The Making of (Modern) Banks[*]

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Abstract

To issue riskless, money-like claims, banks' capital and organizational structure, and bankers' compensation contracts, must be jointly designed to both induce effort and discourage risk-taking. Our model explains why bankers receive high pay for producing mediocre outcomes, and why pure charter value (or market value of equity) is insufficient to prevent risk-taking. Outside shareholders contributing book equity are useful, despite introducing another layer of agency problems. 'Big' banks with multiple bankers issuing joint liabilities are endogenously most efficient in money creation. Each banker's pay should depend on the entire bank's performance although he exerts control only over his own project.

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1 Introduction

Jensen and Meckling argue that 'most organizations are simply legal fictions, which serve as a nexus for a set of contracting relationships among individuals' (Jensen and Meckling (1976), p310). Of perhaps no organization is this more true than of a bank. There has been much analysis of contracting between banks and their creditors (depositors), and between banks and their borrowers. The contracting relationship between a bank and its key decision-making employees, though less studied, is arguably equally important. After all, it is those employees who determine the nature of the bank's investments. But almost all of the literature analyzes bilateral contracts between a bank and a single counterparty – be it creditor, borrower, or employee. How a bank's financing and employment contracts interact with one another – how a bank's capital structure affects the way its shareholders design incentives for its key decision-making employees, especially in an endogenous organizational structure – has been hardly studied at all. In this paper, we study banks as a whole: as a system of principal-agent relationships which interact with one another.

We remain true to the framework Jensen and Meckling envisaged, by modeling a setting in which agents must take effort to find profitable investment projects, and in which they may decide to invest in risky, unprofitable projects if their incentives make this advantageous for them. While many organizations feature effort and risk-taking problems, the need to provide incentives both to make effort and to avoid excessive risk-taking is particularly acute for banks, where opportunities to take risk are relatively easy for agents to find, hard for principals to detect, and excessive risk-taking has the potential to result in significant losses and even the insolvency of the organization. In addition, we highlight in our model that one role of banks, as compared to other financial institutions, is that they must attempt to convert potentially risky investments into truly safe 'money-like' deposits.[1] We study how the nexus of contracts described by Jensen and Meckling should be designed in order to allow the bank to create private money most efficiently, using bankers' human capital and scarce risk-bearing capital.

We begin our study with a short tour through the history of banking. We show that when depositors desire risk-free claims, the risk-shifting action available to a banker makes it impossible for a sole proprietor bank to obtain financing even when his investment has very positive net present value, unless the banker himself has (enough) equity to contribute. We then examine partnership banks, where two penniless bankers can join together in a partnership and share the returns of their investments. We show that when the riskiness of the two partners' investment projects are independent of one another, a partnership can be viable where a sole proprietorship is not. This happens because a banker's potential loss of his share in the NPV of his partner's project to creditors, when his own gamble turn out badly, effectively slackens his limited liability constraint, making risk-taking less attractive. Counterintuitively, exchanging some of the "skin in the game" a banker has in his own investment for "skin in the game" in a partner banker's investment which he neither observes nor controls, improves incentives, and makes a partnership viable.

Nevertheless, when gambles are sufficiently likely to turn out well (i.e. risk-taking is sufficiently tempting), the charter value provided by the stake in his partner's project will be insufficient to prevent an individual banker from gambling. In this case, a bank

[1] Financial claims that circulate as private money are often short-term IOUs, which are designed to be risk free. Gorton and Pennacchi (1990), and Dang et al. (2015, 2017) provide microfoundation as to why banks gain from issuing risk free securities instead of risky ones. Stein (2012) adapts this idea, developing a model of the financial system in which investors will pay a premium (γ) for assets which are completely risk free. For simplicity, in this model, we assume the premium is sufficiently large that banks issue only safe debt; any risk must be borne by shareholders. While this is an extreme assumption, it remains true that the 'moneyness' of bank deposits distinguishes banks from non-banks and shadow bank institutions.

cannot be sustained using only the 'market' value of inside equity; actual paid-in 'book' equity from an external shareholder is required. This weakness of partnership banks when agents with banking skills have little or no cash to pay into the business themselves points to a role for outside equity in the modern banking structure that we see today. This structure, together with the financing and compensation contracts that it involves, is the main focus of our analysis.

Consistent with public ownership in the real world, our outside equity holder has no banking skills per se, but, unlike the bankers themselves, she is endowed with a limited quantity of risk-bearing capital which she can inject into her bank(s). Doing so has a benefit, in that it reduces the leverage of the bank, and a cost, in that it introduces an extra layer of principal-agent relationship. Now, the depositors contract with the external equity holder, who in turn contracts with the bankers who make investment decisions. Because our bank is not a black box, risk-taking does not depend on leverage per se, but on the incentive contracts that the shareholder writes with the bankers, who control the bank's risk. Indeed, corporate finance theory is often criticized on the grounds that capital structure is a very blunt instrument for controlling individual managers' incentives. Our model is immune to this criticism because the risk-taking incentives of individual bankers are determined not by the capital structure of the bank, but by the incentive contracts offered to them by the shareholder.[2] The shareholder's incentives are then determined by the amount of leverage in the bank, which the shareholder endogenously chooses. This two-layer structure (which arises endogenously) allows us to separate the compensation problem from the capital structure problem.

[2] John et al. (2000) argues that capital regulation can be ineffective in containing bank risks and that a more direct mechanism is to link deposit insurance premium to the incentive features of top-management compensation. Similarly, Bolton et al. (2015) suggest incorporating the bank's CDS spread into the design of its executive compensation. In our model, the bank's capital structure provides incentives to the shareholder, who in turn provide incentives to bankers via compensation contracts.

We consider three different degrees of internal transparency of banks with outside shareholders: public contracts, where everyone including bank creditors can observe the compensation contracts inside the banks; semi-public contracts, where bankers can observe each others contracts but creditors cannot see them; and private contracts, where one banker cannot observe the other's compensation. In all three cases, the agency cost of inducing banker effort while simultaneously discouraging risk-taking plays a key role. Specifically, a banker with incentives to pass up risky opportunities must receive a higher level of expected pay than one who takes every investment opportunity, risky or safe. To see why, note first that to induce effort, an agent (banker) must receive more from a successful investment than from simply doing nothing, (and returning depositors money at the end of the period). In the standard setting without risk-taking, a risk-neutral banker can be paid zero (limited liability imposes this lower bound) unless his effort yields the most successful outcome, in which case he can be paid the cost of effort divided by the probability of the most successful outcome. Thus, with no risk-shifting problem, the banker can be made to work for zero rent in expectation. But in our problem, in order for bankers to avoid risk as well, they must also be paid more than for making no investment than for taking the risky investment. Otherwise, when a risky investment arises, the banker will take it, rather than passing it up and not investing depositors' money. Taking a risky investment has positive value to the banker since when it pays off it is indistinguishable from a safe investment and so yields positive expected compensation, and limited liability implies his compensation is zero when it does not pay off. Therefore bankers must be paid a rent for taking no investment if they are to be persuaded to avoid risky investments, and hence must be paid even more to induce them to take effort to find projects rather than making no effort and no investment. This feature makes it more expensive to compensate bankers to act safely than to take risks. It is also what makes it impossible to fund a sole proprietorship (and hard to sustain a partnership) since in the absence of paid-in equity, there are no funds available to pay the banker for not finding a profitable, safe investment when no excess returns are generated and yet deposits must be paid out in full.

When creditors can observe banker compensation contracts, then such "public" contracts can be used to make bankers' incentives to control risk credible to depositors, giving banks with outside shareholders an advantage over partnership banks. Whereas in a partnership bank, it is impossible to commit to no risk-taking if the upside is too tempting, an outside shareholder can act as a budget breaker in a transparent public bank, extracting the upside from risk-taking, and removing the temptation.

However, outside shareholders are not needed just for writing contracts: they must also provide external financing. Paid in equity is required to deleverage the bank, ensuring that there are always sufficient funds available to pay bankers the agency rent they are promised, even in the most unfavorable states. Although a correctly organized bank has high market value from potential profitable opportunities, this is insufficient to sustain bankers incentives when they know that available opportunities are risky, because if all risky investments are avoided, there is no surplus capital to pay agency rents, and we are back to the same problems that plagued the sole proprietor and partnership banks.

Naturally, if compensation contracts are only visible to bankers but not creditors ("semi-public") the outside shareholder, who owns a leveraged bank, may be tempted to change the banker contracts to take risk. The creditors, fearing such risk-shifting, will be unwilling to deposit their funds unless more outside equity is injected, so that not only the budget constraint in the worst states (as with public contracts), but also shareholder incentive constraint is satisfied. When compensation contracts are not transparent to outsiders, shareholders' "skin in the game" determines their motives in writing incentive contracts controlling bankers' actions. However, in our model, the shareholder's gain from allowing risk-taking in a bank arises not only for standard risk-shifting reasons (i.e., the equity holder's claim is junior to the depositors'). there is a further factor which has been overlooked by the literature. Recall from above that is more expensive to induce safe behavior than risky behavior from bankers. This implies that the shareholder has an additional gain from allowing risk-taking because it allows her to reduce the expected cost of banker compensation. Further, when bankers cannot see each others' incentive contracts, a scenario we call "private contracts", the shareholder can use risk-shifting to expropriate not only depositors, but also bankers who are playing safe and are expropriated by the unexpected loss of compensation resulting from their colleagues playing risky.[3]

We explore different organizational structures for a bank that is financed by outside equity. One option, which we call 'small banks', is for the outside shareholder to inject equity into two separate banks that are fully insulated and ring-fenced from each other. Each 'small' bank is then run by an individual banker and issues debt separately to its own depositors (i.e., the two banks issue no joint liabilities). The outside equity injection allows a banker to receive positive compensation when he has to ignore the risky investment and simply return capital to depositors. Without additional paid-in capital, and with separate liability structures, the bankers would necessarily receive zero compensation in this case, and hence would be tempted to gamble. So outside equity makes safe 'small' banks possible.

An alternative arrangement is what we call a 'large bank', which hires two bankers and issue deposits to finance both bankers' investment. The joint liabilities create the risk that one banker's gambling can bring the entire bank down, as the failing project's

[3]Thanassoulis (2012), quoting a former Lehman employee, noted how a banker's compensation is clearly linked to the whole bank's performance: "what is unfair is if you are an analyst who takes zero risk for the bank, and yet you can still be harmed by somebody who has been acting like they work for a mortgage hedge fund rather than an investment bank."

liabilities will have a claim against the successful one. This potential for 'risk contamination' might seem to make large banks undesirable. However, because in our model the risk taken by the bankers is endogenous and controlled by the shareholder, the risk that everything may be lost if a single risk is taken actually enhances the shareholder's incentives to control risk, and we find that because of this, depositors can trust the large bank to operate safely with a smaller amount of paid-in equity than in the case of small banks.

Since each banker in a large bank controls only his own investment, it would seem natural for each banker's compensation to depend only on the performance of his investment and not on the performance of other bankers. But our model reveals three reasons why is efficient to let a banker's compensation also depend on the performance of the whole bank, so that a banker's compensation increases (decreases) when the other banker's project generates high (low) returns. First, a banker's expected 'skin in the game' in the other investment not managed by him can provide incentives for him to play safe on his own investment, because with joint liabilities, a loss on his own investment will jeopardize his stake in the other project as well (as in the partnership case described above). Second, institution-performance-sensitive compensation relaxes the budget constraint in the low-return states and mitigates the conflict between paying the bankers to preserve their incentives and repaying depositors to keep their claims risk-free. This is important when compensation contracts are public. Third, under private contracting, the role of institution-performance-sensitive compensation is to redistribute part of the gain from risk-taking to the banker who plays safe if the shareholder ever contracts the other banker to engage in risk-taking. Here, it is not the reduction of a banker's compensation when the other banker generates a low return that improves efficiency, but rather the reduction in the shareholder's compensation when the other banker generates high return that is the important feature of institutional-performance-related pay.

In summary, our paper models the endogenous emergence of public ownership for banks and highlights the importance of paid-in capital versus market equity. We explain why a 'big' bank with multiple divisions and joint liabilities can perform the function of asset transformation better than 'small' banks. Through the friction of imperfect incentive contracting within the bank, we can explain why bankers' compensation should depend on the performance of divisions that they cannot influence. Finally, we use our model to provide a unified framework that provide normative perspectives on various policy issues surrounding banker pay, bank capital, and ring-fencing.

Related literature: Bankers in our model need to be motivated both to make effort and to avoid risk-taking, and the two moral hazard problems interact with each other. Such intertwined agency problems are also featured in contributions such as Biais and Casamatta (1999), Inderst and Ottaviani (2009), Hakenes and Schnabel (2014), and Song and Thakor (2019). We analyze a situation where multiple bankers can form a coalition to run a bank or be contracted to do by a shareholder, and analyze the interdependence of their compensation contracts. Furthermore, the bankers' compensation contracts must be aligned with the bank's capital structure to provide correct incentives to both bankers and the shareholder. As far as we are aware, analysis of such a setting is novel to the banking literature.

Since a partnership bank in our model issues no external equity, such a bank can also be seen as a private bank. In this sense, our model's prediction that public ownership facilitates the issuance of risk-free debt is broadly inline with empirical evidence that public ownership can reduce the cost of debt in non-financial industries, e.g., Badertscher et al. (2019). We provide an explicit agency model to explain how the injection of external equity can contain bank risks and facilitate deposit issuance.

Our model's prediction that a 'big' bank outperforms 'small' banks is broadly related to the literature where diversification and greater scale reduce the agency cost of contracting for banks, such as mitigating costly state verification in Diamond (1984). Banal-Estañol et al. (2013) point out that such increases in scale and diversification have the downside of risk contamination, in our model, the very fact that one failed banking project can destroy the value of a successful one strengthens incentives for the shareholder to contract bankers to avoid risk-taking in each project.[4] This relaxed incentive constraint from putting multiple bankers in one bank is linked to the idea of 'cross-pledging' as in Cerasi and Daltung (2000), Laux (2001), and Chapter 4 of Tirole (2006). Our model, however, deviates from the literature in at least three ways. First, and most importantly, those papers feature a single agent acting on two projects issuing joint liabilities. By contrast, in our model, each individual project is operated by a different agent, so issuing joint liabilities ties one agent's compensation to another agent's performance, which is generally not a good idea, Hölmstrom (1979). Second, because our model features risk taking, higher output does not necessarily signal efficient actions from the agent, and the extremely convex compensation that arises in the literature (whereby the agent will be paid only if all project succeeds), will not be optimal in our model. Third, our model features a two-layer agency problem. The two bankers, who have direct control over risk-taking, do not own any of the assets and so are not able to engage in cross-pledging; their actions are determined solely by their incentive contracts. Instead, it is the shareholder who owns the assets but has no direct control

[4]A crucial difference leading to contrasting results is that the distributions of cash flows in Banal-Estañol et al. (2013) are exogenous and the risk of contamination is on the equilibrium path,we allow the riskiness of cash flow to be endogenous in our framework, and so the risk of contamination arises only off the equilibrium path.

over the moral hazard actions related to those assets, who can engage in cross-pledging to relax her incentive to set safety-inducing incentive contracts for the bankers.

The problem of private contracting with multiple agents was first analyzed in the industrial organization literature on vertical relationships, (Mcafee and Schwartz (1994); Rey and Verge (2004)) and was more recently introduced to applications in finance by Gryglewicz and Mayer (2023), Demarzo and Kaniel (2023), and Buffa et al. (2020). While the vertical relationship in these papers is mostly exogenous (e.g., one upstream monopoly must contract with two downstream firms, or one principal must contract with two agents), the organizational structure where a shareholder contracts with two bankers emerges endogenously as a more efficient structure in our model despite potential negative externalities between bankers.

