increases at a rate in excess of u.

Consider now the possibility of the bank not increasing the vested pay by enough. This would break the no risk-shifting constraint and so move the banker into either the mixing region, or the always risk-shift region described in Proposition 1. A banker of lesser ability would now risk-shift with some positive probability. Such risk-shifting will lower the value of the bank, gross of salary payments. The amount of such a reduction is unrelated to the banker's outside option. The banker will also have to receive utility equaling the outside option. However as the no risk-shifting constraint is broken, less of the pay need be vested. Hence the cost to the bank of the remuneration grows by less than in the no risk-shifting case.

It may be that the benefits of not risk-shifting outweigh the costs. If so then the bank will increase vested pay just enough to keep the contract as one ruling out risk-shifting. However, at some point, once the outside option of the banker becomes high enough, the gain from not using vested pay outweighs the expected loss to the fund from the possibility of risk-shifting with some probability. It then becomes optimal for the bank to break the no risk-shifting constraint and jump to a contract which permits risk-shifting. The result then follows.

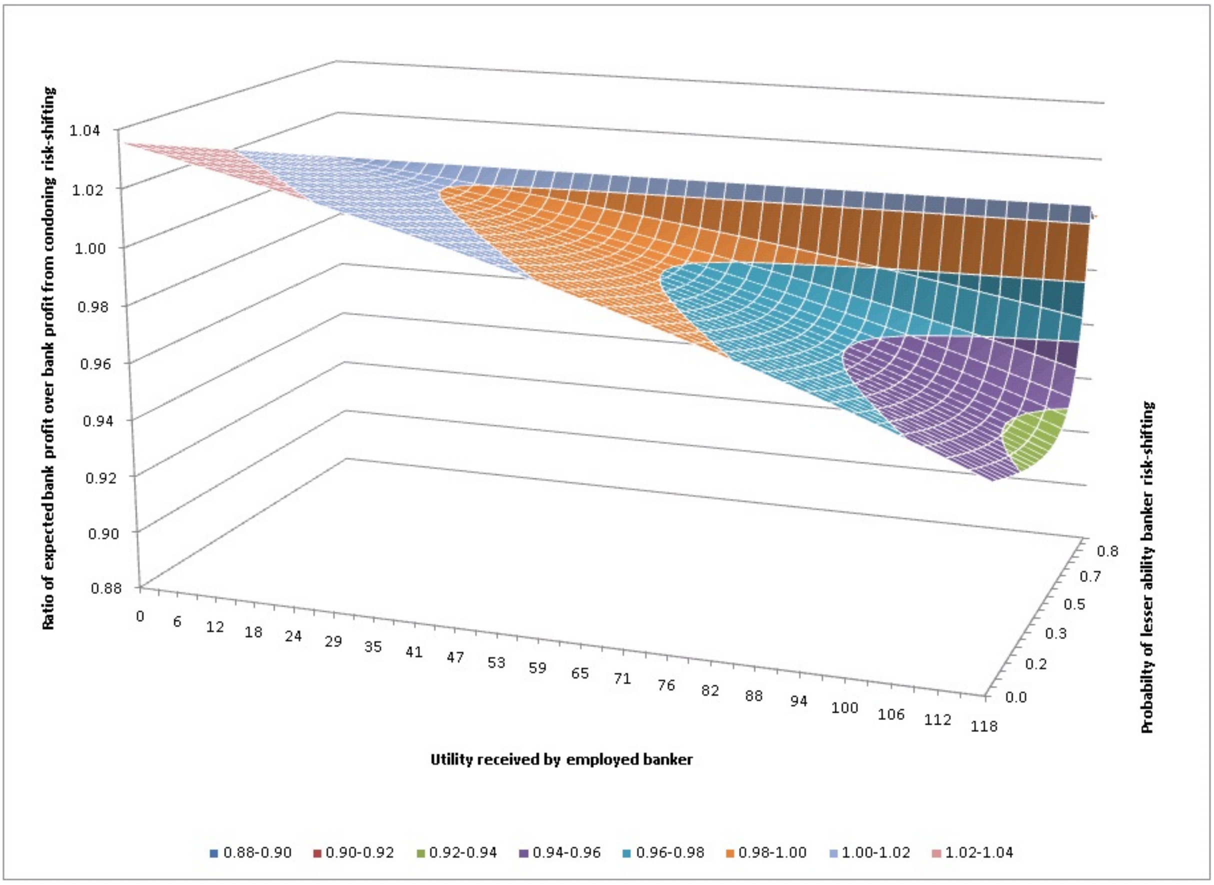

Figure 2: Numerical Simulation Of Expected Bank Profit Scaled By Profit From Full Risk-Shifting.

Notes: The longer horizontal axis measures the utility, u, which needs to be provided to the banker. The shorter base axis captures the probability with which a lesser ability banker risk-shifts: λ. The no risk-shifting contract is depicted at $\lambda = 0$. The vertical axis measures the bank profit from the selected contract scaled by the profit the bank would receive by allowing full risk-shifting. The working to generate the graph is provided in Appendix B. For low values of utility to the banker avoiding risk-shifting is the better course as the graph slopes down so that any risk-shifting lowers bank value. However the surface maps out a valley shape. Thus as the utility which needs to be awarded to the banker rises (high u), then it becomes optimal to jump to a contract with a positive probability of risk-shifting. This numerical simulation uses $S = 1,000, \rho = 0.2, a = 0.01, z = 0.9, \eta = 0.05, r = 0.5, \mu = 0.6, \Lambda = 0.5$. The bank jumps to a risk-shifting contract if $u > 52.9$. Full risk-shifting dominates no risk-shifting for $u > 58.8$.

The mechanism by which the optimal contract jumps from no risk-shifting to risk-shifting can be depicted graphically. In Figure 2 the bank profit from a contract which targets risk-shifting with probability λ by a lesser ability banker is compared with the expected profits from allowing risk-shifting by all lesser ability bankers. The contract with no risk-shifting is delivered by setting the probability of risk-shifting, λ, to be 0. The figure demonstrates the content of Proposition 4. For low values of utility to the banker avoiding risk-shifting is the better course and the bank would endogenously seek a contract with sufficient vested pay to ensure the banker does not risk-shift. However the benefit of avoiding risk-shifting declines quickly as the banker utility rises. If the utility to the banker should grow sufficiently then it becomes optimal to jump to a contract with a positive probability of risk-shifting. In the selected numerical simulation of Figure 2 the contract form is not continuous: once it is optimal to allow risk-shifting the contract jumps to allow risk-shifting with substantial probability. Next I will endogenise the utility which needs to be provided to the bankers – this will create a clear link between industrial structure and optimal contract form.