In our model, it is efficient to make a banker's compensation depend on the bank's overall performance, instead of the performance of his individual project. Such institution-performance-sensitive compensation contracts are also the focus of papers such as DeMarzo and Kaniel (2017), Chen (2020), and Efing et al. (2022). DeMarzo and Kaniel (2017) explain agent pay's low sensitivity to his individual performance by 'keeping up with Joneses' (KUJ) preferences, whereas Chen (2020) explains the phenomenon by arguing that equity compensation insures employees against the risk of low promotion perspectives. Efing et al. (2022), in particular, empirically document such institution-performance-sensitive compensation in the banking sector and provide a theoretical model explaining the phenomenon as arising from capital market frictions. In our model, the institution-performance-sensitive contracts serve two purposes: they ease the shareholder's budget constraint in the worst states, reducing the need for paid-in equity; and they force a risk-taking banker and shareholder to share the upside from risk-taking with other bankers, reducing the incentive for risk-taking.

Our paper is structured as follows: Section 2 sets up the model. Section 3 analyzes how a bank, as a nexus of contracts, should be organized, and how its financing and compensation contracts should be jointly designed, to enhance asset transformation. Section 4 discuss the model's policy implications, and Section 5 concludes.

2 The Model

We consider an economy with three groups of economic agents: (1) two risk-neutral, penniless bankers with access to a productive investment technology, (2) a risk-neutral investor with limited wealth, and (3) investors who are infinitely risk-averse but will provide funds in unlimited supply in exchange for risk-free claims. For the ease of exposition, we will refer to the risk-neutral investor as the 'shareholder' and the infinitely risk-averse investors as 'depositors'.[5]

2.1 Bankers' investment technology and agency problems

The two bankers have identical investment technologies, each capable of managing an investment of size I. In conducting his investment, a banker needs to exert both effort and risk control. In particular, after having raised capital I, the banker needs to take unobservable effort to find an investment opportunity, e.g., to devise a trading strategy

[5]Our model of banking does not feature deposit insurance. Therefore, depositors will be willing to invest only if the financing and compensation contracts the bank features ensure that the claims they receive are risk free. Thus, one could think of our depositors as sophisticated uninsured creditors (e.g., other banks, bondholders). Alternatively, one can consider that because of free-riding and/or deposit insurance, most depositors do not monitor, and that it is for a bank regulator to put in place rules ensuring the contracts comprising a bank do not compromise the safety of depositors' claims, Dewatripont and Tirole (2010). Our paper can then be seen as speaking to the rules around bank structure and compensation which such a regulator should put in place. For more discussion on this interpretation, see Section 4.

or to identify a potential borrower. Without the effort, the banker will find no investment opportunity and can only sit on capital I. Once the banker exerts the effort at a private cost τ, an investment opportunity arises, which can be either safe or risky, known only to the banker. A safe investment, occurring with probability q, will generate a return of $R \in (I, 2I)$ with certainty. If the investment opportunity is risky, which occurs with probability $1-q$, the banker must decide to either avoid the risk, preserving the capital I (playing safe), or take the risk (gambling), which will return R with probability p and 0 with probability $1-p$. When a banker takes effort but gambles upon a risky investment opportunity, the probability of his investment returning R is

$$\mu = q + (1-q)p.$$

The banker is protected by limited liability and cannot be required to add more funds to a failed project. We assume that effort is socially efficient when there is no risk-taking:

$$\tau \leq q(R - I) \equiv \widehat{\tau}_{FB}. \tag{1}$$

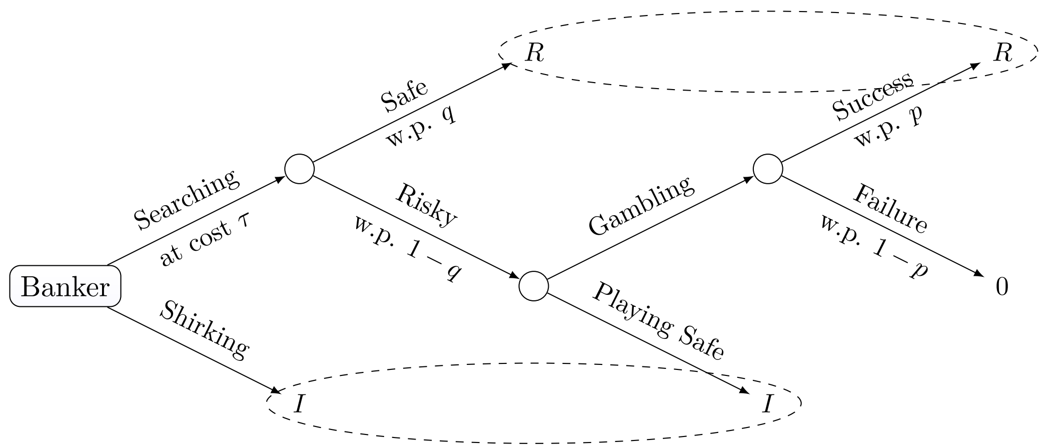
And the risk-taking is inefficient:

$$pR < I. \tag{2}$$

We summarize the bankers' investment technology in Figure 1.

While the final payoff generated by a banker is publicly observable, neither the bankers' actions (i.e., shirking and gambling) nor the intermediate state (i.e., the investment opportunity being risky or safe) are observable. A return R can result from a safe investment or successful gambling. Similarly, when a banker returns only I, the zero net return can be due to a lack of effort or the banker choosing to play safe when

Figure 1: Agency problems in the banking technology



facing a risky investment opportunity. The dashed circles in Figure 1 emphasize that an observed return (an information set) can stem from different combinations of actions.

When two bankers manage their respective investments, we assume all risks are independent. Specifically, whether a banker encounters a risky or safe investment opportunity is independent of the other banker's investment opportunity being risky or not; and whether a banker's risk-taking pays off (if he decides to gamble) is independent of whether the other banker gets a safe/risky investment opportunity or whether the other banker's risk-taking succeeds.

2.2 Bank financing and compensation contracts

Since bankers are penniless, the capital outlay for their investments has to be raised from depositors and the shareholder. We denote the risk-neutral shareholder's wealth by A and assume this risk-bearing capital to be limited, $A < 2I$, so that the shareholder cannot finance both bankers' investments entirely with her endowment. Therefore, financing the investments must involve the depositors who are infinitely risk averse and require their claims to be risk-free. This preference for safety can be interpreted as the depositors' need to access a store of value, a form of money, for transaction purposes.[6] The restriction that the bank is required to issue safe claims also reduces the number of cases that we need to study, by ruling out the possibility of a bank where shareholders allow bankers to take the risky investment even though it is negative NPV.

The shareholder can create a bank by contracting with depositors to raise funding (i.e., issuing the bank's financing contracts) and contracting with bankers who run the bank (i.e., offering compensation contracts). While the shareholder cannot observe the bankers' actions or the intermediate states, she can design the bankers' compensation contracts to indirectly control the bankers' effort and risk-taking decisions. As outsiders, depositors may not observe the bankers' actions, the intermediate states, or the compensation contracts that the shareholder offers to the bankers. The shareholder, therefore, may be tempted to shift risk to the depositors.

2.3 The bank

Our model features a mismatch between skilled labor and capital (bankers have skilled labor but no wealth to finance any investment) and a mismatch between capital and risk-bearing capacity (the shareholder who can bear risks has only limited endowment). A bank emerges as an organization created by financing and compensation contracts that link the different economic agents and meet their respective needs: the bank issues risk-free liabilities to satisfy the depositors' demand for safety, while allowing the skilled but penniless bankers to deploy their investment technology and earn profits (if running a

[6] Safe claims are money-like and therefore yield lower returns than risky claims, reducing the bank's funding cost. The bank's need to provide fully safe claims to satisfying the infinite risk-aversion of depositors can be micro-founded using the arguments of Stein (2012), Gennaioli et al. (2012), and Gorton and Pennacchi (1990). An alternative interpretation is that depositors are insured, but the regulatory authority requires insured banks to be organized and/or sufficiently capitalized that the bankers avoid taking the risky negative NPV investment.

bank of sole proprietorship or partnership) or agency rents via compensation (if hired by the shareholder). The shareholder, when creating a bank connecting the former parties, bears possible risks with her equity, enables productive investments, and earns a return. Such a bank in our model also fulfills the classic function of asset transformation: when properly structured with well-designed financing and compensation contracts, the bank allows the bankers to search for and pursue safe and productive investments amid risky ones and to issue risk-free claims to depositors. For the remainder of the paper, we will refer to the issuance of risk-free liabilities as money creation.

A bank in our model is characterized by an endogenous, nested, two-layer design: it is created by financing and compensation contracts that are embedded in and adapted to the bank's endogenous organizational structure. Depending on whether (1) the bank is partly financed by the shareholder's paid-in equity or not, and (2) whether the two bankers' projects issue joint or individual liabilities to depositors, a bank in our model can be organized in one of the four ways as summarized in Table 1.

	w/o paid-in equity	w/ paid-in equity
w/o joint liabilities	sole proprietorship	shareholder-owned 'small' bank
w/ joint liabilities	partnership	shareholder-owned 'big' bank

Table 1: Possible organizational structures of a bank

When the bank is partly financed by the shareholder's paid-in equity, the bank is also characterized by its capital structure, in particular, the fraction of investment financed by paid-in equity capital vis-à-vis risk-free deposits. We study how a bank's organizational structure as well as its financing and compensation contracts should be jointly designed to maximize money creation. We consider a banking sector to be more efficient when the bankers' investments are financed with more risk-free claims issued to depositors.[7]

We assume that the loss-absorbing buffer provided by the shareholder is limited relative to the potential loss from risk-taking: when a banker's failed gamble returns 0, her bank whose liabilities are jointly backed by the cash flows of both bankers' projects will fail, even if the other banker's project returns R. That is, $R + 0 \leq 2I - A$ or

$$A \leq 2I - R. \tag{3}$$

Since total project returns are verifiable, we assume that the depositors will take action to claim all available cash flows in any off-equilibrium outcomes. In particular, in the case of a bank failure, all available funds will go to the depositors. Both the shareholder and the bankers will receive zero payoffs in that contingency.[8]

3 Making Banks

In a frictionless world where the intermediate states are verifiable and bankers' actions directly contractible, bankers will pursue only safe investment opportunities and be compensated for their cost of effort. Specifically, a banker will receive τ/q for generating R from a safe investment and 0 when he faces a risky project and generates I from

[7]This consideration is highlighted in Diamond and Rajan (2000) and can be micro-founded, for example, because the shareholder can also use her scarce capital to make productive investments in a non-financial sector (Gorton and Winton (2017)).

[8]For example, when a bank has two projects, the depositors will claim all the cash flow of the bank when the bank's total cash flow is not $2R$, $R + I$ or $2I$. This assumption reduces the shareholder's and the bankers' off-equilibrium payoffs and makes a safe bank easier to sustain. The amount of paid-in equity required to run a safe bank is thus a lower bound on what could be obtained with any other priority of claims in bankruptcy.

avoiding the risk. In such a scenario, a bank's organizational and capital structures are irrelevant. Lemma 1 summarizes the first-best allocation.

Lemma 1. *(First Best) In the absence of frictions, a safe bank can be established for* $\tau \leq \widehat{\tau}_{FB}$*. The bank's organizational structure is irrelevant, and the entire investment of* $2I$ *can be financed by risk-free deposits, with no external shareholder financing required.*

In the remainder of this section, we explore whether it is possible for the bankers to operate without external shareholder equity when bankers' actions and the intermediate states are unobservable. We show that, due to bankers' inability to commit to no risk-taking, a sole proprietorship bank without paid-in equity cannot attract depositors. By contrast, two bankers acting together can form a partnership bank to issue risk-free claims, as long as risk-taking opportunities are sufficiently unattractive (Section 3.1). Otherwise, the involvement of the shareholder is necessary. For a bank with shareholder ownership, we consider three scenarios, highlighting how informational frictions shape the bank's organizational structure, capital structure, and compensation contracts.

1. We start with a case where bankers' compensation contracts are observable both internally among bankers and externally to depositors. This case of public contracting is equivalent to assuming that the shareholder can commit to no risk-shifting to both depositors and bankers (Section 3.2).

2. We then consider semi-public contracting, where contracts are observable within a bank among bankers but not to outside depositors. The shareholder, therefore, can shift risks to depositors (Section 3.3).

3. Finally, we examine private contracting, where contracts are observable only to the signing parties. That is, a banker's compensation can be observed neither by

the other banker nor by outside depositors. This allows the shareholder to shift risks not only to depositors but also to the bankers (Section 3.4).

3.1 Banks without Paid-in Equity?

3.1.1 A sole proprietorship bank of a lone banker

A safe sole proprietorship bank run by a single banker is infeasible. To see this, suppose that such a bank is financed by deposits I. To encourage effort, the banker must receive a positive payoff when his project generates R. Meanwhile, to discourage the banker from risk-taking, the banker must receive a positive payoff when he gives up a risky investment opportunity because otherwise, the banker has nothing to lose and can possibly gain from gambling (if the gamble happens to pay off). However, when the banker chooses not to invest, only I is available for distribution. Paying the banker any positive amount in this contingency will reduce the depositors' payoff below I, making deposits no longer risk-free. Therefore, a sole banker cannot finance his project without an external shareholder to provide risk-bearing equity. We summarize this result in Proposition 1.

Proposition 1. *A sole banker with no endowment cannot create a safe proprietorship bank by directly issuing risk-free debt to depositors.*

3.1.2 A partnership bank of two bankers

We now allow the two penniless bankers to form a partnership and explore under what conditions a safe bank can be established. We focus on symmetric monotonic profit-sharing rules that stipulate the following. When the partnership bank generates $2R$, the two bankers share the residual value equally. When the bank generates $R + I$, the banker who returns R obtains a β share of the residual value, whereas the banker who returns I obtains $1-\beta$ share. We require $\beta \geq 1/2$ so that a banker's payoff is monotonic in the performance of his own investment. In any other scenarios, the bankers' will be 0 under our assumption $R < 2I$. We prove the following proposition.

Proposition 2. *When $p \leq 1/2$, a symmetric profit-sharing rule with $\beta \in \left[\frac{\tau}{\widehat{\tau}_{FB}}, \frac{\mu-p}{\mu}\right]$ allows a safe partnership bank to be established and fully financed by risk-free deposits in a Nash equilibrium. That is, no banker will find it profitable to defect by shirking or gambling unilaterally. The set of such β is non-empty if and only if $\tau \leq \frac{\mu-p}{\mu} \cdot \widehat{\tau}_{FB} \equiv \widehat{\tau}_s$.*

Proof. See Appendix A.1. □

Proposition 2 shows that establishing a partnership without paid-in equity, is difficult, but not impossible (as it was with sole proprietorship). Intuitively, while β needs to be sufficiently high to induce effort but cannot be too high – otherwise risk-taking becomes an attractive defection. The condition $p \leq 1/2$ makes risk-taking by the two bankers unprofitable,[9] and the condition $\tau \leq \widehat{\tau}_s$ ensures that there is enough surplus to preserve the bankers' incentives. Why does joining two projects and compensating partners out of joint profits allow a safe bank to be funded? The reason is that it eases the limited liability constraint of each banker when he is faced with a risky project. A banker, if he gambles and fails, will forfeit his stake in the other banker's project that has a positive NPV. This does not happen with sole proprietorship because there is no other banker's project. Joining two units creates a form of incentive synergy. The benefit is not from diversification per se, because the risk is endogenous: simply putting two risky units together would not reduce risk enough on its own to reassure the infinitely risk-averse depositors, and it is entirely possible to eliminate risk even with a single project. It is

[9] We show in Appendix A.2 that $p > 1/2$ is also a sufficient condition for the bankers to have incentives to *collectively* defect on depositors.

rather that risk is endogenous, and imperfect correlation between the charter value of the two banking units reduces each partner's incentives to gamble. A successful partnership relies, however, on the stringent assumption that the two bankers must not observe the realization of each other's project types: if they do, they will always take risk when there are two risky draws, making it impossible to fund the bank ex ante.