5 Competition For Bankers And Excessive Risk

We now solve the full model and endogenise the bankers' outside options. We begin by characterising the equilibrium in which all the banks compete in contracts to hire bankers and which deliver no risk-shifting. In this equilibrium we can establish the matching of bankers to banks, and the outside options and remuneration the bankers will command. This equilibrium is not however unique. If the utility that bankers had to be provided were high enough then banks would rather use contracts which allowed risk-shifting (Proposition 4). However a financial regulator concerned about the possible systemic implications of risk-shifting would hope that the financial market was characterised by contracting which sought to prevent risk-shifting. The no risk-shifting equilibrium is therefore of substantial interest. We will be able to determine when this equilibrium breaks down with banks resorting to risk-shifting contracts.

Proposition 5 *In the equilibrium in which no bank prefers to make risk-shifting offers to the bankers, there will be positive assortative matching. The banker of rank n, will be employed at bank n with fund S_n. The banker of rank n will receive utility u^n where*

$$u^n = \left[\sum_{j=n+1}^{N} S_j \left[\mu_{j-1} - \mu_j \right] \right] \cdot 2a \left[1 + r \frac{a}{(\rho + a)\eta} \left(\frac{\rho + a\mu_n}{\frac{\rho}{\Lambda} + a\mu_n} \right) \right]^{-1} \tag{6}$$

Before discussing the implications of Proposition 5 let us first consider the economics which underlie it. If there were no impatience or risk-shifting problems then positive assortative matching would follow from standard arguments. In particular efficiency is maximised by positive assortative matching as a bank ranked higher in this asset space has a larger fund devoted to the sector, and this can benefit most from a banker of greater skill. Here however the result is complicated by the fact that transfers from the bank to its banker need to be achieved in such a way that risk-shifting is not induced. This requires some of the transfer to come via vested pay. However this deferred pay is worth less to the banker than the bank. Hence we are in a setting of non-transferable utility. The proof calculates how much utility a bank is willing to bid, if necessary, for a given banker. I then show that a higher ranked bank would be willing, if forced, to deliver more utility to a banker than a lower ranked bank would. Hence positive assortative matching results.

A bank of rank n will hire the banker of the same rank. However the bank will also be a bidder for the banker one spot up in the league table of quality. The amount bank n is willing to bid for this banker of rank $n-1$ will determine the amount that bank $n-1$ is forced to pay the banker. The amount bank n is willing to bid for banker $n-1$ can be explicitly established using the optimal contract derived in the proof of Proposition 2. Thus, iterating the argument, the utility which has to be offered to the banker of rank $n-1$ depends upon the fund size of all the banks which rank below S_{n-1} in the size league table. This concretely captures that the utility which must be provided to a banker is decided by a competitive labour market – and the marginal bidder for the banker is the fund with fund one notch down in the distribution of fund size. Applying this approach inductively the result follows.

An equilibrium of the entire market without risk-shifting is thus determined explicitly. The utility which needs to be offered to the bankers depends upon the size of the rival banks, as well as the bankers' skill and features of the investment technology.

5.1 Effect Of Competition On Risk Taking

Proposition 5 demonstrates the market rate of surplus which the bankers will secure when the banks bid for bankers using contracts which prevent risk-shifting. Note that if the banks of lower rank should grow then competition to hire the banker becomes more intense. This acts to drive up the utility which the banker must be awarded; (see 6). This follows as the marginal competing bank to hire the banker of rank n is the bank whose fund ranks one level below bank S_n, namely bank $n+1$. This is the bank whose bidding pushes up the utility which bank n offers to her banker. As the size of the fund bank $n+1$ has grows, the value of securing the better banker of rank n also grows. Hence bank $n+1$ would be willing to bid more aggressively, and so bank n must pay more to keep her banker.

We have already determined that as the utility which a bank must award its banker rises, so the temptation to move to contacts which allow some risk-shifting grows. This was the content of Proposition 4. One might suspect therefore that the equilibrium identified in Proposition 5 would break down as the competition to hire the bankers becomes more intense due to rival banks becoming larger, and hence closer, competitors. I now aim to illustrate exactly this, and develop a sufficient condition for risk-shifting to enter the banks' contracting arrangements.

Proposition 6 *A sufficient condition for the no risk-shifting equilibrium of Proposition 5 to break down, and for risk-shifting permitting contracts to enter the system, is if for some bank* n :

$$\sum_{j=n+1}^{N} \frac{S_j}{S_n} \left[\frac{\mu_{j-1} - \mu_j}{1 - \mu_n} \right] > \left[\frac{\eta (\rho + a + z)}{2a} - 1 \right] \left[\frac{\eta}{r} \frac{(\rho + a)}{a} \left(\frac{\frac{\rho}{\Lambda} + a\mu_n}{\rho + a\mu_n} \right) + 1 \right]$$

This section therefore explicitly demonstrates the negative externality arising from competition between the banks for the bankers. As consolidation drives bank balance sheets up, by the reasoning above, the banks are willing to bid more aggressively for bankers they will not ultimately win. This raises the surplus secured by these bankers and, equivalently, increases the market determined level of utility which the banks must make available to the bankers they hire. In pushing remuneration up for bankers they will not ultimately hire, the banks are not considering the risks which they impose on their rival banks. In particular, to deliver ever higher levels of utility the employing bank will ultimately find it preferable to use contracts which permit risk-shifting with some probability (Proposition 4).

Proposition 6 provides a sufficient condition under which the negative externality described becomes so strong it rules out an equilibrium in which no bank risk-shifts. The condition is only sufficient as it can be shown that before bank n felt compelled to use risk-shifting contracts, bank $n+1$, competing for banker n, would bid with a risk-shifting contract. This would push the utility which bank n needed to offer its banker higher, and bring forward the point at which risk-shifting occurred for bank n or one of the banks of higher rank.