Proposition 1 and 2 establish that without paid-in equity, establishing a safe bank is either impossible (with sole proprietorship) or difficult (feasible only for $p \leq 1/2$ with partnership). In the next section, we ask whether we can improve the situation by introducing the shareholder's risk-bearing capital and external ownership. In this sense, our model features an endogenous owner-management relationship formation. The fact that banking skills and risk-bearing capital are not endowed to the same agents leads to the need to create an institution, a bank, that matches the skilled labor with capital.

Assumption 1. *To focus on the empirically relevant case where partnership is not a mainstream form of banking, we assume $p > 1/2$ for the remainder of the paper.*

3.2 Making banks with public contracts

We now introduce the risk-neutral shareholder, who has no skill in searching for or selecting projects but can provide her limited wealth A as the risk-bearing, paid-in equity of a bank. We assume the shareholder has full bargaining power when contracting with both the bankers and depositors and will make them take-it-or-leave-it offers. We begin with the simplest case, where a banker's compensation contract is observable to all other parties. This implies that the shareholder can commit to no risk-shifting by choosing appropriate incentive contracts for bankers. We will relax this assumption in Sections 3.3 and 3.4.

3.2.1 'Small' banks under public contracting

First, consider that the shareholder creates two separate banks: she injects $A/2$ into each bank as paid-in equity and hires one banker to run each bank. We interpret this structure as two 'small' banks, since each bank has only one project managed by a single banker. The two banks are completely separate entities with no joint liabilities, and each banker's compensation depends only on the performance of his own bank. We denote by by $C_{\{s\}}$ (compensation) a banker's compensation when his bank returns I and by $B_{\{s\}}$ (bonus) a banker's compensation if his bank returns R. The shareholder aims to induce depositor participation by creating safe banks, at the least cost of compensating the bankers. That is,

$$\begin{aligned} \min_{\{B_{\{s\}},C_{\{s\}}\}} \quad & qB_{\{s\}} + (1-q)C_{\{s\}} \\ \text{s.t.} \quad & C_{\{s\}} \geq pB_{\{s\}} && (4) \\ & qB_{\{s\}} + (1-q)C_{\{s\}} - \tau \geq C_{\{s\}}. && (5) \end{aligned}$$

Inequalities (4) and (5) represent a banker's (ex-post) incentive constraint for no gambling when the banker has encountered a risky investment opportunity, and the (ex-ante) incentive constraint for exerting effort.[10] The solution of the program entails both incentive constraints binding, and Lemma 2 characterizes the optimal compensation contract.

Lemma 2. *When hiring a single banker to run a 'small' bank, the shareholder will offer to the banker* $B^*_{\{s\}} = \frac{1}{\mu-p}\tau$ *and* $C^*_{\{s\}} = \frac{p}{\mu-p}\tau$ *in order to induce effort and prevent gambling. The banker gains a rent* $X = C^*_{\{s\}}$.

[10]Since a banker cannot establish a bank (either as with a sole proprietorship or a partnership) without the shareholder's paid-in equity and would earn a zero payoff, the value of the banker's outside opportunity is zero. Therefore the banker's participation constraint is implied by inequality (5).

Our model highlights an intrinsic conflict between generating returns and controlling risk in a setting of delegated investment. Increasing a banker's compensation when he returns R both induces effort but also creates incentives for risk-taking. To offset such incentives for risk-taking, Lemma 2 shows that we must have $C^* > 0$, in other words, a banker's compensation must not be compressed even if he generates a zero net return.[11] In this sense, the banker may appear to be compensated for 'having done nothing'. Indeed, since the banker can also return I by taking no effort rather than searching for and then letting go a risky investment opportunity, a positive C implies that B has to increase accordingly to induce effort. The whole compensation schedule is shifted upwards by the risk-shifting opportunity. In fact, the banker obtains an expected rent

$$X \equiv qB^*_{\{s\}} + (1-q)C^*_{\{s\}} - \tau = C^*_{\{s\}}, \tag{6}$$

which exactly equals his compensation when generating a zero net return. The risk-shifting problem in our model means that part of the cash flow of the investment cannot be pledged to external financiers in the, low return, I state. This is in contrast with agency models with only an effort problem, where the limit to the pledgeable income exists in the high state of the world, e.g., Holmstrom and Tirole (1997).

Given the optimal compensation contract $\left\{B^*_{\{s\}}, C^*_{\{s\}}\right\}$, the shareholder can create two safe 'small' banks by injecting equity $A/2$ into each to satisfy the budget constraint

[11] It should be noted that, in our setting, the positive compensation C is not provided to insure the banker as agent as in P-A models with principal-agent risk-sharing because the banker is risk neutral. It is instead necessary to avoid risk-taking under the banker's limited liability. This feature that low performance is rewarded is also present in Manso (2011), which, like the current paper, features a tension between two desirable but potentially conflicting actions.

when the bank has an income I, i.e., inequality (7), and that when the bank has an income R, i.e., inequality (8):

$$A/2 \geq C^*_{\{s\}} \tag{7}$$

$$A/2 \geq B^*_{\{s\}} - (R - I). \tag{8}$$

Since the shareholder herself does not directly control risk-taking, equity is not used to preserve shareholder's incentives, as it would be in many models of banking. Instead, risk-taking is controlled by the bankers, shareholder paid-in equity is needed only to deleverage the bank sufficiently to pay the banker's compensation in state I, i.e., $A/2 \geq C^*_{\{s\}}$.[12] In addition to the budget constraints, the shareholder's participation constraint (9) also needs to be met

$$2\Big[q \cdot \big[R - (I - A/2) - B_{\{s\}}\big] + (1-q) \cdot \big[I - (I - A/2) - C_{\{s\}}\big] - A/2\Big] = 2q(R-I) - 2X - 2\tau \geq 0. \tag{9}$$

The shareholder cannot obtain the full NPV of the projects because she must concede agency rents to the bankers. Her participation constraint is therefore satisfied only for $\tau \leq \widehat{\tau}_s \equiv \frac{\mu-p}{\mu}\widehat{\tau}_{FB} < \widehat{\tau}_{FB}$, and there is credit-rationing for $\tau \in (\widehat{\tau}_s, \widehat{\tau}_{FB}]$.

Proposition 3. *When $\tau \leq \widehat{\tau}_s$, the shareholder can create two 'small' banks by offering compensation contract $\{B^*_{\{s\}}, C^*_{\{s\}}\}$ to each banker and injecting in total equity $A_1 \equiv X$ into the two banks, so that each banker can be paid $C^*_{\{s\}}$ when his bank returns I.*

Proof. See Appendix A.3. □

[12]The lack of funds to compensate bankers in this state is why a sole proprietorship cannot survive. By contrast, the shareholder can provide funds up front, delevering the bank in the lowest state so that there will be funds available to pay the banker not to take risk when the opportunity arises. The shareholder is compensated by extracting funds in the higher state(s). In a way, the outside equity mitigates the incomplete market problem due to the unobservability of the interim state.

3.2.2 A 'big' bank under public contracting

We now show that creating a 'big' bank that contracts with both bankers and allows each banker's compensation to depend on the whole bank's performance (and, therefore, the performance of the other banker's project) can improve efficiency.[13] The shareholder now injects A into the 'big' bank as paid-in equity, raises $2I-A$ from external depositors who demand safety, and hires two bankers each running one division. Let $C_{\{s,s\}}(I)$ and $C_{\{s,s\}}(R)$ denote a banker's compensation when his own project returns I whereas the other banker's project returns I and R respectively, where the subscript $\{s,s\}$ indicates both bankers playing safe. Similarly, $B_{\{s,s\}}(I)$ and $B_{\{s,s\}}(R)$ denote a banker's compensation when his own project returns R whereas the other banker's project returns I and R respectively. We define institution-performance sensitive compensation W as follows.

Definition 1. *Institution-performance sensitive compensation: a banker's pay not only increases in the return of his own project but also in the return of the investment managed by the other banker.*

$$C_{\{s,s\}}(R) \geq C_{\{s,s\}}(I) \qquad\qquad B_{\{s,s\}}(R) \geq B_{\{s,s\}}(I) \tag{10}$$

$$B_{\{s,s\}}(I) \geq C_{\{s,s\}}(R) \tag{11}$$

The institution-performance-sensitive compensation maintains monotonicity in two dimensions. First, Banker i's compensation (weakly) increases in Banker j's performance holding Banker i's own performance constant, i.e., inequalities (10). Second, Banker i's compensation (weakly) increases in his own performance, independent of Banker j's performance, i.e., inequality (11). In the absence of this second monotonicity constraint, a

[13]This can be counter-intuitive because standard agency theory suggests that agents' compensation should not depend on variables outside their control, so making compensation depend on the performance of individuals whose incentive contracts the agent does not observe seems like it should be counter-productive.

banker would have incentives to sabotage his own investment project or mis-report its return, Innes (1990),[14] whereas the first set of monotonicity constraints suggest that a banker's compensation is *not negatively correlated* with the bank's overall performance. Otherwise, a banker would have incentives to sabotage his colleague's investment. Efing et al. (2022), for example, also documents a positive correlation between bankers' pay and their bank's overall performance.The institution-performance-sensitive compensation is consistent with practices such as providing equity and/or stock options of a whole banking group to bankers who do not oversee the conglomerate, as well as the creation of a bonus pool whose size dependent on the overall bank performance, and then divide the bonus pool according to divisional and individual performance.

The shareholder solves the following program when creating a 'big' bank, by optimizing on the bankers' compensation contract $\mathcal{C} \equiv \left\{C_{\{s,s\}}(I), C_{\{s,s\}}(R), B_{\{s,s\}}(I), B_{\{s,s\}}(R)\right\}$.

$$\max_{\mathcal{C}} \quad \Pi = q^2 \cdot \left[2R - (2I - A) - 2B_{\{s,s\}}(R)\right] + 2q(1-q) \cdot \left[(R + I) - (2I - A) - (B_{\{s,s\}}(I) + C_{\{s,s\}}(R))\right]$$
$$+ (1-q)^2 \cdot \left[2I - (2I - A) - 2C_{\{s,s\}}(I)\right] - A$$
$$A \geq 2C_{\{s,s\}}(I) \tag{12}$$
$$A \geq B_{\{s,s\}}(I) + C_{\{s,s\}}(R) - (R - I) \tag{13}$$
$$A \geq 2B_{\{s,s\}}(R) - 2(R - I) \tag{14}$$
$$\left[qC_{\{s,s\}}(R) + (1-q)C_{\{s,s\}}(I)\right] \geq p \cdot \left[qB_{\{s,s\}}(R) + (1-q)B_{\{s,s\}}(I)\right] \tag{15}$$
$$q \cdot \left[qB_{\{s,s\}}(R) + (1-q)B_{\{s,s\}}(I)\right] + (1-q) \cdot \left[qC_{\{s,s\}}(R) + (1-q)C_{\{s,s\}}(I)\right] - \tau$$
$$\geq qC_{\{s,s\}}(R) + (1-q)C_{\{s,s\}}(I) \tag{16}$$
$$\Pi \geq 0 \tag{17}$$

Parallel to the program in the 'small' bank case, inequalities (12), (13), and (14), are the budget constraints when the bank's total income is $2I$, $I + R$, and $2R$, respectively. Inequalities (15) and (16) are a banker's ex-post incentive constraint for no gambling

[14]This constraint also mimics the requirement of $\beta \geq 1/2$ in the case of a partnership bank.

and ex-ante incentive constraint for taking effort, and inequality (17) is the shareholder's participation constraint. Lemma 3 characterizes a continuum of contracts that minimize the shareholder's expected compensation cost, which is necessary for the maximization of the shareholder's payoff. When equity is scarce, it is plausible that the shareholder will try to minimize the use of paid-in equity in financing the bank, this can be due to the opportunity cost of equity, or the existence of convenience yield for bank deposits.[15]

Lemma 3. *When designing institution-performance-sensitive compensation, the shareholder optimally make a banker's expected compensation for returning I or R the same as in the case where the banker's compensation depends only on his own project return:*

$$qB^*_{\{s,s\}}(R) + (1-q)B^*_{\{s,s\}}(I) = B^*_{\{s\}} \quad \textit{and} \quad qC^*_{\{s,s\}}(R) + (1-q)C^*_{\{s,s\}}(I) = C^*_{\{s\}}. \quad (18)$$

Proof. See Appendix A.4. □

The condition (18) suggests that the shareholder concede no more rent to the bankers as compared to the case where a banker's pay depends only on his own project's performance. Intuitively, any more rent to the bankers will reduce the shareholder's expected payoff and tighten her participation constraint. Furthermore, paying the bankers more in the low-return states (e.g., when both bankers returning I) will also tighten the bud-

[15]Minimizing the use of equity in the bank's funding mix can be rationalized in a model of variable investment size. For the opportunity cost of equity and the existence of the convenience yield, one may see Gorton and Winton (2017) and Drechsler et al. (2017, 2021), respectively. Arguably, banks may have little comparative disadvantage in issuing equity as compared to non-bank firms, e.g., equally subject to asymmetric information and possible underpricing of equity, but have comparative advantage in issuing debt such as deposits.

get constraint in such states. Lemma 3 suggests that there is no loss of generality to express the institution-performance sensitive compensation contracts as the following

$$B^*_{\{s,s\}}(R) = B^*_{\{s\}} + \delta_B \qquad B^*_{\{s,s\}}(I) = B^*_{\{s\}} - \tfrac{q}{1-q}\delta_B, \tag{19}$$

$$C^*_{\{s,s\}}(R) = C^*_{\{s\}} + \delta_C \qquad C^*_{\{s,s\}}(I) = C^*_{\{s\}} - \tfrac{q}{1-q}\delta_C, \tag{20}$$

where δ_B and δ_C satisfy $\delta_B \geq 0$, $\delta_C \geq 0$, and $q\delta_B + (1-q)\delta_C \leq \frac{1-q}{q}\tau$, so that the monotonicity conditions as in Definition 1 are met. These compensation contracts 'tweak' the contract under which a banker's pay depends only on his own performance (i.e., $C^*_{\{s\}}$ and $B^*_{\{s\}}$ in Lemma 2): for the same *expected* pay for individual performance, a banker's pay is boosted by δ when the other banker's investment returns R, and reduced when the other banker's investment only yields the low return I. δ_B and δ_C measure the sensitivity of a banker's pay to the other banker's (therefore the whole bank's) performance.

The shareholder can use the 'tweaked' compensation contract to minimize the use of paid-in equity. In particular, the shareholder can do so by minimizing $C^*_{\{s,s\}}(I)$ so as to minimize the compensation when both bankers return I and the bank's income is the lowest, while paying the bankers in the states where the overall revenue of the bank is higher.[16] Designing such compensation contracts is particularly important if shareholder's endowment is low enough that $A < 2C^*_{\{s\}}$, so that creating a safe bank with the compensation contract in Lemma 2 is infeasible. Lemma 4 characterizes to what extent the shareholder can reduce $C^*_{\{s,s\}}(I)$.