A first implication of Proposition 6 is that if there is bank consolidation, which will imply growth in the balance sheets of rival funds (and rival banks), then it becomes more likely that unknown risk will be introduced into the system through the introduction of risk-shifting contracts. In Section 6 we will address the empirical relevance of the result.

A more detailed investigation of the pressures on corporate cultures to allow risk-shifting is possible:

Corollary 1 *Risk-shifting is more likely to enter the financial system as:*

1. *There is convergence in balance sheet size.*
2. *Bankers are more impatient.*
3. *Ability makes a greater contribution to profit generation (holding $\rho+a$ constant, a increases and ρ decreases).*
4. *The risk of large loss (η) which a risk-shifting banker inflicts on the bank becomes smaller.*

Proof. Consider the sufficient condition for risk-shifting to arrive (Proposition 6). Part 1 follows as the left hand side increases as S_j/S_n increases for $j > n$. For part 2 note that increasing r lowers the right hand side. For part 3 note that if $\rho + a$ is held constant then both right hand terms are decreasing in a. For part 4 note that as η increases both terms on the right hand side increase. ■

Part 1 of Corollary 1 presents a force which increases the utility which bankers secure and so makes risk-shifting more likely (Proposition 4). The intuition as to why convergent balance sheets drives up banker utility was explained above; and the empirical relevance of this mechanism will be considered next. However any change in the broader nature of banking and shadow banking which causes the amount of utility bankers secure to rise would also generate pressures to move to risk-shifting. For example it seems likely that efficiency-wages (Shapiro and Stiglitz 1984) in banking have risen in recent decades. Morrison and Wilhelm (2008) provide evidence that banker mobility has increased over the last 50 years; and many popular commentators allege that the 'poaching' of staff has become endemic in banking.[8] In this case bankers would not expect to face a long wait to secure another post should they lose, or be in danger of losing, their current position. This would therefore force up the efficiency-wage which an employer had to provide to her banker and so trigger the mechanism studied in this paper.

Part 2 notes that if the agents, the bankers, become more impatient then the pressure to jump to contracts which permit risk-shifting increases. If bankers are more impatient they discount the vested pay by a greater amount. As a result to prevent risk-shifting vested pay must rise. As consolidation between the firms drives up the agents' surplus the cost of preventing risk-shifting

[8] See for example 'Rise in City jobs leads to poaching fear', Financial Times, May 4, 2010.

goes up faster still on account of the enhanced discount rate. Overall therefore banks will feel the benefits of jumping to risk-shifting contracts sooner.

In part 3 we consider what happens if the contribution that ability makes to returns is higher. Some commentators have suggested that modern finance has become increasingly complicated (the use of derivatives, CDOs and CDO squareds are often cited). If so it is plausible that the relative importance of ability in generating returns has gone up. This motivates the study of a shift in returns to ability. Holding the total return $(\rho + a)$ fixed, the expected profit to a banker from risk-shifting remains unchanged as if the risk of failure materialises all returns are lost (the ρ and the a). With increased weight on ability the amount of vested pay which needs to be awarded increases if risk-shifting is to be avoided. This is because a banker who discovers they are not of the highest ability has a lot to lose if they do not risk-shift. To prevent this much pay must be deferred which raises the costs of avoiding risk-shifting. Hence a high return to ability makes it more likely that contracts permitting risk-shifting will become optimal.

Finally in part 4 suppose that the risk of loss in the case of risk-shifting (η) declines. The banker now becomes very tempted to cheat as the possibility of reduced period $t = 2$ pay is more remote. If the bank is to counteract this, more vested pay is required. As this is expensive banks are more likely to find it optimal to jump to a contract which permits some risk-shifting. One might be tempted to think that risk-shifting in this scenario matters less as the possibility of loss (η) is reduced. But note that, on account of limited liability, the banker is indifferent to the size of the loss (z). Hence if fund melt-downs became more severe in cost, but less likely to occur, the banker would be more tempted to risk-shift just when the expected cost from risk-shifting was rising.

6 Balance Sheet Consolidation – A Cause For Concern?

I have presented a model of bankers' remuneration in a competitive market for banker talent, in combination with risk-shifting and moral hazard contracting problems. The work has demonstrated that as the balance sheets converge in size, then banker rents rise. As banker rents rise the banks become more likely to introduce contracts which allow for some risk-shifting.

Thus we have a mechanism which links industrial structure to optimal tolerance, or not, of risk-shifting. In essence therefore this study provides a theory of how industrial structure can affect organizational culture towards risk. Others have argued that organizational culture is determined, in part, by industrial structure (Kotter and Heskett 1992, Gordon 1991, Chatman and Jehn 1994). This is a first model endogenising this link. Here I ask whether the data suggests, in the case of financial services, that risk-shifting, or its absence, would be a more compelling concern over the last 40 years.

To assess the extent to which balance sheet consolidation is a legitimate concern we must consult balance sheet data. To this end I downloaded all firm-year observations of total assets from Compustat for firms with Standard Industry Classification (SIC) codes between 6000 and 6300 for the years 1970 to 2009 inclusive.[9] I convert this dollar value into real 2005 dollars using

[9] I excluded firms with SIC code 6282 (Investment Advice), as these are neither lenders nor investors and so neither a bank nor a shadow bank. This leaves 31,333 observations capturing 2,829 separate firms over the 40 years of data.

a GDP deflator from the Bureau of Economic Analysis.

It has been widely reported that leverage grew substantially in the run up to the financial crisis. Indeed the total balance sheet (in real terms) of the 5 largest financial institutions grew from just $450 billion in 1970 to just under $14 trillion in 2008 (measured in 2005 dollars). Proposition 6 demonstrates that if smaller banks failed to grow at an even faster rate then the pressure to move to risk-shifting contracts would dissipate. However, if it were the case that banks ranked below 5 grew at an even faster rate, then the pressure to move to risk-shifting contracts would increase.

Which of these is the relevant empirical case can be analysed by comparing the evolution of the balance sheets of the top 5 banks against banks ranked 6 to 10, and again against banks ranked 11 to 15. This is done in Figure 3.

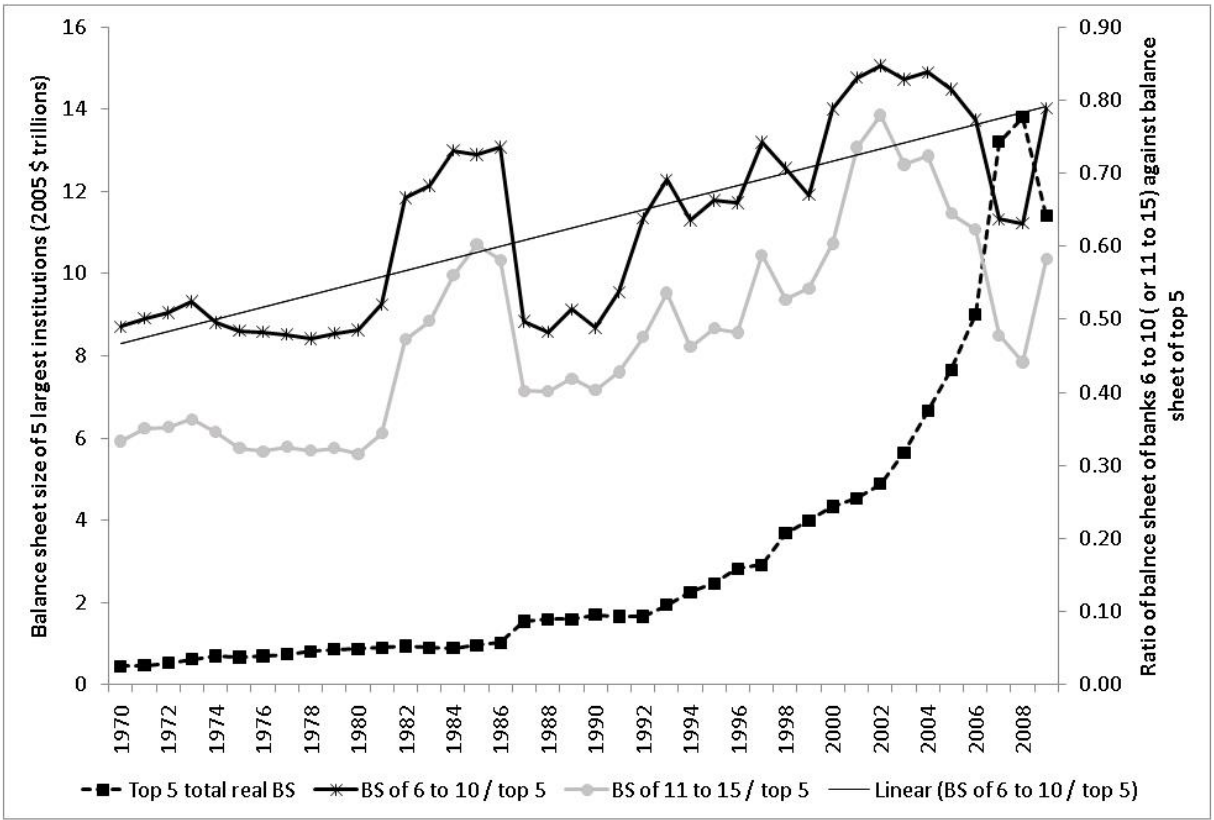

Figure 3: The evolution of bank and shadow bank balance sheets 1970-2009.
Notes: The graph shows that the US finance industry has seen substantial consolidation in balance sheets (BS), and so an increase in competitive pressure over a forty year period. The balance sheets of banks ranked 6 to 10 was about half of the top 5 in 1970. In the early years of this millennium banks 6 to 10 had grown to almost 90% the size of the top 5. The consolidation at the top increases the cost to the largest banks of maintaining contracts for their bankers which rule out risk-shifting as well as manage moral hazard. Such increases in competition, according to this analysis, increase the pressure on banks to allow some risk-shifting. [Compustat data on all financial institutions (SIC 6000-6300, excluding 6282)].

Figure 3 depicts the evolution of the total balance sheets of banks ranked 6 to 10, and also of banks ranked 11 to 15, as a proportion of the balance sheets of the five largest financial institutions. Given the explosive growth of the 5 largest institutions in each year (dotted line, left hand axis), one might suspect that the 5 largest institutions' growth would outpace their smaller rivals. In fact the opposite has been the case. The banks ranked 6 to 10 have grown their balance sheets even faster to become larger in relation to the very largest firms. For example, the banks ranked 6 to 10 in size in 1970 were half the size of the top 5 banks in 1970. By the early years of this millennium the banks ranked 6 to 10 had grown to nearly 90% of the size of the top 5. The same story is repeated for banks 11 to 15. This effect is statistically significant.[10]

The convergence in balance sheet size amongst the largest banks and financial institutions has therefore been unprecedented. Further Figure 3 depicts a lower bound for this convergence. The bound would only apply if all the smaller banks and shadow banks sought to cover all aspects of banking and so divided their balance sheets between the different activities in the same proportions as the larger banks. To the extent that smaller institutions focus on particular activities the convergence of balance sheets in any given asset class is more intense.

Figure 3 does not indicate whether the smallest banks in the US and internationally were converging, however the influence of these smaller banks on the risk-shifting condition of Proposition 6 is second order for two reasons. First the impact on a bank of rank n of a smaller bank of rank $j > n$ is given by the ratio of the fund sizes: S_j/S_n. By definition banks of lower rank have a smaller fund, and so for banks ranked a long way below n, their impact will be much diminished. Secondly the impact of a bank of rank j on larger banks is weighted by the term $\mu_{j-1} - \mu_j$ which measures the difference in ability between the banker j secures, and the banker one notch up in the skills league table. The individuals hired to run large sums of money will have banking and investing skills in the tails of the distribution of investing skills across the whole population. Therefore extreme value theory predicts that this difference shrinks at an exponential rate (Gabaix and Landier 2008). This reasoning implies that only banks of very high rank (the largest banks) will have a material impact on the condition of Proposition 6, and so Figure 3 is informative.

Thus we conclude that over the period 1970 to 2009 the pressure on the largest financial institutions to move to contracts with less vesting, contracts which would tolerate some risk-shifting by bankers of lesser ability, has increased. This section demonstrates that the empirically relevant part of this risk-shifting study concerns the increased pressures on each institution to risk-shift.

7 Conclusion

This paper has modelled bankers' incentive contracts in the context of competition between the banks for bankers. By doing so cleanly and tractably it has allowed the pressures created by industrial structure on bankers' remuneration to be analysed. This work contributes to the necessary intellectual deliberations which underpin the new regulations on the structure and level of bankers' pay: regulations which are currently being enacted in the EU and in the US.