Lemma 4. *To create a safe 'big' bank with a minimum amount of paid-in equity, the shareholder can set $C^*_{\{s,s\}}(I) = 0$ for $\tau \leq \frac{\mu-p}{2p}\widehat{\tau}_{FB}$, whereas for $\tau > \frac{\mu-p}{2p}\widehat{\tau}_{FB}$, the minimum $C^*_{\{s,s\}}(I) = C_{\{s\}} - \frac{1}{2}\widehat{\tau}_{FB} > 0$ and needs to be financed by shareholder's equity.*

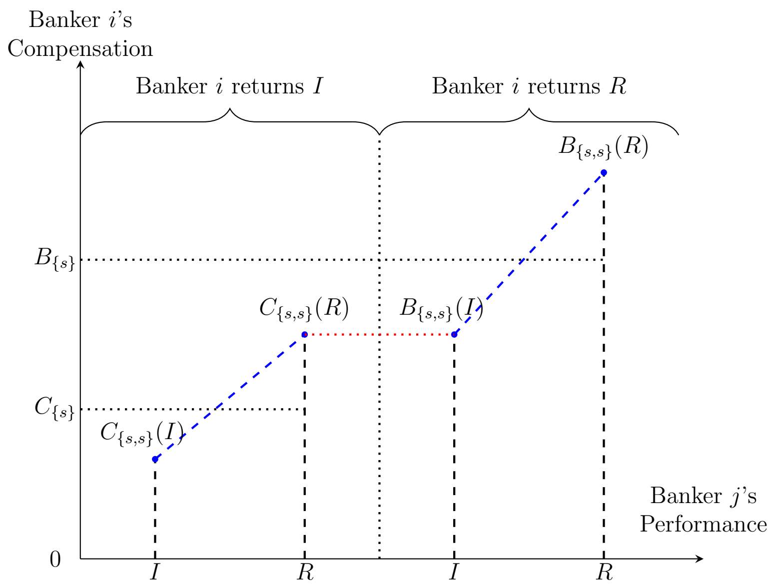
[16]This is similar to the partnership, where a banker's incentive to behave is preserved by his skin-in-the-game in the other banker's project.

Proof. See Appendix A.5. □

Intuitively, when lowering $C^*_{\{s,s\}}(I)$, the shareholder must simultaneously increase $C^*_{\{s,s\}}(R)$ to ensure that the bankers receive sufficient expected compensation for avoiding risk. When the agency cost is low, this process remains feasible till $C^*_{\{s,s\}}(I)$ is reduced all the way to zero, without breaching the budget constraint in the middle state where one banker returns I and the other banker returns R. Whereas if the agency cost is high, to prevent the increase in $C^*_{\{s,s\}}(R)$ from breaching the budget constraint in the middle state, the shareholder will need to reduce the compensation $B^*_{\{s,s\}}(I)$, the compensation to the banker who returns R. But $B^*_{\{s,s\}}(I)$ is bounded from below by the compensation for the worse-performing banker, $C^*_{\{s,s\}}(R)$, due to the monotonicity constraint. When the monotonicity constraint binds, the only way to provide more compensation for avoiding risk is for the shareholder to deleverage the bank with paid-in equity so that the bankers can be paid in the worst states to avoid gambling. That is, when the monotonicity constraint $C^*_{\{s,s\}}(R) \leq B^*_{\{s,s\}}(I)$ and the middle-state budget constraint both become binding, $C^*_{\{s,s\}}(I)$ is positive and needs to be covered by the paid-in equity. In such a case, the bankers' compensation will depend only on the revenue of the whole bank $I+I$, $I+R$, or $R+R$ and not at all on individual performance, for the banker who returns I and the banker who returns R receive the same pay.

Figure 2 illustrates the 'tweaked' compensation for this second case in Lemma 4, where the low shareholder endowment and the high agency cost make it necessary to set $C^*_{\{s,s\}}(I) > 0$ and $C^*_{\{s,s\}}(R) = B^*_{\{s,s\}}(I)$. In its essence, the benefit of institution-performance-sensitive compensation is that it allows the shareholder to shift compensation into the high-return state (where both bankers' projects return R) as much as possible. This reduces the need for paid-in equity, and Proposition 4 characterizes the minimum amount of paid-in equity required to establish a safe bank.

Figure 2: Institution-performance-sensitive Compensation



The figure shows an example of the institution-performance-sensitive compensation, whereby a Banker i's compensation not only increases in his own performance but also in Banker j's performance. Meanwhile, the expected compensation when Banker i generates I (R) remains the same as under individual-performance-sensitive compensation. This plot shows a case where $C_{\{s,s\}}(R) = B_{\{s,s\}}(I)$.

Proposition 4. *When $\tau \leq \widehat{\tau}_s$ and the shareholder can commit to no risk-shifting, she can increase money creation by setting up a safe, 'big' bank that hires both bankers. By allowing a banker's compensation to depend on the whole bank's performance, the shareholder only needs to provide paid-in equity*

$$A \geq A_2^{pub}(\tau) = 2C^*_{\{s,s\}}(I) = \begin{cases} 0 & \tau \in \left[0, \frac{\mu-p}{2p}\widehat{\tau}_{FB}\right] \\ 2C^*_{\{s\}} - q(R-I) & \tau \in \left(\frac{\mu-p}{2p}\widehat{\tau}_{FB}, \widehat{\tau}_s\right], \end{cases} \tag{21}$$

with the big bank's maximum money creation being $2I - A_2^{pub}(\tau)$.

A safe bank is feasible for the same $\tau \leq \widehat{\tau}_s$ as in the case of a partnership, since we allow the shareholder to write transparent, binding compensation contracts with the bankers, which cannot be renegotiated and therefore commit all sides to no risk-taking.

In a way, the shareholder here brings only the benefit of being a budget breaker, who takes away the gains from the upside of risk-taking from the bankers, but cannot take risks herself because of the commitment provided by public compensation contracts. For this reason, the safe bank is also feasible for $p > 1/2$, whereas it is not for a partnership that retains the gain from risk-taking rather than selling it to a third party.

We now examine the connection between the bank's capital structure and bankers' compensation design from a different angle by answering the question: for a given amount of equity financing A, how should the bankers' compensation be structured? A contract of particular interest is one that entails the minimum amount of 'tweak' and exposes a banker least to his colleague's performance. This can be desirable even if the bankers show an arbitrarily low level of risk aversion or because the measure of output from each individual project is noisy – compensation contracts need not to be complicated unless necessary. Let δ_C^* and δ_B^* be the minimum 'tweak' to the bankers' compensation in order to implement a safe bank. Proposition 5 shows that the need to expose bankers to each other's performance decreases in the bank's paid-in equity A, and the result is visualized in Figure 3.

Proposition 5. *The need to expose a banker's compensation to the performance of the other banker decreases in the bank's A equity capitalization A.*

- *When $A \in \left[2C_{\{s\}}, 2I\right]$, $\delta_C^* = 0$ and $\delta_B^* = 0$ so that a banker's compensation can depend on his own performance only.*
- *When $A \in \left[A_2^{\delta_B^*=0}(\tau), 2C_{\{s\}}\right)$, where $A_2^{\delta_B^*=0}(\tau) = \frac{2}{1+q}\left[\frac{p+q}{p}C_{\{s\}}^* - \widehat{\tau}_{FB}\right]$, a banker i's compensation needs to be exposed to the banker j's performance only when banker i returns I on his own project. That is, $\delta_C^* > 0$, and $\delta_B^* = 0$.*

- *When* $A \in \left[A_2^{pub}(\tau), A_2^{\delta_B^*=0}(\tau)\right)$*, a banker* i*'s compensation needs to be always exposed to the banker* j*'s performance, whether banker* i *returns* I *or* R *on his own project. That is,* $\delta_C^* > 0$*, and* $\delta_B^* > 0$*.*

Furthermore, for $\forall\tau \in (0, \widehat{\tau}_s]$*, we have* $\delta_C^* > \delta_B^*$*,* $\partial\delta_C^*/\partial A \leq 0$*, and* $\partial\delta_B^*/\partial A \leq 0$*, and* $\delta_B^* > 0$ *only if* δ_C^* *hits its maximum value* $C_{\{s\}}/q$*.*

Proof. See Appendix A.6. □

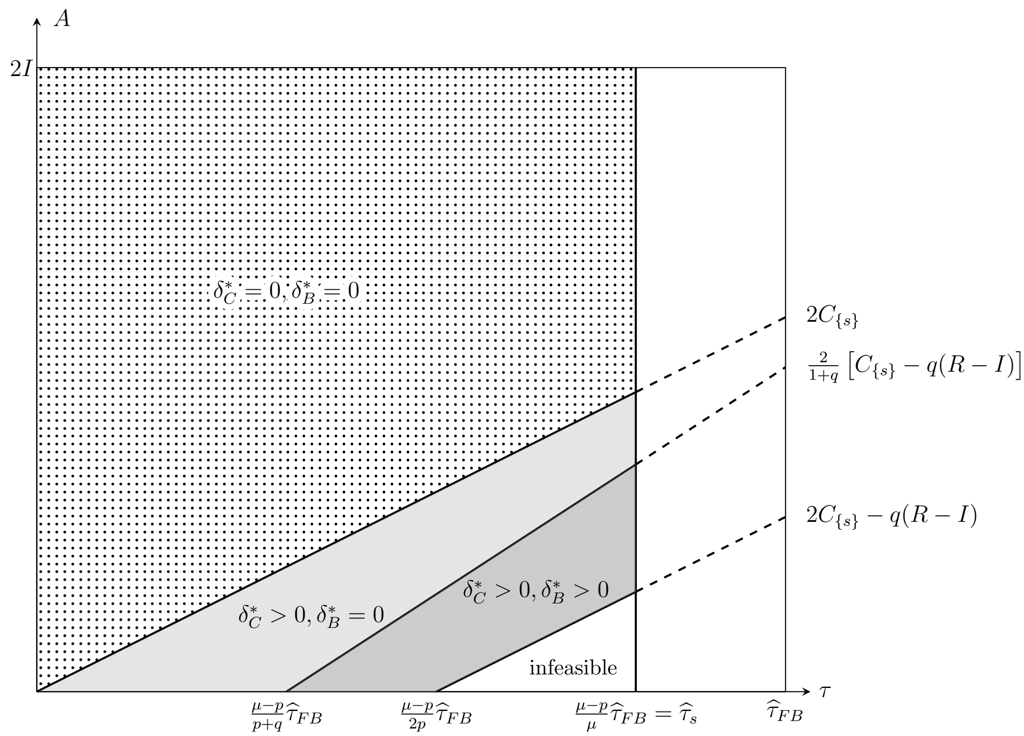
The proposition also reveals how bankers' compensation depends on the bank's overall income. When the paid-in equity is relatively high, i.e., $A \in \left[A_2^{\delta_B^*=0}(\tau), 2C_{\{s\}}(\tau)\right)$, 'tweaking' compensation is necessary only when the overall bank income is relatively low (i.e., $2I$ or $R+I$). When the paid-in equity is relatively low, i.e., $A \in \left[A_2^{pub}(\tau), A_2^{\delta_B^*=0}(\tau)\right)$, 'tweaking' compensation is necessary also when the overall bank income is high, that is, for all income levels $2I$, $R+I$, and $2R$.

Our theory leads to empirically testable hypotheses: the strong correlation between an individual banker's compensation and the overall bank performance and, therefore, the use of compensation contract such as bonus pool, options and equity of the bank, is more likely to be observed when (1) the bank has relatively low outside equity capitalization (in the model, $\delta_C^* > 0$ and/or $\delta_C^* > 0$ only for low levels of A), and (2) when the bank's overall income is relatively low (in the model, for $A \in \left[A_2^{\delta_B^*=0}(\tau), 2C_{\{s\}}\right)$, compensation is tweaked for income $2I$ and $I+R$ but not for the high income $2R$).

3.2.3 Making banks with public contracts: a summary

Figure 4 visually summarize the results from this section. In Panel (a), the gray area, given by $A \geq 2C_{\{s\}}$ and $\tau \leq \widehat{\tau}_s$, illustrates the region where the creation of 'small' safe

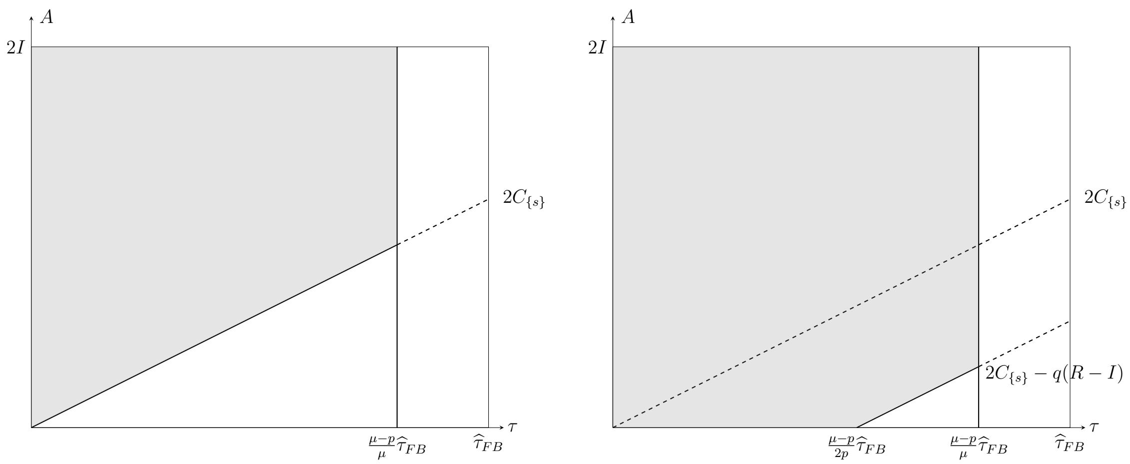
Figure 3: Bankers' exposure to each other's performance decreases in bank equity



The dotted area, given by $A \geq 2C^*$ and $\tau \leq \widehat{\tau}_s$, illustrates the region where the creation of 'small' safe banks is feasible. Compared to the first-best allocation, where safe and productive banking is feasible for any $A \geq 0$ and $\tau \leq \widehat{\tau}_{FB}$, the reduced region reflects that (1) the paid-in equity is needed to deleverage the bank in the I-state so that the banker can receive the incentive pay, and (2) conceding the agency rent to the bankers makes a safe bank unprofitable for the shareholder for $\tau \in (\widehat{\tau}_s, \widehat{\tau}_{FB})$. The shaded area demonstrates the improvement in efficiency that is achievable with a 'big' bank where a banker's compensation can depend on the other banker's performance. First, by making individual compensation dependent on whole bank performance only when the bank does badly (light gray), and second by making it always dependent on whole bank performance, even when the bank does well (dark gray).

banks is feasible. Compared to the first-best allocation, where money creation is feasible for any $A \geq 0$ and $\tau \leq \widehat{\tau}_{FB}$, the reduced region reflects that (1) the paid-in equity must deleverage the bank in the I-state so that the banker can receive the incentive pay, and (2) conceding the agency rent to the bankers makes a safe bank unprofitable for the shareholder for $\tau \in (\widehat{\tau}_s, \widehat{\tau}_{FB})$. Panel (b) demonstrates the improvement in efficiency that is achievable with a 'big' bank where bankers' incentives are preserved for the relatively low level of τ even if $A = 0$.

Figure 4: Money Creation when the Shareholder Can Commit to No Risk-shifting



(a) 'Small' banks under full transparency (b) A 'big' bank under full transparency

To an extent, transparency and paid-in (book) equity are substitutes: full transparency of contracting to depositors allows outside equity holders to commit to no risk-taking and operate with little (small bank) or no (big bank) equity.[17]

It is useful to create a 'big' bank because skin-in-the-game from the other unit can substitute for book equity in preventing a banker from taking risk, while market value in the banker's own unit cannot. Therefore, firm-performance sensitive compensation is useful: it eases the budget constraint.