Competition between the banks for bankers creates a negative externality which acts to

[10]Consider the trend line depicted in Figure 3 for the evolution of the ratio of banks ranked 6 to 10 against the top 5. This trend line has a positive slope of 0.0083 with a standard error of 0.001. Thus the gradient is positive and is easily significant at the 1% level. The figures for a trend line of the evolution of banks 11 to 15 against the top 5 are similar.

make it relatively more expensive for a bank to manage the risk-shifting problem than the moral-hazard problem. Banks need to maintain a proportion of bonus pay based on the npv of expected future revenues to manage moral hazard. But such incentives encourage risk-shifting. Hence a further proportion of bonus pay must be deferred, or vested. Such pay is of reduced value due to the bankers' discounting. Industry consolidation leading to closely matched firms drives the surplus which must be delivered to the employees up. The cost of ensuring sufficient pay is vested therefore rises at an even faster rate. Ultimately a bank can find it optimal to jump to contracts which allow risk-shifting with some probability. Once this occurs the extent of risk-shifting, and indeed even if any is, becomes unknown to the bank and the market.

The link I have studied between industrial structure and optimal tolerance of excessive risk taking applies widely. The analysis of the model is made, I believe, more compelling as key features of the Financial Sector have been evolving in a manner which triggers the studied mechanism. US banking data has shown convergence in the size of the balance sheets over a forty year period. This convergence grew to an unprecedented extent in the years just before the financial crisis. This convergence in balance sheets is one mechanism which leads to risk-shifting pressure. Further, the balance sheet analysis underestimates this pressure to the extent that smaller institutions and hedge funds decide to focus their balance sheets on subsets of the activities undertaken by financial intermediators.

As there is a market failure here there is a role for appropriate regulation of bankers' pay. This analysis offers support for a policy of mandating a minimum proportion of pay which should be deferred, and be responsive to actually realised revenues over the lifetime of the investments. This is the structure the Financial Stability Board have been proposing.

A Technical Proofs

Proof of Proposition 1. We consider in turn the conditions on the remuneration $\{f, \beta, v\}$ necessary to deliver no risk-shifting in equilibrium, then full risk-shifting and finally risk-shifting sometimes.

Corporate Governance Works: no risk-shifting. A no risk-shifting equilibrium is a separating equilibrium as lesser ability bankers are discovered promptly at the end of $t = 1$. By conforming to this equilibrium the lesser ability banker generates a profit at $t = 1$ of ρS and so the principal assigns an npv to the full profits of $2\rho S$. The payoff to the banker is:

$$U\left(\text{reveal}\right) = f + \beta 2\rho S + \frac{v}{1+r}\rho S \tag{7}$$

If instead the banker decides to risk-shift and emulate the high ability banker then the principal (mistakenly) assumes that the banker is high ability and assigns a value to the npv of profits as measured at the end of $t = 1$ of $2\left(\rho + a\right)S$. Hence the payoff from risk-shifting and emulating the high ability banker becomes

$$U\left(\text{risk-shift deviation}\right) = f + \beta 2\left(\rho + a\right)S + \tfrac{v}{1+r}\underbrace{\left[\left(1-\eta\right)\left(\rho + a\right)S + \eta\cdot 0\right]}_{\text{Limited liability}}$$

Therefore the no risk-shifting separating equilibrium can only be sustained if
$U\left(\text{reveal}\right) \geq U\left(\text{risk-shift deviation}\right) \Leftrightarrow 2a\beta \leq \frac{v}{1+r}\left[\rho\eta - a\left(1-\eta\right)\right]$ yielding (3).

Corporate Governance Fails Every Time – full risk-shifting. In an equilibrium in which the lesser ability banker emulates the high ability type then the principal remains ignorant of the true skill of the banker when she sees high first period profits. Hence the npv of the profit stream measured at time $t = 1$ is

$$\begin{aligned} \Pi_1^{\text{risk-shift}} &= S\left[\rho + a + (\rho + a)\left[\mu + (1-\mu)(1-\eta)\right] - z\eta(1-\mu)\right] \\ &= 2(\rho + a)S - \eta(1-\mu)(\rho + a + z)S \end{aligned} \tag{8}$$

This may or may not be positive. As the banker is governed by limited liability the payoff to a lesser ability banker from risk-shifting is now

$U(\text{risk-shift}) = f + \beta \max\left(0, \Pi_1^{\text{risk-shift}}\right) + \frac{v}{1+r}(1-\eta)(\rho + a)S$

Alternatively the lesser ability type can decide not to risk-shift. The principal would then know she was a lesser ability type at the end of $t = 1$. The npv of profits would then be $2\rho S$. And the lesser ability type would have utility (7). Incentive Compatibility for the lesser ability banker to risk-shift and so emulate a high ability type by risk-shifting requires

$U(\text{risk-shift}) \geq U(\text{reveal}) \Rightarrow \beta\left\{\max\left(0, \Pi_1^{\text{risk-shift}}\right) - 2\rho S\right\} \geq \frac{v}{1+r}\left[\rho\eta - a(1-\eta)\right]S$

yielding (4).

Corporate Governance Fails Some Of The Time – partial risk-shifting. Now consider an equilibrium in which a lesser ability banker risk-shifts with probability λ. If a lesser ability banker signals her type by not risk-shifting then her payoff is $U(\text{reveal})$ as given in (7). However, suppose that instead the lesser ability banker risk-shifts to disguise her type. In this case, using Bayes rule, when high profits are delivered at $t = 1$, the principal believes that the banker is actually of high ability with probability

$$\tilde{\mu} = \mu / \left[\mu + \lambda(1-\mu)\right] \tag{9}$$

Hence the principal assigns an npv to profits of

$\Pi_1^{\text{partial risk-shift}} = 2(\rho + a)S - \eta(1-\tilde{\mu})(\rho + a + z)S$

Thus the payoff to the lesser ability banker from risk-shifting is

$U(\text{partial risk-shift}) = f + \beta \max\left(\Pi_1^{\text{partial risk-shift}}, 0\right) + \frac{v}{1+r}(1-\eta)(\rho + a)S$

For the lesser ability bankers to be willing to randomise over whether to risk-shift or not the payoff from both activities must be the same. This will determine the probability λ:

$$\begin{aligned} U(\text{reveal}) &= U(\text{partial risk-shift}) \\ \Leftrightarrow \frac{v}{1+r}\left[\rho\eta - a(1-\eta)\right]S &= \beta\left(\max\left(\Pi_1^{\text{partial risk-shift}}, 0\right) - 2\rho S\right) \\ \frac{v}{1+r}\left[(\rho + a)\eta - a\right] &= \beta \max\left\{2a - (\rho + z + a)\eta(1-\tilde{\mu}), -2\rho\right\} \end{aligned} \tag{10}$$

(10) defines λ (contained in $\tilde{\mu}$) implicitly in terms of β and v. As $\lambda \in [0,1]$ we have $(1-\tilde{\mu}) \in [0, 1-\mu]$ (from 9). Hence the range of $\{f, \beta, v\} \geq 0$ in which there is partial risk-shifting, given in Proposition 1, is confirmed. ■

Proof of Proposition 2. By Proposition 1 a lesser ability banker will not risk-shift iff

$$v \cdot \left[\rho\eta - a(1-\eta)\right] / (1+r) \geq 2a\beta \tag{11}$$

The banker will be willing to accept the contract if

$$\begin{aligned} \mu\left(2\beta+\frac{v}{1+r}\right)(\rho+a)S+(1-\mu)\left(2\beta+\frac{v}{1+r}\right)\rho S &\geq u-f \\ 2\beta+\frac{v}{1+r} &\geq \frac{u-f}{(\rho+a\mu)S} \end{aligned} \tag{12}$$

If the banker should not exert effort then the principal will observe profits of $\varepsilon\rho S$ and so determine that the npv of the total profit stream is negative (Z is assumed sufficiently large). Hence for a banker who discovers they are of lesser ability to be willing to exert effort we require: $f+\beta 2\rho S+\frac{v}{1+r}\rho S\geq f\frac{1}{1-\Lambda}$
The condition for the high ability banker is easier to satisfy as this banker secures a greater payment when she does exert effort, while the payment from not exerting effort is unchanged. Hence we can rewrite this incentive compatibility condition as

$$2\beta+\frac{v}{1+r}\geq\frac{f}{\rho S}\frac{\Lambda}{1-\Lambda} \tag{13}$$

The principal's problem is therefore, noting that the principal does not discount vested pay:

$$\max_{\{f,\beta,v\}}\left[2-(2\beta+v)\right](\rho+a\mu)S-f\text{ , subject to }(11)\text{, }(12)\text{ and }(13)\text{.}$$

First we show that the no-risk-shifting condition, (11), must be tight. Suppose otherwise that (11) is slack at the optimum and so can be ignored. Holding $f+2\beta(\rho+a\mu)S$ constant, lower f and raise β. This leaves the objective function and (12) unaffected whilst making (13) easier to satisfy. Hence wlog f can be lowered to 0. The effort constraint, (13) is now satisfied and so can be ignored. Finally lower v and β until the participation constraint (12) is binding. The objective function can now be written
$\max_{\{f,\beta,v\}}\left[2-(2\beta+v)\right](\rho+\mu a)S=\max_v 2S(\rho+a\mu)-u-\frac{r}{1+r}v(\rho+\mu a)S$
As $r>0$ this is declining in v and so maximised at $v=0$. But this is a violation of the no shirking constraint (11) yielding the desired contradiction. Therefore at the optimum (11) is binding.

The bank's problem can therefore be rewritten

$$\max_{\{f,\beta,v\}}\left[2-\left(\frac{v}{1+r}\frac{\rho\eta-a(1-\eta)}{a}+v\right)\right](\rho+\mu a)S-f$$

$$\text{subject to }\frac{v}{1+r}\frac{\rho\eta-a(1-\eta)+a}{a}\geq\frac{f}{\rho S}\frac{\Lambda}{1-\Lambda} \tag{14}$$

$$\geq\frac{u-f}{(\rho+a\mu)S} \tag{15}$$

The objective function is decreasing in v. Hence v is optimally reduced until at least one of the constraints (14), (15) binds. Suppose, for a contradiction that (15) was slack. In this case (14) can be satisfied, and remuneration minimised, by setting $v=0=f$. But this contradicts (15) slack as $u\geq 0$. Hence (15) binds. Replacing f, the objective function remains decreasing in v as

$r > 0$. Substituting for f, constraint (14) becomes

$$\frac{v}{1+r}\frac{\rho+a}{a}\eta\left(1+\frac{\rho+a\mu}{\rho}\frac{\Lambda}{1-\Lambda}\right) \geq \frac{u}{\rho S}\frac{\Lambda}{1-\Lambda}$$

The objective function is maximised by lowering v until the above inequality is binding. Hence the optimal remuneration has both (14) and (15) binding. Using equality in (11) in addition, the optimal contract can then be explicitly solved for:

$$\begin{aligned} \frac{v}{1+r}\frac{\rho+a}{a}\eta\left(\frac{\rho}{\Lambda}+a\mu\right) &= \frac{u}{S} \\ f\left(\frac{\rho}{\Lambda}+a\mu\right) &= u\rho\frac{1-\Lambda}{\Lambda} \\ 2\beta &= \frac{v}{1+r}\frac{\rho\eta-a(1-\eta)}{a} \end{aligned} \tag{16}$$

■

Proof of Proposition 3. From Proposition 1 a lesser ability banker will always risk-shift if the remuneration contract satisfies

$$\frac{v}{1+r}\left[\rho\eta-a(1-\eta)\right] \leq \beta\max\left(-2\rho, 2a-\eta(1-\mu)(\rho+a+z)\right) \tag{17}$$

In an equilibrium in which the banker who discovers she is of lesser ability always risk-shifts, the principal will, at the end of period $t=1$ set expected npv of profits from the banker at $\Pi_1^{\text{risk-shift}}$ given in (8). Hence the banker will be willing to accept the contract if

$$\begin{array}{r} \mu\left[\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)+\frac{v}{1+r}(\rho+a)S\right] \\ +(1-\mu)\left[\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)+\frac{v}{1+r}(\rho+a)(1-\eta)S\right] \end{array} \geq u-f$$

This can be simplified to

$$\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)+\frac{v}{1+r}(\rho+a)\left[1-\eta(1-\mu)\right]S \geq u-f \tag{18}$$

Finally a banker who discovers they are of lesser ability will be willing to exert effort if

$$f+\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)+\frac{v}{1+r}(\rho+a)(1-\eta)S \geq f\frac{1}{1-\Lambda} \tag{19}$$

The expected remuneration the bank pays is

$$f+\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)+\left[1-\eta(1-\mu)\right]v(\rho+a)S \tag{20}$$

Let us assume the constraint (17) is slack at the optimum for the moment and so can be ignored. We first show that the participation constraint (18) must be binding at the optimum. Suppose otherwise, in this case remuneration would be minimised by lowering $\{f,\beta,v\}$ to 0 which would leave (19) satisfied. This is a contradiction to (18) being slack, and indeed (18) is contradicted if $u > 0$.