Notice that the efficiency gain from establishing a 'big' bank stems from the flexibility in setting bankers' compensation, not from the issuance of joint liabilities in financing the bankers' projects. We will see in Section 3.3 that the joint liabilities will also help improve efficiency once the shareholder cannot commit to no risk-shifting.

[17] One may argue that the similar idea underlies Basel Accords' emphasis on market discipline that promote banks to disclose their risk profiles.

3.3 Making banks with semi-public contracts

We now move onto the case where a banker's compensation contract cannot be observed by the outside depositors but remains observable to the other banker if the shareholder creates a 'big' bank that hires both bankers. We call such a compensation contract semi-public. As the bankers' compensation contracts are not observable by the depositors, the shareholder can contract with the bankers to shift risk onto the depositors if it is in her interest.

3.3.1 'Small' banks under semi-public contracting

Suppose first that the shareholder creates two 'small' banks and injects equity $A/2$ into each.[18] For each bank, the shareholder hires one banker to manage the bank's investment and raises additional funding from depositors. The two 'small' banks are independent as a banker's compensation does not depend on the other bank's performance, and the depositors of one bank have no claim over the other bank's cash flow.

Since the two banks are identical, there is no loss of generality in examining the contracting problem for one of them. The shareholder has two possible defections from establishing a safe bank with effort: to offer the banker a contract that allows gambling, or one that induces no effort (equivalently, not hiring the banker at all). When allowing the banker to take risk, the shareholder will offer compensation $C_{\{r\}} = 0$ if the banker returns I, and $B_{\{r\}}$ if the banker returns R. Recall that $\mu \equiv q + (1-q)p$ denotes the

[18] We assume that the bank holds no cash and all the funds raised by the issuance of deposits and outside equity are handed to the banker for a possible investment, so that the bank carries out the function of asset transformation – creating safe claims only with its potentially risky investment. However, even if we remove this assumption, reserving the shareholder's endowment wealth only for compensation – instead of financing the initial investment – is sub-optimal. The intuition is that such an arrangement aggravates shareholder's commitment problem. In a way, the result shows that cash is not equivalent to negative debt.

probability of obtaining a return R when the banker also pursues a risky investment opportunity. The lowest possible compensation entails $B_{\{r\}} = \tau/\mu$ to cover just the banker's cost of effort. Note that allowing risk-taking reduces the shareholder's burden of compensating bankers at the cost of allowing negative NPV projects to be chosen when they arise. Implementing such a 'small' risky bank (denoted by subscript $\{r\}$) with the aforementioned compensation leads to a defection payoff

$$\Pi^{semi}_{\{r\}}(A) = \mu(R - I) - \tau - (1 - \mu)\frac{A}{2}, \tag{22}$$

which will not exceed the payoff from a 'small' safe bank (denoted by subscript $\{s\}$)

$$\Pi^{semi}_{\{s\}} = q(R - I) - \tau - X \tag{23}$$

if and only if the amount of paid-in equity is sufficiently high. Intuitively, part of the cost of the negative NPV risky projects is borne by depositors, and the shareholder will only find it worthwhile to avoid these if she has sufficient equity at stake. On the other hand, the shareholder will never contract a banker to exert no effort because that leads to a zero shareholder payoff.

Proposition 6. *When hiring the two bankers to run two 'small' banks separately, the shareholder will make the banks safe only if she capitalizes each bank with paid-in equity no less than*

$$\frac{A^{semi}_1(\tau)}{2} = \frac{1}{1-\mu}\Big[(\mu - q)(R - I) + X\Big] > C_{\{s\}} = X. \tag{24}$$

Proposition 6 gives a necessary condition for a safe bank to be feasible. The critical level of paid-in equity A_1 increases in $(R - I)$ which measures the direct gain from risk-shifting. A_1 also increases in the banker's rent X, so that any friction in the (internal) contracting with the banker will aggravate the shareholder's (external) contracting problem with depositors. Intuitively, the greater the rent the shareholder needs to concede to the banker, the less she can keep to herself, and therefore, the stronger motive to shift risk to depositors. The result $A_1/2 > C_{\{s\}}$ illustrates this point: the shareholder's equity input must be more than is required simply to cover only the banker's compensation in the I state. Otherwise, the shareholder would gain a zero payoff in that state and would have no incentive to prevent banker risk-taking. In other words, the paid-in equity must now sufficiently deleverage the bank to not only provide correct incentives to bankers but also to the shareholder.[19]

Other than providing a sufficient amount of paid-in equity to prevent risk-shifting, the shareholder needs to earn a non-negative payoff from creating a safe bank, i.e., $\tau \leq \widehat{\tau}_s$. We focus on a case where the return of the project is not too high:

$$\frac{R}{I} < 1 + \frac{1-p}{p}\frac{\mu(1-q)}{\mu(1-q)+q}. \tag{25}$$

Otherwise, the shareholder's participation constraint $\tau \leq \widehat{\tau}_s$ will be redundant and always implied by the incentive constraint.

Assumption 2. *For the remainder of the paper, we assume that inequality* (48) *holds.*

Under Assumption 2, we have the following result regarding money creation.

[19]If a social planner were able to re-distribute the initial endowment, so that an amount $a \leq A$ of risk-bearing capital is reallocated from the shareholder to the bankers, it would take $a < A_1$ for a banker to be able to implement a safe bank. Thus a lone banker can run a safe small bank with less inside equity than a shareholder can with outside equity. Thus such a redistribution improves money creation efficiency. This is again because introducing an external shareholder creates a further layer of incentive problems. The shareholder's paid-in capital A_1 is not only used to address the bankers' incentive problem but should also be sufficiently large to address her own incentive problem. Such an improvement, however, is clearly not a Pareto improvement.

Corollary 1. *With shareholder risk-shifting motives, the maximum money creation with two separate 'small' banks of paid-in shareholder equity is* $2I - A_1^{semi}(\tau)$ *for* $\tau \leq \widehat{\tau}_s$.

Proof. See Appendix A.7 □

3.3.2 A 'big' bank under semi-public contracting

In this section, we analyze a case where the shareholder sets up a 'big' bank that hires two bankers and jointly finances the two bankers' projects. The depositors as external financiers can observe the bank's organizational structure and the overall performance of the 'big' bank but still cannot observe the compensation contracts that the shareholder offers to the bankers. Since depositors demand absolute safety, a 'big' bank can be financed only if the shareholder contracts both bankers to play safe, a scenario we denote by subscript $\{s, s\}$. For each banker, the shareholder can also defect and offer a contract to induce the banker to play risky (denoted by 'r' in subscripts) or take no effort (denoted by 'n' in subscripts). To start with, note that the shareholder will never find it profitable to implement an $\{s, n\}$ bank as that is dominated by the profit from an $\{s, s\}$ bank. Lemma 5 summarizes the equilibrium compensation contract and also the cheapest compensation for all relevant shareholder defections.

Lemma 5. *Depending on the level of risk/effort that the shareholder wants to implement, the cheapest compensation contracts are as follows.*

- *To create an* $\{s, s\}$ *bank where it is a Nash equilibrium for both bankers to exert effort and take no risk, the shareholder can minimize her compensation cost by offering contracts as specified in Lemma 3.*

- *To create an $\{s,r\}$ bank where it is a Nash equilibrium for Banker i to exert effort and take no risk while Banker j exerts effort and can gamble, the shareholder can minimize her compensation cost by paying Banker i $B^i_{\{s,r\}} = B_{\{s\}}/\mu$ and $C^i_{\{s,r\}} = C_{\{s\}}/\mu$ when he generates R and I respectively, and paying Banker j $B^j_{\{s,r\}} = B_{\{r\}} = \tau/\mu$ and $C^j_{\{s,r\}} = 0$ when he generates R and I respectively.*

- *To create a $\{r,r\}$ bank where it is a Nash equilibrium for both bankers exert effort and gamble upon risky investment opportunities, the shareholder can minimize her compensation cost by paying $B_{\{r,r\}} = \tau/\mu^2$ and $C_{\{r,r\}} = 0$ when a banker generates R and I respectively.*

- *To create a $\{r,n\}$ bank where Banker i exerts effort and can gamble and Banker j shirks, the shareholder can minimize her compensation cost by paying Banker i compensation $B^i_{\{r,n\}} = \tau/\mu$ and $C^i_{\{r,n\}} = 0$ when he generates R and I respectively, and paying Banker j $B^j_{\{r,n\}} = C^j_{\{r,n\}} = 0$ (or not to hire Banker j at all).*

Proof. See Appendix A.8. □

To determine the shareholder's most profitable defection, note that she earns a profit

$$\Pi^{semi}_{\{s,r\}}(A) = \mu(1+q)(R-I) - X - 2\tau - (1-\mu)A \tag{26}$$

from implementing an $\{s,r\}$ bank; a profit

$$\Pi^{semi}_{\{r,r\}}(A) = 2\mu^2(R-I) - 2\tau - (1-\mu^2)A \tag{27}$$

from implementing a $\{r,r\}$ bank; a profit

$$\Pi^{semi}_{\{r,n\}}(A) = \mu(R-I) - \tau - (1-\mu)A \tag{28}$$

from implementing a $\{r,n\}$ bank. Appendix A.9 derives critical levels of τ,

$$\widehat{\tau}_{\{s,r\}} = \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s \qquad \text{and} \qquad \widehat{\tau}_{\{r,r\}} = \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s,$$

such that the shareholder's most profitable defection is to create an $\{s,r\}$ bank for $\tau \in \left[0, \widehat{\tau}_{\{s,r\}}\right]$; to create a $\{r,r\}$ bank for $\tau \in \left(\widehat{\tau}_{\{s,r\}}, \widehat{\tau}_{\{r,r\}}\right]$; and to create a $\{r,n\}$ bank for $\tau > \widehat{\tau}_{\{r,r\}}$. One can show that $\widehat{\tau}_{\{r,r\}} \leq \widehat{\tau}_s$ always holds, and the interval $\left(\widehat{\tau}_{\{s,r\}}, \widehat{\tau}_{\{r,r\}}\right]$ is non-empty if and only if

$$p \cdot q \geq (1-q)\mu. \tag{29}$$

Intuitively, defection $\{r,n\}$ is more profitable than defection $\{s,n\}$ only when the agency cost τ is high, in which case the rent that the shareholder has to concede to induce effort and avoid risk-shifting is high. Compared to defection $\{r,n\}$, defection $\{r,r\}$ does not entail conceding more agency rent. The additional risky division generates a positive NPV from an ex-ante perspective, though only at the cost of a higher potential for risk contamination, in the sense that one division that generates 0 will wipe out the shareholder's gain from the other division that generates R. Therefore, defection $\{r,r\}$ is relevant if and only if the former dominates, or mathematically, inequality (29) holds.

Assumption 3. *We assume inequality* (29) *holds for the remainder of the paper.*

We maintain Assumption 3 to reduce the number of cases to consider and keep the analysis general since $\{r,r\}$, in principle, can be the shareholder's most profitable defection.

We characterize the incentive constraint for an $\{s, s\}$ bank to be most profitable in Proposition 7, with the required amount of paid-in equity plotted in Figure 5.

Proposition 7. *When the shareholder sets up one 'big' bank that hires two bankers, each to locate and manage one project, a safe 'big' bank can be established only if the shareholder provides paid-in equity*

$$A \geq A_2^{semi}(\tau) = \begin{cases} A_{\{s,r\}}^{semi}(\tau) = \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R-I) + X\Big] & \tau \in \big[0, \widehat{\tau}_{\{s,r\}}\big] \\ A_{\{r,r\}}^{semi}(\tau) = \frac{1}{1-\mu^2}\big[(\mu^2 - q)2(R-I) + 2X\big] & \tau \in \big(\widehat{\tau}_{\{s,r\}}, \widehat{\tau}_{\{r,r\}}\big] \\ A_{\{r,n\}}^{semi}(\tau) = \frac{1}{1-\mu}\big[(\mu - 2q)(R-I) + \tau + 2X\big] & \tau > \widehat{\tau}_{\{r,r\}}, \end{cases} \tag{30}$$

where $A_{\{s,r\}}^{semi}$, $A_{\{r,r\}}^{semi}$, and $A_{\{r,n\}}^{semi}$ are the critical paid-in equity levels that prevent the shareholder from defecting and implementing a $\{s, r\}$, $\{r, r\}$, and $\{r, n\}$ bank respectively.

Proof. See Appendix A.9. □

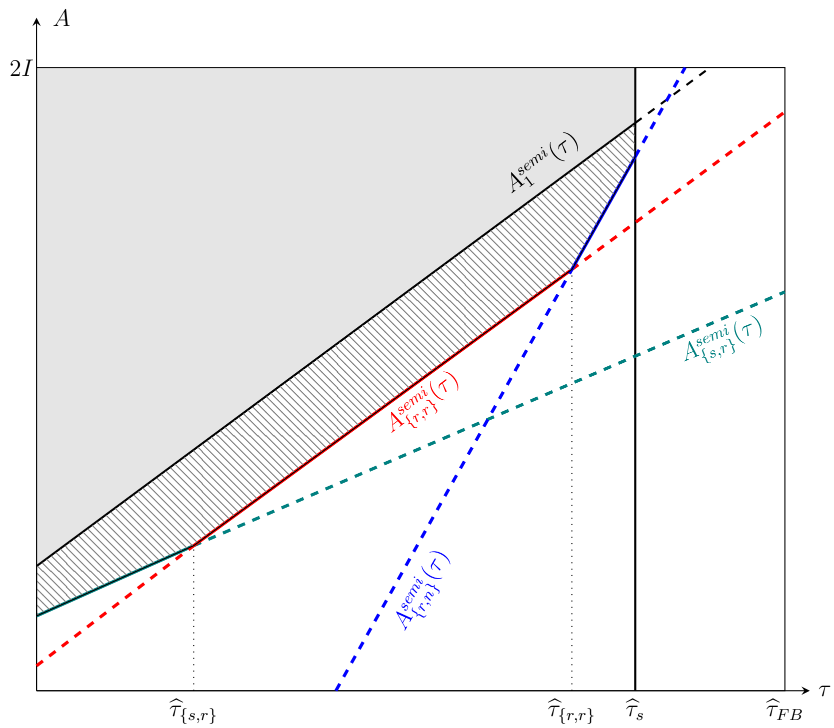
Similar to our analysis in Section 3.3.1, Proposition 7 provides only a necessary condition for a safe bank to be feasible. Combining with the shareholder's participation constraint, we have the following result regarding the money creation of a 'big' bank.

Proposition 8. *When the shareholder hires two bankers to run a 'big' bank whose two projects are jointly financed, the bank's maximum money creation is $2I - A_2^{semi}(\tau)$. The amount is always positive for $\forall \tau \leq \widehat{\tau}_s$, and it holds that $A_2^{semi}(\tau) < A_1^{semi}(\tau)$ so there is efficiency gain as compared to the 'small' bank setting.*

Proof. See Appendix A.10. □

This result resembles the effects of 'cross-pledging' in the literature (Chapter 4 of Tirole (2006)) but with two twists. First, there is a risk-shifting problem rather than a pure

Figure 5: The required amount of paid-in equity for a 'big' bank



The figure demonstrates how a 'big' bank improves efficiency by allowing the creation of a safe bank for a wide range of parameters. In particular, the frontier is pushed from $A_1^{semi}(\tau)$ to $A_2^{semi}(\tau)$, with the latter given by the maximum of $A_{\{s,r\}}^{semi}(\tau)$ (in green), $A_{\{r,r\}}^{semi}(\tau)$ (in red), and $A_{\{r,n\}}^{semi}(\tau)$ (in blue). The binding incentive constraint for a given τ is indicated by the solid line. The efficiency gain as compared to the 'small' bank case – in the sense that issuing risk-free deposits becomes feasible – is indicated by the hatched area.

effort problem, and agents' payoffs cannot be made (extremely) convex as in that literature because such compensation would induce strong incentives for risk-taking. Indeed, both the shareholder and the bankers need to receive positive payoffs for intermediate levels of bank performance. Second, no single agent conducts two projects (each banker has only one project) in our setting. In the existing literature, cross pledging is helpful because one agent makes effort on both projects and his reward for succeeding in one project can be made contingent on his success in the other project. Here instead, the shareholder, who takes no action to manage the investments herself, needs to contract with two different bankers whose rewards depend only on their own performance and not on the performance of the other project. Thus the benefit of cross-pledging is indirect via its effect on shareholder incentives affecting compensation contracts and hence different agents' actions. We will see in the next section that this difference gives rise to a further problem when the bankers cannot observe one another's compensation contracts, which will compromise somewhat the efficiency gain from issuing joint liabilities.

This benefit of joint liabilities also contrasts with the literature on financial synergy and risk contamination. In Banal-Estañol et al. (2013) for example, issuing joint liabilities entails a trade-off between the benefit of risk-sharing (the cost of borrowing drops as diversification shrinks the set of states where default on joint liabilities occurs) and the risk of cross-contamination (a healthy division dragged into bankruptcy by a failed division). In our "big bank", the diversification benefit of risk-sharing is largely absent because when one banker returns R and the other returns 0, the bank will still fail. Risk contamination exists but, in contrast with the existing literature, it plays a positive role. That is, if a shareholder allows one banker to take risks, then the shareholder faces possible risk contamination – one banker who generates 0 endangers the shareholder's equity value in the other banker's project that may generate R. This contamination penalizes the shareholder's risk-taking and helps to sustain a safe bank. This beneficial effect of risk contamination contrasts with Banal-Estañol et al. (2013), where it is always harmful, and arises due to the fact that the riskiness of cash flows is endogenously chosen by the shareholder in our paper, and risk contamination is off the equilibrium path, whereas in Banal-Estañol et al. (2013) the risk is exogenous and therefore always on the equilibrium path.[20]

[20] Tucker (2014) argues that bank subsidiaries should issue junior debt or equity to holding companies, such that losses can be passed up to bank holding companies as a way of resolving troubled subsidiaries. The holding companies should be forced to issue sufficient debt at the holding company level such that regulators can, if needed, write down this debt as a way of preventing losses at one subsidiary from

3.3.3 Making banks with semi-public contracts: a summary

When depositors cannot observe bankers' compensation, they are concerned about whether the shareholder will induce bankers to take risks. The loss of external transparency means that the shareholder's incentive constraint in setting safety-inducing banker compensation must hold, which requires skin-in-the-game for the shareholder, and entails paid-in equity, whether the bank is 'big' or 'small'.

A 'big' bank with joint liabilities still does better than two 'small' banks but for a subtly different reason than with publicly observable compensation contracts. Previously, the second unit eased the compensation burden and helped satisfy the budget constraint in low states, and so reduced the need for external equity. With only semi-public contracts, the budget constraint no longer binds; instead, the shareholder's incentive constraint binds. The second unit eases the incentive constraint because if one of the risks does not work out, the shareholder has more to lose. This makes the it easier to induce the shareholder to raise bankers' compensation in the middle state sufficiently that they have incentives to avoid risk,

Market equity (i.e., the positive NPV of the two bankers' projects) is always insufficient for the shareholder's incentive constraint to hold. This "charter value" slackens it but can never fulfill it entirely because the market value of equity disappears precisely when it is most needed – when both bankers face only risky investment opportunities. Paid-in book equity is therefore always required as well. Intuitively, paid-in equity en-

infecting other subsidiaries. In this way, the shareholders of the holding company will be forced to bear the consequences of a failed subsidiary while other subsidiaries with positive net present value are insulated from the shock. Since we make the simplifying assumption that any failure of risk-taking will result in sufficient losses that only depositors will receive anything in this scenario, we do not address the issue of optimal bank resolution, we rather focus on the ex ante perspective of how to provide incentives to avoid excessive risk taking.

sures that the shareholder has skin-in-the-game across all possible states, even when market opportunities are scarce or absent.

3.4 Making a bank with private contracts

A natural friction when the shareholder contracts with two bankers is that the bankers may not observe each other's compensation contract.[21] To illustrate the impact this friction, we consider a setting where the shareholder signs compensation contracts with the two bankers i and j sequentially.[22] We suppose that Banker i is hired first, and Banker j can observe Banker i's incentive contract when he signs his own contract, but Banker i cannot observe and can only anticipate Banker j's contract when he agrees to his contract, since Banker j's compensation is agreed only after Banker i's compensation is already set). Thus the compensation contract between the shareholder and Banker j is privately observed by only these two parties, and not by Banker i. This additional unobservability implies that, when contracting with Banker i, the shareholder cannot directly commit to inducing a safe strategy from Banker j. The additional friction can reduce the efficiency of a large bank if the shareholder allows a banker's compensation to only depend on his own performance (section 3.4.1), because if the shareholder contracts with Banker j to take risky projects, she shifts risk not only to depositors but also onto Banker i, who stands to lose anticipated compensation if Banker j's risk-taking ends badly. Institution-performance-sensitive compensation again helps but for a different reason compared to the case of public contracting (where it slackens the budget constraint in the low-return state). Under private contracting, institution-performance-

[21] Compensation contracts are typically private information between the employee and employer. Cullen and Perez-Truglia (2023) provide evidence from a large Asian bank that bank employees have a significant lack of knowledge about the compensation of other bank employees.

[22] The sequential setting helps simplify the analysis by avoiding the necessity to discuss bankers' higher order beliefs *off equilibrium path*.

sensitive compensation works, instead, by committing the shareholder to share any gains from risk-taking by those agents with the other agents who stand to lose from risk taking (because of joint liability). This gain-sharing reduces the shareholder's gain from risk-taking and helps commit her to incentivize safe actions (section 3.4.2).

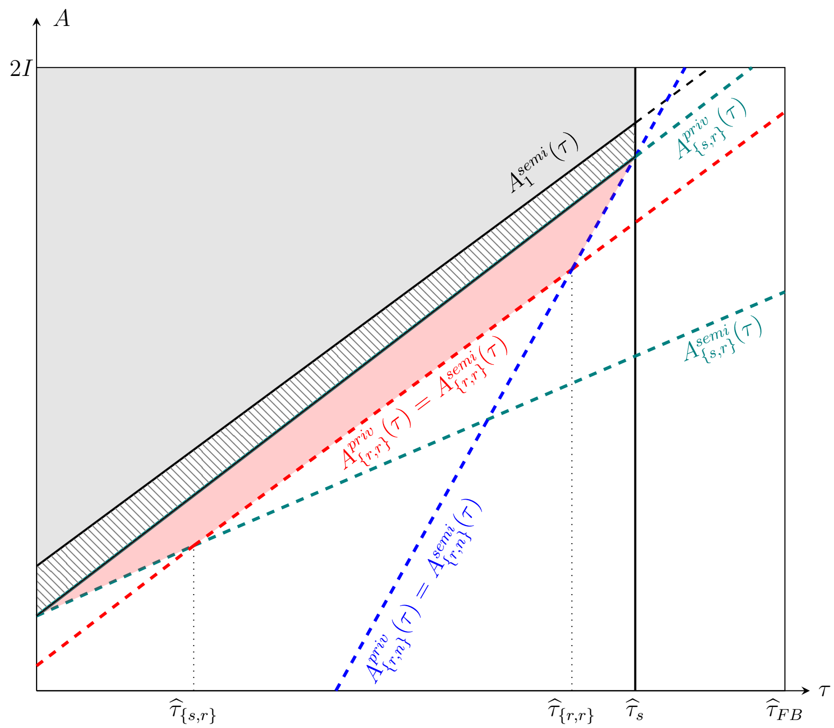
3.4.1 Individual performance sensitive contracts

To identify the efficiency loss from private contracting, we start by analyzing what happens if the shareholder makes a banker's compensation only depend on his own project return. In an equilibrium where a safe bank can be established, to be willing to accept the compensation contract $\left(B_{\{s\}}, C_{\{s\}}\right)$, Banker i must believe that the shareholder will also contract with Banker j to play safe. The shareholder, can now expropriate not only depositors but also Banker i, by instructing Banker j to play risky, as Banker j's risk-taking creates a chance that his risky division will generate 0, in which case Banker i will not receive any compensation. The shareholder's incentive constraint to not deviate in this way is therefore tighter than before. It becomes:

$$A \geq A_{\{s,r\}}^{priv}(\tau) = \frac{1}{1-\mu}\Big[\big(\mu(1+q)-2q\big)(R-I) + X + (1-\mu)(X+\tau)\Big].$$

Comparing the expression of $A_{\{s,r\}}^{priv}(\tau)$ with that of $A_{\{s,r\}}^{semi}(\tau)$, one can identify the additional term $(1-\mu)(X+\tau)$ which captures the shareholder's temptation to expropriate Banker i of his expected compensation $(X+\tau)$. Figure 6 illustrates the tightening of the incentive constraint which leads $A_{\{s,r\}}^{pub}(\tau)$ to rotate around its intercept, because the additional friction of private contracting affects only the internal contracting cost within the bank (compensation contracts are already opaque to depositors).

Figure 6: The required amount of paid-in equity under private contracting



The figure demonstrates how private contracting shrinks the range of parameters where it is feasible to create a safe bank. In particular, the incentive constraint for the shareholder to avoid a 'semi-risky' bank tightens and becomes the most relevant incentive constraint. While a 'big' bank would still outperform a 'small' bank, the benefit of having a 'big' bank is reduced by the intensified internal contracting problem when Banker j's compensation contract is private. The efficiency loss is indicated by the red area.

This additional friction leaves the shareholder's incentives to take the $\{r, r\}$ or $\{r, n\}$ defection unchanged if, when Banker i himself receives a contract that induces risk-taking, he believes that Banker j will also be contracted to play risky.[23] To see this, note that the shareholder's profit from the $\{r, r\}$ defection equals that under semi-public contracting, because both bankers hold correct beliefs regarding the other banker's action of risk-taking. To take the defection $\{r, n\}$ defection, the shareholder should first offer

[23]A banker's beliefs after receiving a null contract inducing zero effort are irrelevant, since it is impossible for him to be expropriated in that case. We will generalize and justify this assumption regarding off-equilibrium-path beliefs in the next section with the discussion on Assumption 4.

Banker i zero compensation and then contract Banker j to play risky, because the alternative ordering induces Banker i to believe that Banker j will take risk and Banker i demands higher compensation. On the other hand, when Banker j observes that Banker i is contracted to exert no effort, Banker j can be contracted to play risky with compensation $B_{\{r\}} = \tau/\mu$ and $C_{\{r\}} = 0$, leading to again the same defection profit for the shareholder in the case of semi-public contracting.

Proposition 9 establishes that when a banker's compensation depends only on his own performance, the shareholder's most profitable defection is indeed to contract Banker i to play safe while allowing Banker j to gamble for any $\tau \leq \widehat{\tau}_s$. Intuitively, such a semi-risky bank is profitable because it allows the shareholder to expropriate the Banker i who plays safe, and shifts risk to depositors at the cost of only a limited decline in project value. As a result, the necessary amount of paid-in equity to prevent shareholder defection is given only by $A \geq A^{priv}_{\{s,r\}}(\tau)$ and the incentive-compatibility boundary no longer shows different segments as in the case of semi-public compensation.

Proposition 9. *When the shareholder's contract with Banker j is private and the shareholder offers only individual-performance-sensitive compensation to the bankers, the shareholder prefers to establish a safe bank only if she puts in paid-in equity no less than $A^{priv}_2(\tau) = A^{priv}_{\{s,r\}}(\tau)$.*

As the shareholder's incentive constraint tightens, the amount of paid-in equity that the shareholder has to inject into the bank increases. The result shows us one possible limitation of creating a 'big' bank: while financing two divisions with joint liabilities reduces the shareholder's *external* risk-taking motives, contracting with two bankers also entails an increase in the cost of *internal* contracting that was absent when the two bankers worked in institutions with separate liabilities. Corollary 2 shows that the beneficial effects of cross-pledging still dominate on balance in the current model.[24]

Corollary 2. *A 'big' bank's money creation capacity is compromised under private contracting when bankers' compensation can only depend on their own performance, but still exceeds that of a 'small' bank. That is,* $A_2^{pub}(\tau) < A_2^{priv}(\tau) < A_1(\tau)$ *hold for* $\forall \tau < \widehat{\tau}_s$.

Proof. See Appendix A.11. □

3.4.2 Institution-performance sensitive contracts

We now show that the shareholder can improve allocation with institution-performance sensitive compensation. In fact, it is sufficient to consider the following contracts that satisfy condition (18) in Lemma 3:

$$B_{\{s,s\}}(R) = B_{\{s\}} + \delta \qquad B_{\{s,s\}}(I) = B_{\{s\}} - \tfrac{q}{1-q}\delta, \tag{31}$$

$$C_{\{s,s\}}(R) = C_{\{s\}} + \delta \qquad C_{\{s,s\}}(I) = C_{\{s\}} - \tfrac{q}{1-q}\delta, \tag{32}$$

where $\delta \in [0, (1-q)/q\tau]$ so that the monotonicity conditions as in Definition 1 are met. The compensation contract again 'tweaks' $B_{\{s\}}$ and $C_{\{s\}}$ as in Lemma 2: for the same *expected* pay for individual performance, a banker's pay is boosted by δ when the other banker returns R, and is reduced when the banker returns I. This 'tweak' is subtly different from that in Section 3.2.1: it is no longer necessary to set $\delta_C \neq \delta_B$ (i.e., tweaking Banker i's compensation differently depending on his own performance) because the purpose of the 'tweak' is no longer to relax the budget constraint when both bankers return I. Instead, what is required is to boost Banker i's compensation

[24]The friction arising from private contracting is likely to become stronger when the bank grows in size with more bankers working on their respective projects.

whenever Banker j returns R that can be from risk-taking. Therefore, 'tweaking' $B_{\{s\}}$ and $C_{\{s\}}$ uniformly by δ is sufficient: it distributes part of the gain from risk-taking to Banker i rather than to the shareholder and reduces the latter's risk-shifting incentives.

As Banker i cannot observe the contract to be signed between the shareholder and Banker j, he will need to form a belief about Banker j's strategy. Suppose that an equilibrium exists where a safe bank can be created with bankers' compensation contracts featuring a $\delta^* \in [0, (1-q)/q\tau]$. By focusing on Nash implementation, we assume Banker i will believe that Banker j is to play safe if he observes this equilibrium contract. But what if Banker i is offered an alternative, unexpected, contract? We assume the following off-the-equilibrium beliefs for Banker i when he receives an alternative contract.

Assumption 4. *Banker i will believe that Banker j is contracted to play safe when Banker i himself receives a compensation contract with $\delta \geq \delta^*$. Otherwise, Banker i believes that Banker j is contracted to gamble.*

Assumption 4 suggests that an (insufficiently tweaked) compensation contract with $\delta < \delta^*$ (including the special case where a banker's compensation depending on his own performance, i.e., $\delta = 0$) should lead Banker i to believe that Banker j is contracted to take risks. The intuitive justification for such an off-equilibrium belief is as follows. The private contracting between the shareholder and Banker j allows the shareholder to shift the risk from Banker j's gamble not only to depositors but also to Banker i. The gain from risk-shifting is larger if Banker i's contract is less tweaked, because in that case, less of the gain from a high return from Banker j will be shared with Banker i, and so the shareholder will pocket more of the gain of Banker j's risk-taking. Therefore, it is exactly when the shareholder plans to take risks through Banker j that the shareholder would want to write a lower-than-equilibrium δ contract with Banker i. Thus such a contract offer should alert Banker i to the shareholder's intention to induce risk-taking in Banker j's division.