Therefore subbing (18) with equality into the objective function (20), expected remuneration can be written

$$u+\frac{r}{1+r}v\left(\rho+a\right)S\left[1-\eta\left(1-\mu\right)\right] \tag{21}$$

Hence remuneration is increasing in v. Therefore optimality would require v to be lowered subject to the constraints (18) with equality, and (19). The deferred pay, v, can be lowered to 0 if f and β can be found such that $\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)=u-f$ and $\beta\max\left(0,\Pi_1^{\text{risk-shift}}\right)\geq f\Lambda/(1-\Lambda)$. If $\max\left(0,\Pi_1^{\text{risk-shift}}\right)>0$ this is possible by setting $f=0$. In this case the optimal contract has been found as (17) is slack. If $\max\left(0,\Pi_1^{\text{risk-shift}}\right)=0$ and if $u>0$ then v cannot be lowered to 0 and so is positive. ■

Proof of Proposition 4. To hire her banker the bank must deliver to the banker a utility of u. The expected value of the bank under a contract which delivers no risk-shifting is

$$\begin{aligned}\text{Value} &= \mu\left[\begin{array}{c}2\left(\rho+a\right)S\\-\left(2\beta+v\right)\left(\rho+a\right)S\end{array}\right]+\left(1-\mu\right)\left[\begin{array}{c}2\rho S\\-\left(2\beta+v\right)\rho S\end{array}\right]-f\\&= \left[2-\left(2\beta+v\right)\right]\left(\rho+a\mu\right)S-f\end{aligned}$$

From Proposition 2 and in particular (16) we can substitute in and derive the bank's value:

$$\begin{aligned}\text{Value} &= 2\left(\rho+a\mu\right)S-\frac{v}{1+r}\frac{\rho\eta-a\left(1-\eta\right)+a\left(1+r\right)}{a}\left(\rho+a\mu\right)S-\frac{u}{\left(\frac{\rho}{\Lambda}+a\mu\right)}\rho\frac{1-\Lambda}{\Lambda}\\&= 2\left(\rho+a\mu\right)S-\frac{u}{\left(\frac{\rho}{\Lambda}+a\mu\right)}\frac{\left(\rho+a\right)\eta+ar}{\left(\rho+a\right)\eta}\left(\rho+a\mu\right)-\frac{u}{\left(\frac{\rho}{\Lambda}+a\mu\right)}\rho\frac{1-\Lambda}{\Lambda}\\&= 2\left(\rho+a\mu\right)S-u\left\{1+r\frac{a}{\left(\rho+a\right)\eta}\left(\frac{\rho+a\mu}{\frac{\rho}{\Lambda}+a\mu}\right)\right\}\end{aligned} \tag{22}$$

The bank could however offer a risk-shifting contract which delivers u to the banker. Consider a risk-shifting contract which induces lesser ability bankers to always risk-shift (Proposition 3). As we restrict to the case where the npv of the fund under risk-shifting is positive then vested pay (v) in such a contract is optimally set to 0. The cost of remuneration to the bank in this case is given by (21) as equal to u. Hence the value of the bank from enforcing such a contract is

$$\Pi_1^{\text{risk-shift}}-u=2\left(\rho+a\right)S-\eta\left(1-\mu\right)\left(\rho+a+z\right)S-u \tag{23}$$

Comparing (22) to (23) and re-arranging, risk-shifting becomes preferable for the bank if

$$ur\frac{a}{\left(\rho+a\right)\eta}\left(\frac{\rho+a\mu}{\frac{\rho}{\Lambda}+a\mu}\right)>S\left(1-\mu\right)\left[\eta\left(\rho+a+z\right)-2a\right] \tag{24}$$

Note that applying (1) and (2) guarantees that the right hand side is strictly positive. Hence the bank will resort to using risk-shifting contracts if u is large enough. ■

Proof of Proposition 5. Let us assume all the banks prefer to use contracts which ensure no risk-shifting, as stated in the proposition. We first demonstrate that the market equilibrium is characterised by positive assortative matching. Consider two banks m and $m-1$ and two bankers n and $n-1$. Suppose the banker n has an outside option of utility u^n. Bank m, can either hire banker n or try for the better $n-1$. Bank m will be willing to bid a utility of $u^{m,n-1}$

for banker $n-1$ where, using (22):

$$\begin{array}{ccc} [\rho+\mu_{n-1}a]\,2S_m & & [\rho+\mu_n a]\,2S_m \\ -u^{m,n-1}\left\{1+r\frac{a}{(\rho+a)\eta}\left(\frac{\rho+a\mu_{n-1}}{\frac{\rho}{\Lambda}+a\mu_{n-1}}\right)\right\} & = & -u^{n}\left\{1+r\frac{a}{(\rho+a)\eta}\left(\frac{\rho+a\mu_{n}}{\frac{\rho}{\Lambda}+a\mu_{n}}\right)\right\} \end{array} \tag{25}$$

Note that $u^{m,n-1}$ is increasing in S_m as $\mu_{n-1} > \mu_n$. Hence bank $m-1$ is willing to offer more utility to the better banker than bank m. Thus we have positive assortative matching.