Assumption 4 also suggests that Banker i would believe Banker j is to gamble when Banker i himself receives a compensation contract that induces risk-taking (e.g., one that gives a zero payoff when Banker i generates I). Intuitively, if the shareholder is only to induce risk-taking from one and only one banker, she would better do so with Banker j, because Banker j can observe that Banker i is not contracted to gamble and would only demand a compensation τ/μ when generating R. Therefore, being offered a compensation contract that induces risk-taking, Banker i should make an educated guess that the shareholder intends to induce risk-taking in more than one division and also contracts Banker j to gamble.

We describe in Lemma 6 how the shareholder may defect to implement a (semi-)risky $\{s, r\}$ bank given Banker i's beliefs.

Lemma 6. *Provided that an equilibrium exists where a safe bank can be created with a tweaked compensation contract featuring δ^*, to defect and establish a semi-safe $\{s, r\}$ bank, the shareholder will contract Banker i to play safe with a tweaked contract of $\delta = \delta^*$, and contract Banker j to play risky with a compensation $B_{\{r\}} = \tau/\mu$ and $C_{\{r\}} = 0$.*

Indeed, when facing an off-equilibrium contract with $\delta < \delta^*$, Banker i will believe that Banker j is contracted to play risky according to Assumption 4. In that case, it can be shown that Banker i will accept the contract but will not take effort. Offering any $\delta > \delta^*$, on the other hand, reduces the shareholder's payoff from the $\{s, r\}$ defection, for she would allocate an unnecessarily large amount of gain from Banker j's risk-taking to Banker i. Finally, the shareholder will not contract Banker j to play safe and Banker i to play risky, because in that case Banker i will believe that Banker j is to play risky and will accordingly demand a compensation τ/μ^2 when he generates R. By comparison, as Banker j can observe that Banker i is contracted to play safe, and can be contracted to play risky with a lower compensation $B_{\{r\}} = \tau/\mu$.

We prove in Proposition 10 that the tweaked compensation can relax the shareholder's incentive constraints and recover the potential efficiency loss due to private contracting. In fact, the tweaked contract that is most powerful in de-incentivizing the shareholder from risk-taking involves setting $C_{\{s,s\}}(R) = B_{\{s,s\}}(I)$ such that the two bankers receive the same compensation when one of them returns R and the other returns I. That is, in the middle state where the bank has cash flow $I + R$, the bankers' compensation does not depend on their individual performance at all.

Proposition 10. *When the shareholder sets institution-performance-sensitive compensation and 'tweaks' the bankers' compensation contract by δ, the shareholder will not defect and implement a semi-safe $\{s, r\}$ bank if and only if she pays equity into the bank*

$$A \geq A^{tweak}_{\{s,r\}}(\tau, \delta) = \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R - I) + X + (1-\mu)(X+\tau) - \mu\delta\Big]. \quad (33)$$

In particular, when δ is set to its upper bound $(1-q)\tau/q$ so that $C_{\{s,s\}}(R) = B_{\{s,s\}}(I)$, the inefficiency caused by private contracting under individual-performance-sensitive compensation will be completely eliminated, and a safe bank can be established if and only if the shareholder's paid-in equity $A \geq A^{semi}_2(\tau)$.

Intuitively, the shareholder can use a tweaked compensation contract to distribute profit from Banker j's risk-taking as compensation to Banker i, which dampens her own incentive for defection. This impact on the shareholder's incentive increases in $B_{\{s,s\}}(R)$, i.e., when the highest possible amount of gains from Banker j's risk-taking is distributed to Banker i who plays safe. The result that $C_{\{s,s\}}(R) = B_{\{s,s\}}(I)$ is given by the monotonicity constraint (11).[25] Also, since we have only allowed for more flexibility for the equilibrium compensation, the shareholder's payoff from the $\{r, r\}$ and $\{r, n\}$ defections are not affected by the tweaked contract. As a result, the incentive constraints to prevent those defections $A \geq A^{semi}_{\{r,r\}}(\tau)$ and $A \geq A^{semi}_{\{r,n\}}(\tau)$ are unaffected.

Corollary 3. *For a given level of paid-in equity A, when a compensation contract with a tweak δ^* can implement a safe bank, a compensation contract with $\delta \in (\delta^*, (1-q)\tau/q)$ can implement a safe bank too. For a paid-in equity level $A \in \left[A^{semi}_2(\tau), A^{priv}_2(\tau)\right]$, the minimum 'tweak' required to implement a safe bank is*

$$\underline{\delta}(A) = \frac{1}{\mu}\Big[\big(\mu(1+q) - 2q\big)(R - I) + X + (1-\mu)(X+\tau)\Big] - \frac{1-\mu}{\mu}A, \tag{34}$$

with $\underline{\delta}(A) = 0$ when $A = A^{priv}_2(\tau)$ and $\underline{\delta}(A) = (1-q)\tau/q$ when $A = A^{semi}_2(\tau)$.

3.4.3 Making banks with private contracts: a summary

The further lack of transparency increases shareholder incentives to cheat, not only on depositors but now also on bankers. In particular, inducing risk-taking with one banker becomes the most profitable defection. Such a strategy saves on the compensation that must be paid to the risky banker: his compensation becomes more convex and hence lower in expected terms. It also saves on compensation to the safe banker: this banker receives less than expected because sometimes this banker will get no payment despite making a safe choice, because his risky colleague blows up the bank. And in addition, this defection also expropriates depositors through risk-shifting in the usual way. Thus, when contracts are private and based on individual, not firm (bank), performance, more

[25] Relaxing the monotonicity constraint and setting $C_{\{s,s\}}(R) > B_{\{s,s\}}(I)$ can further lower the payoff from an $\{s, r\}$ defection, pushing the critical paid-in equity $A^{priv}_{\{s,r\}}$ even below the level with transparent compensation contracts. We do not explore this case because it can lead to other agency problems on the bankers' side.

outside equity is required to reassure bankers that the shareholder will not expropriate them.

Introducing firm-performance-sensitive pay can solve this problem. It allows the banker who plays safe to claim some of the return from successful risk-taking, if risk-taking should be allowed to happen by the shareholder. If the firm-sensitive component of pay is large enough, so much of the gain is shared with bankers that the shareholder no longer gains from risk-shifting them, and gains only from risk-shifting to depositors. Thus firm-performance-sensitive compensation provides an alternative mechanism to paid-in equity to allow the shareholder to commit to his own employees not to shift risk, and allows the bank to operate with the same level of paid in equity as in the semi-public case (where bankers observe each others contracts, so risk-shifting can only hurt depositors).

4 Discussion and Policy Implications

Our model provide normative analyses that are relevant for some widely debated issues in banking, such as what qualifies as bank capital, how partnership vs. publicly owned banks perform in terms of stability, the benefits and costs of ring-fencing assets, and the regulation of bankers' pay.

Bank vs market value of capital

Academics are inclined to emphasize the importance of market value over the book value of banks; whereas regulators tend to rely more on the book values for regulatory purposes. While it is often believed that charter value alone can prevent wrongdoing, our model helps highlight the difference between the market value arising from future business and (the book value of) paid-in equity provided by outside shareholders. While not denying the importance of the former, we emphasize the often neglected importance of the latter.[26] When the bank is in an ex-post interim low-return state, the charter value is limited and insufficient to prevent risk-taking, but this is evident only to the insiders (one or more bankers). The shareholders of the bank do not observe the quality of the projects currently being considered (but not yet undertaken) by the banks, and so this may not yet be reflected in the market value of the bank, which still reflects ex-ante expectations. Paid-in equity, on the other hand, deleverages the bank in all states and preserves the incentive for pursuing a safe strategy when positive NPV opportunities become scarce.

Public ownership

While some question whether publicly owned banks lack the accountability of partnership banks, we argue that proper incentives can still be provided when a publicly owned bank is sufficiently capitalized. Paid-in equity limits external shareholders' incentives to shift risks to depositors and also makes them willing to provide bankers compensation contracts that allow for only prudent investment strategies — despite such contracts being more expensive than those allowing for risk-taking. A capital-constrained partnership bank, on the other hand, can be risky, especially when risk-taking is relatively attractive.[27]

Small vs big banks

[26] Indeed, Atkeson et al. (2019) document that the market-to-book ratios of American banks doubled in the run-up of the global financial crisis, which suggests that the market value of equity alone can be a poor indicator of the soundness of banks.

[27] If we extend our current framework to allow for variable investment size, then a capital-constrained partnership bank, if feasible, would only be able to operate on a small scale. In that sense, our framework can shed light on why partnerships may wish to become publicly owned, as the injection of external equity will allow bankers to lever up their skilled labor and invest more. Public ownership may also facilitate greater transparency of incentive contracts.

The global financial crisis also spurred the policy response of breaking financial institutions into smaller pieces with no joint liabilities — on the basis that some high-risk business lines should not have access to insured deposit funding (e.g., the break-up of ING and the implementation of ring-fencing in the UK). Our result that having a 'big' bank with 'cross-pledging' at the shareholder's level can reduce shareholder risk-taking incentives suggests that regulators should be cautious with such reforms, for joint liabilities, while posing the risk of contamination within a financial conglomerate, create an incentive for risk-reduction for precisely that reason. The desire not to lose the charter value of a deposit franchise will provide an incentive for a universal bank to carefully control the risks taken by its investment banking division, other things being equal. This 'incentive synergy' means that investment banks with retail divisions may truly be able to operate with lower equity capital than the two business lines would need if they were separated.[28]

Bankers' Compensation

While there was public outrage over uncompressed bankers' compensation during crisis (low-return) periods, our model points out that some remuneration in such states is essential to prevent bankers from gambling for higher pay. Bankers' compensation in those states can account for much of the agency rent they earn (in fact, the full amount in our model) and cannot be easily eliminated when a banker is tasked with both finding profitable investment opportunities and making decisions on risk-taking.

[28]Boot and Ratnovski (2016), for example, provides an argument for combining business lines with low pledgeability with that of high pledgeability. Clearly, an investment bank and a retail bank have different opportunities for risk-taking. It would be interesting, in future work, to extend our model to allow asymmetric investment opportunities for Bankers i and j.

Finally, while compensation contract features such as bonus pools may appear theoretically puzzling,[29] our model provides two reasons why such contracts are useful in a bank. First, they ease the budget constraint in the very worst states when all divisions do badly, by shifting compensation to states when only some divisions do badly while maintaining expected pay as a function of own performance, and hence banker incentives. Second, they reduce shareholder incentives to induce risk-taking from bankers through low fixed-pay high variable-pay contracts, because if one division has a big success from gabmling, shareholders must share the gains from this success with employees from other divisions.

5 Conclusion

Our paper uses agency theory to study the creation of a bank through jointly-designed financing and compensation contracts, enabling the transformation of risky investments into safe deposits. Bankers, who must both make effort to locate investment opportunities and avoid inefficient risk-taking when investing, must receive high compensation even if they produce only mediocre outcomes, because otherwise they will be tempted to make risky low expected return investments when these are all that is available. When funds are raised from risk-averse depositors, allocating a positive payoff to the banker in these low-return states conflicts with the depositors' desire for risk-free claims, making sole-proprietor banks infeasible. A partnership between two bankers helps to solve the problem, because one banker's successful project offers some expected financial slack to pay the other banker when his returns are mediocre (as a result of resisting risky project). But the partnership as a whole still has incentives to shift risks to depositors when the

[29] Such compensation contracts might appear to be a "payment for luck" as employees in one division are rewarded for the good performance of others division over which they have no insight or control.

chance of risk-taking paying off is sufficiently high and the partners themselves have no cash to pay into the bank. Therefore, we find a role for paid-in equity from external shareholders in banks. The market value, or the prospect of positive NPV projects, that the skilled bankers bring to the table does not provide sufficient incentives to avoid risk in all states of the world; whereas the advantage of paid in equity is that it that deleverages the bank no matter what happens. In particular, paid-in equity preserves bankers' incentives in low-return states, which is precisely when they would otherwise be tempted to gamble. Thus we highlight an important difference between book and market leverage: market leverage can be low because of anticipated good prospects, but if these do not arise, and the bankers observe the state before the shareholder does, then low market leverage is still consistent with excessive risk taking. The situation in US banks with large inventories of subprime mortgages in the run up to the global financial crisis would be a case in point.

Thus our model rationalizes how external shareholders can provide value for a bank by deleveraging it relative to what would be possible in the absence of external capital. We provide this rationalization without simply assuming that those managing the bank's assets (the bankers) automatically act in the interest of the shareholders, as is common in the literature. We take seriously the fact that introducing external shareholders into a sole proprietorship or partnership bank introduces another layer of agency problems as the shareholders must provide appropriate incentives for the bankers.

We study how a publicly-owned a bank should be organized, and how its financing and compensation contracts should be jointly designed. Indeed, when the shareholder has limited wealth and provides only a fraction of the bank's funding, the shareholder herself has risk-taking incentives just as banking partners do. The shareholder implicitly allows or encourages bankers to take risk by cutting their base compensation for mediocre performance and rewarding them only for high performance. To prevent such risk-taking, the shareholder's equity injection into the bank, has to be sufficient — not only enough to allow the shareholder have sufficient to compensate the banker after paying out depositors in the low-return state, but also to maintain skin in the game for the shareholder in this state so that she desires to do so. To minimize the use of paid-in equity (or to create more risk-free deposits per unit of equity), it is efficient to create a 'big' bank that hires multiple bankers to run separate, independent projects. Previous literature has pointed out the risk of cross contamination from financing separate banking divisions with joint liabilities, because risk taking in one division could bring down the entire bank. Our work shows that financing separate divisions with joint liabilities discourages shareholders from allowing for risk-taking within any individual division, because the failure of such risk-taking endangers safe projects in other divisions. To put it another way, when risk-taking is endogenous, a financial conglomerate has more incentive to reduce risk than a stand-alone bank facing the same parameters. Our model, therefore, speaks to the empirical observation that modern banks are generally multi-division organizations that combine different business lines.

Multidivisional banks, however, pose additional complications for contracting: in particular, a compensation contract offered to one banker can be unobservable to other bankers. If the bankers themselves are concerned that risk-taking in a different division may bring down their bank, there is little point in their playing safe in their own division. Thus, such "private contracting" problems increase the cost of internal contracting within a big bank, which in turn make it more difficult to preserve shareholder's incentives. We show that this challenge can be partly resolved with banker compensation that is sensitive not only to the performance of a banker's own project but also to the performance of the entire bank (i.e., the other bankers). This is very common in practice, but is surprising in a moral hazard model, because one would not expect a banker's compensation to depend on the performance of projects over which he has no control. Our model explains why: bank-performance-sensitive compensation dampens shareholders' risk-taking incentives in individual divisions, because part of the gains from allowing one banker to engage in risk-taking will be paid to the other bankers, and hence the shareholder herself gains less from divisional risk-taking.

In summary, we have explored the structure of banking, starting with individual bankers who must find and finance potentially risky projects, and who can form coalitions with each other and/or with an external shareholder to raise deposit financing for their projects. Our model sheds new light on some widely-debated policy issues in banking, such as to what extent regulators should cap a banker's pay when his bank only delivers mediocre performance; what qualifies as bank capital — would it be sufficient to focus on the market value of bank equity or must paid-in/book equity be required; whether public ownership in banking is desirable despite many believing that accountability of bankers would be higher in partnership banks; and whether ring-fencing the assets of banks' different subsidiaries and separating their liabilities are likely to promote financial stability.