In equilibrium bank n will need to match the utility which bank $n+1$ is willing to bid for banker n. This utility is $u^{n+1,n}$. Using (25) the utility that bank $n+1$ would bid for banker n is:

$$u^{n+1,n}\left\{1+r\frac{a}{(\rho+a)\,\eta}\left(\frac{\rho+a\mu_n}{\frac{\rho}{\Lambda}+a\mu_n}\right)\right\} = 2S_{n+1}a\left[\mu_n-\mu_{n+1}\right]+u^{n+1}\left\{1+r\frac{a}{(\rho+a)\,\eta}\left(\frac{\rho+a\mu_{n+1}}{\frac{\rho}{\Lambda}+a\mu_{n+1}}\right)\right\}$$

Bank n will match this utility. Hence $u^n = u^{n+1,n}$. Iterating we have

$$u^{n}\left\{1+r\frac{a}{(\rho+a)\,\eta}\left(\frac{\rho+a\mu_n}{\frac{\rho}{\Lambda}+a\mu_n}\right)\right\} = \sum_{j=n+1}^{N} 2aS_j\left[\mu_{j-1}-\mu_j\right]+u^{N}\left\{1+r\frac{a}{(\rho+a)\,\eta}\left(\frac{\rho+a\mu_{N}}{\frac{\rho}{\Lambda}+a\mu_{N}}\right)\right\}$$

The results then follow as $u^N = 0$. ■

Proof of Proposition 6. From the proof of Proposition 4 we have that bank n would rather resort to risk-shifting if the utility u^n which must be delivered to the banker satisfies (24). Substituting in the value for u^n derived in Proposition 5 yields the result. ■

B Numerical Simulation Details

The value of the bank if using the optimal contract which delivers no risk-shifting is given by (22); (23) gives the bank value if risk-shifting is guaranteed. We now determine the bank value if it targets risk-shifting with probability $\lambda \in (0,1)$. In this case high profits at $t=1$ deliver an ex post belief that the banker is of high ability of $\tilde{\mu} = \mu/\left[\mu+\lambda(1-\mu)\right]$. The banker of lesser ability must be willing to randomise between risk-shifting and revealing her ability. Hence λ must satisfy (10). As the left hand side is positive this is only possible if $\tilde{\mu}$ is large enough (λ small enough) that the right hand is positive also. Hence we can write this as

$$\frac{v}{1+r}\left[(\rho+a)\,\eta-a\right] = \beta\left[2a-(\rho+z+a)\,\eta\,(1-\tilde{\mu})\right] \tag{26}$$

A high ability banker will deliver high $t=1$ profits, but the bank will only believe the banker is indeed high ability with probability $\tilde{\mu}$. Hence the banker will be willing to accept the contract if

$$\begin{aligned} & \mu\left[\beta\cdot\left[2(\rho+a)S-\eta(1-\tilde{\mu})(\rho+a+z)S\right]+\frac{v}{1+r}(\rho+a)S\right] \\ + \quad & (1-\mu)\left[\beta\cdot\left[2(\rho+a)S-\eta(1-\tilde{\mu})(\rho+a+z)S\right]+\frac{v}{1+r}(\rho+a)(1-\eta)S\right] \geq u-f \end{aligned}$$

I have used the fact that if the banker discovers she is of lesser ability, she is indifferent between risk-shifting and not. We can simplify the participation constraint to
$\beta\cdot\left[2(\rho+a)S-\eta(1-\tilde{\mu})(\rho+a+z)S\right]+\frac{v}{1+r}(\rho+a)\left[1-\eta(1-\mu)\right]S \geq u-f$

Now applying (26) we have the participation constraint. The optimal contract will lower the payments so that this binds:

$$2\beta\rho S + f = u - \frac{v}{1+r}\left[(\rho + a)\,\eta\mu + \rho\right] S \tag{27}$$

Next a banker who discovers they are of low ability will be indifferent between risk-shifting and not, and so will be willing to exert effort if:

$$f + \beta 2\rho S + \frac{v}{1+r}\rho S \geq f\frac{1}{1-\Lambda} \tag{28}$$

It can be shown that the optimal contract will lower the payments so that this moral hazard constraint binds also. This yields three equations which can be solved in terms of λ. In particular

$$\frac{v}{1+r}\left\{(\rho + a)\,\eta\mu + \frac{\rho}{\Lambda} + 2\frac{\rho}{\Lambda}\frac{\left[(\rho + a)\,\eta - a\right]}{\left[2a - (\rho + z + a)\,\eta\,(1-\tilde{\mu})\right]}\right\} = \frac{u}{S} \tag{29}$$

And then (26) yields β and finally f is given most simply by combining (27) and (28) to yield:

$$f\frac{1}{1-\Lambda} = u - \frac{v}{1+r}\,(\rho + a)\,\eta\mu S$$

The value of the bank depends upon the risk-shifting probability both through the actual value of profits and also the remuneration. Hence if a lesser ability banker risk-shifts with probability λ then the bank's profit net of payments to the banker is

$$\begin{aligned}
&\mu 2\,(\rho + a)\,S + (1-\mu)\left[(1-\lambda)\,2\rho + \lambda\left[2\,(\rho + a) - \eta\,(\rho + a + z)\right]\right] S \\
&\mu\cdot\left\{-\beta\left[2\,(\rho + a)\,S - \eta\,(1-\tilde{\mu})\,(\rho + a + z)\,S\right] - v\,(\rho + a)\,S\right\} - f \\
&+ (1-\mu)\cdot\left\{\begin{array}{c} -\,(1-\lambda)\,(2\beta + v)\,\rho S \\ +\lambda\left[-\beta\left[2\,(\rho + a)\,S - \eta\,(1-\tilde{\mu})\,(\rho + a + z)\,S\right] - v\,(\rho + a)\,S\,(1-\eta)\right] \end{array}\right\}
\end{aligned}$$

Application of (26) simplifies this bank profit term to

$$\begin{aligned}
&\mu 2\,(\rho + a)\,S + (1-\mu)\left[(1-\lambda)\,2\rho + \lambda\left[2\,(\rho + a) - \eta\,(\rho + a + z)\right]\right] S \\
&(\mu + \lambda\,(1-\mu))\cdot\left\{-\beta 2\rho - \frac{v}{1+r}\left[(\rho + a)\,\eta - a\right] - v\,(\rho + a)\right\} S - f \\
&+ (1-\mu)\cdot\left\{-\,(1-\lambda)\,(2\beta + v)\,\rho + \lambda\eta v\,(\rho + a)\right\} S
\end{aligned} \tag{30}$$

Substituting in for the optimal contract $\{f, \beta, v\}$ allows the bank's value to be determined numerically for any given λ. Scaling the profit given by (30) against the return given in (23) for full risk-shifting allows Figure 2 to be generated.

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