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A Proofs of Lemmas and Propositions

A.1 Proof of Proposition 2

Proof. We examine a representative banker's incentive to defect given that his partner sticks to the equilibrium strategy of exerting effort and avoiding gambling.

When facing a risky investment opportunity, the banker expects a payoff

$$(1-\beta) \cdot q \left[(I+R) - 2I\right].$$

from letting it go: he receives a share $1-\beta$ of the net payoff $(I+R)-2I$ only when his partner's investment returns R. Whereas, by gambling, the banker expects a payoff

$$p\left\{\frac{1}{2} \cdot q(2R-2I) + \beta \cdot (1-q)\big[(R+I) - 2I\big]\right\}.$$

In case of the banker's gamble succeeds (with probability p), the banker shares the net payoff $2R-2I$ with the other banker equally when the other banker encounters a safe project, and obtains a share β of the net payoff $(R+I)-2I$ when his partner lets go a risky investment. Therefore, the banker has no incentive to gamble if and only if

$$(1-\beta) \cdot q \left[(I+R) - 2I\right] \geq p\left\{\frac{1}{2} \cdot q(2R-2I) + \beta \cdot (1-q)\big[(R+I) - 2I\big]\right\} \Leftrightarrow \beta \leq \frac{q(1-p)}{p+q(1-p)}.$$

Note that $\frac{q(1-p)}{p+q(1-p)} = \frac{\mu-p}{\mu}$ is decreasing in p and is strictly smaller than $1/2$ when $p \geq 1/2$. Because the sharing rule is assumed to be monotonic, i.e., $\beta \geq 1/2$, p has to be smaller than $1/2$ to guarantee the above inequality. Therefore, when $p < 1/2$ and $\beta \leq \frac{\mu-p}{\mu}$, the banker has no incentive to take the gambling opportunity.

From the ex-ante perspective, the banker's expected payoff from exerting effort and letting go any risky investment is:

$$\frac{1}{2} \cdot q^2(2R - 2I) + \beta \cdot q(1-q)[(R+I) - 2I] + (1-\beta) \cdot (1-q)q[(I+R) - 2I] - \tau = q(R-I) - \tau.$$

Instead, the banker's expected payoffs from shirking are:

$$(1-\beta) \cdot q[(I+R) - 2I] = (1-\beta) \cdot q(R-I)$$

Therefore, the banker has no incentive to shirk if and only if

$$q(R-I) - \tau \geq (1-\beta) \cdot q(R-I) \Leftrightarrow \beta \geq \frac{\tau}{\widehat{\tau}_{FB}}.$$

To summarize, provided with $p < 1/2$, a safe partnership bank can be set up when

$$\frac{\tau}{\widehat{\tau}_{FB}} \leq \beta \leq \frac{\mu - p}{\mu}.$$

Such a set of β is non-empty if and only if $\frac{\tau}{\widehat{\tau}_{FB}} \leq \frac{\mu-p}{\mu}$ or equivalently, $\tau \leq \frac{\mu}{\mu-p}\widehat{\tau}_{FB} \equiv \widehat{\tau}_s$, which simply states that the surplus of a project $q(R-I)$ is sufficient to cover a banker's expected incentive pay $\tau + \frac{p}{\mu-p}\tau$. □

A.2 Collective Defection of Bankers as Partners

Result 1. *The two bankers will collectively defect and shift risks to depositors if* $p > 1/2$.

Proof. We show that when $p > 1/2$ the two bankers will sign a side contract between themselves that dictates both bankers to gamble when a risky investment opportunity arises, as such a contract would maximize equity value of the partnership bank. Note that the total value of equity of a risky partnership bank where both bankers gamble is

$$\mu^2(2R - 2I),$$

whereas the total equity value for a safe bank is

$$q^2(2R - 2I) + 2q(1 - q)(R - I) + (1 - q)^2(2I - 2I) = 2q(R - I).$$

The former exceeds the latter if and only if $\mu^2 > q$, which in turn gives a critical value

$$p > \frac{\sqrt{q} - q}{1 - q}$$

which increases in q and is bounded between $(0, 1/2)$ as $q \in (0, 1)$. Therefore, when $p > 1/2$, the two bankers will collectively defect and make the partnership bank risky. □

A.3 Proof of Proposition 3

Proof. Note that now the bank is financed by external deposits and inside equity of a shareholder's. It is optimal for the shareholder to inject the entire amount of equity A into the two 'small' banks to earn a positive net return (i.e., by her participation constraint (9)) instead of a zero return from purchasing deposits issued by the banks or simply investing in the risk-free technology (i.e., do not finance the banks). Without loss of generality, we assume that the shareholder split her equity A equally and injects $A/2$ into each of the 'small' banks.

Given the cheapest compensation in Lemma 2, the shareholder's expected payoff from creating a 'small' safe bank with paid-in equity $A/2$ and deposits $I - A/2$ is $\Pi = q \cdot [R - (I - A/2) - B^*_{\{s\}}] + (1-q) \cdot [I - (I - A/2) - C^*_{\{s\}}] - A/2$. The paid-in equity must satisfy ex-post budget constraints (BCs)

$$A/2 \geq B^*_{\{s\}} - (R - I) \tag{35}$$

$$A/2 \geq C^*_{\{s\}}. \tag{36}$$

It can be shown that BC (36) implies BC (35) because $B^*_{\{s\}} - (R - I) \leq C^*_{\{s\}}$ holds for $\forall \tau < \widehat{\tau}_{FB}$. Therefore, the minimum paid-in equity per bank, i.e., the shareholder's financing capacity is $A/2 = C^*_{\{s\}}$: a bank with paid-in equity $A/2$ less than $C^*_{\{s\}}$ cannot be created.

The shareholder's ex-ante participation constraint (PC)

$$\Pi \geq 0 \tag{37}$$

is satisfied when $\tau \leq \widehat{\tau}_s$. To see this, note $\Pi = q(R - I) - [qB^*_{\{s\}} + (1-q)C^*_{\{s\}}] = q(R - I) - X - \tau$, with $X = C^*_{\{s\}} = \frac{p}{\mu - p}\tau$ being the banker's rent. From PC (37), we have $q(R - I) - X - \tau \geq 0$, or equivalently, $\tau \leq \frac{\mu - p}{\mu} q(R - I) \equiv \widehat{\tau}_s < \widehat{\tau}_{FB}$.

The maximum safe deposits created by two of such 'small' banks is $2I - 2C_{\{s\}}$ as determined by the binding BC (36) .

$\square$

A.4 Proof of Lemma 3

Proof. We first assume that the incentive constraints (15) and (16) are both binding in the shareholder's program, then show that it is indeed the case.

Once the two aforementioned the constraints are binding, we can directly solve the following

$$qC^*_{\{s,s\}}(R) + (1-q)C^*_{\{s,s\}}(I) = \frac{p}{\mu - p}\tau = C^*_{\{s\}} \tag{38}$$

$$qB^*_{\{s,s\}}(R) + (1-q)B^*_{\{s,s\}}(I) = \frac{1}{\mu - p}\tau = B^*_{\{s\}}. \tag{39}$$

Then, the contract $W^* = \left\{C^*_{\{s,s\}}(I), C^*_{\{s,s\}}(R), B^*_{\{s,s\}}(I), B^*_{\{s,s\}}(R)\right\}$ gives each banker the same minimum rent $X = C^*_{\{s\}}$ as the single banker case. This is true because the two projects are identical and independent.

Suppose that now the banker obtains a rent higher than X under a contract W. Then, this must not be the result that only one of the two aforementioned equations is slack because either the banker shirks ex-ante (only equation (39) is the only slack) or he gambles when the risky opportunity arises ex-post (only equation (38) is the only slack). Both of the two ICs must hold with '>'. Note that the budget constraints (12) to (14), and the monotonicity conditions (10) and (11) must be all satisfied under alternative contract. Then, we can reduce $qB_{\{s,s\}}(R) + (1-q)B_{\{s,s\}}(I)$ to make IC (16) binding while still keeping IC (15) satisfied. If the monotonicity condition is such that $B^*_{\{s,s\}}(I) > C^*_{\{s,s\}}(R)$, the shareholder can reduce $B^*_{\{s,s\}}(I)$ while still keeping BC (13) satisfied. Instead, if the monotonicity condition is such that $B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R)$, the shareholder can reduce $B^*_{\{s,s\}}(R)$ while still keeping BC (14) satisfied. If both monotonicity conditions are not binding, the shareholder can reduce both $B^*_{\{s,s\}}(R)$ and $B^*_{\{s,s\}}(I)$

while still keeping the relevant BCs satisfied. A violation of the optimality of the alternative contract W in the first place.

$\square$

A.5 Proof of Lemma 4

Proof. As in the 'small' bank case, it is again optimal for a shareholder to inject the entire amount of equity A into the 'big' bank. Notice that minimizing $C^*_{\{s,s\}}(I)$ is equivalently to reduce the required paid-in equity A to finance the bank.[30] We analyze the minimum A or equivalently the minimum $C^*_{\{s,s\}}(I)$ to determine a shareholder's maximum financing capacity for each τ where creating a big safe bank is profitable for the shareholder.

From the shareholder's program and Lemma 3, the shareholder needs to meet the following constraints when setting the bankers' compensation.

$$
\begin{aligned}
2B^*_{\{s,s\}}(R) &\leq 2(R-I)+A && (40)\\
B^*_{\{s,s\}}(I)+C^*_{\{s,s\}}(R) &\leq (R-I)+A && (41)\\
2C^*_{\{s,s\}}(I) &\leq A && (42)\\
qB^*_{\{s,s\}}(R)+(1-q)B^*_{\{s,s\}}(I) &= B^*_{\{s\}} && (43)\\
qC^*_{\{s,s\}}(R)+(1-q)C^*_{\{s,s\}}(I) &= C^*_{\{s\}} && (44)\\
B^*_{\{s,s\}}(R)\geq B^*_{\{s,s\}}(I) &\geq C^*_{\{s,s\}}(R)\geq C^*_{\{s,s\}}(I) && (45)
\end{aligned}
$$

Inequality (40), (41), and (42) are the budget constraints in the states $2R$, $R+I$, and $2I$ respectively. Constraints (43) and (44) are the incentive constraints for the bankers to

[30]Here, we implicitly assume that the budget constraint in the state $2I$ binds and determines the shareholder's financing capacity. We verify this assumption in the proof.

exert effort and to refrain from risk-taking; those are binding since any slackness would imply the shareholder can reduce the bankers' compensation to increase her own payoff. Finally, (45) are the monotonicity constraints that require a banker's compensation to be non-decreasing in his own performance and the performance of the bank/other banker's project.

Suppose that all the above constraints are satisfied, we obtain the shareholder's expected payoffs as

$$\Pi = 2q(R - I) - \tau - \frac{p}{\mu - p}\tau.$$

Like the 'small' bank case, it is profitable for the shareholder to create a 'big' bank only if the cost of effort $\tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB} = \widehat{\tau}_s$. We now derive the minimum $C^*_{s,s}(I)$ and the paid-in equity needed to operate a safe bank. Note that the two incentive constraints (43) and (44) do not depend on A, and the minimum A depends on which of the budget constraints will be binding. The proof takes three steps.

Step 1: The budget constraint in the $2R$ state is slack.

We show that constraint (40) is slack even if $A = 0$, i.e., $2B^*_{\{s,s\}}(R) \leq 2(R - I)$. A sufficient condition for the inequality to be true is that it holds for the highest possible value of $B^*_{\{s,s\}}(R)$. Note that, by the binding incentive constraint (43), $B_{\{s,s\}}(R)$ reaches its maximum when $B^*_{\{s,s\}}(I)$ is set to its minimum, that is, when $B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R)$ because of the monotonicity constraint $B^*_{\{s,s\}}(I) \geq C^*_{\{s,s\}}(R)$. Furthermore, $C^*_{\{s,s\}}(R)$ is at its minimum when $C^*_{\{s,s\}}(R) = C^*_{\{s,s\}}(I) = C_{\{s\}}$ by the monotonicity constraint $C^*_{\{s,s\}}(R) \geq C^*_{\{s,s\}}(I)$. Therefore, $B^*_{\{s,s\}}(R)$ reaches its maximum when

$$B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R) = C^*_{\{s,s\}}(I) = C^*_{\{s\}} = \frac{p}{q(1-p)}\tau.$$

By the incentive constraint (43), we derive the highest possible value of $B^*_{\{s,s\}}(R)$:

$$\frac{1}{q}\left[B^*_{\{s\}} - (1-q)C^*_{\{s\}}\right] = \frac{1-(1-q)p}{q^2(1-p)}\tau.$$

One can show that

$$\frac{1-(1-q)p}{q^2(1-p)}\tau \leq R - I,$$

as a sufficient condition for the budget constraint (40) to be slack, always holds when $\tau \leq \widehat{\tau}_s$ and $p > 1/2$.

Step 2: The budget constraint in the $2I$ state cannot be slack while that in the $R + I$ state is binding.

Suppose that the opposite is true, that is

$$\begin{aligned} 2C^*_{\{s,s\}}(I) &< A && (46) \\ B^*_{\{s,s\}}(I) + C^*_{\{s,s\}}(R) &= (R-I) + A. && (47) \end{aligned}$$

In this case, minimizing $C^*_{\{s,s\}}(I)$ and A would involve setting

$$B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R) = C^*_{\{s,s\}}(I) = C^*_{\{s\}}.$$

Indeed, if $B^*_{\{s,s\}}(I) > C^*_{\{s,s\}}(R)$, the shareholder can decrease $B^*_{\{s,s\}}(I)$ by ϵ and increase $B^*_{\{s,s\}}(R)$ by $(1-q)\epsilon/q$ to reduce equity $C^*_{\{s,s\}}(I)$ and A because the budget constraint in the $2R$ state is shown to be slack. Whereas if $C^*_{\{s,s\}}(R) > C^*_{\{s,s\}}(I)$, by the presumption that the budget constraint in the $2I$ state is slack, i.e., inequality (46), the shareholder can reduce equity A by decreasing $C_{\{s,s\}}(R)$ by ϵ and increasing $C^*_{\{s,s\}}(I)$ by $q\epsilon/(1-q)$.

Given $B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R) = C^*_{\{s\}}$, the paid-in equity $A = 2C^*_{\{s\}} - (R - I)$ by presumption (47). This, however, contradicts presumption (46) for $(R-I) > 0$. Therefore, it cannot be the case that the budget constraint is slack in the $2I$ state while binding in the $R + I$ state.

Step 3: Derive the minimum $C^*_{s,s}(I)$ and the paid-in equity A.

The minimum amount of paid-in equity is determined by the budget constraints since the incentive constraints and monotonicity constraints are not functions of A. Based on Step 2, we now examine the case where the budget constraint is always binding in the $2I$ state and show that to minimize $C^*_{s,s}(I)$ and economize on the paid-in equity, the budget constraint in the $R + I$ state and the monotonicity condition $B^*_{s,s}(I) \geq C^*_{s,s}(R)$ may bind as well for some range of τ.

When $0 \leq \tau < \frac{\mu-p}{2p}\widehat{\tau}^{FB} < \widehat{\tau}_s$,[31] a shareholder with no paid-in equity can issue safe deposits $2I$ to the external depositors. In order to do so, she has to minimize $C_{\{s,s\}}(I)$ to the level of 0 and set $C^*_{\{s,s\}}(R) = \frac{p}{(1-p)q^2}\tau$ to ensure that each banker is compensated with $qC^*_{\{s,s\}}(R) = q\frac{p}{(1-p)q^2}\tau = C^*_{\{s\}}$ in expectation for producing I to prevent risk taking. It means that the entire cash flow in the state $2I$ can be used to repay deposits $2I$. Observe that for this range of τ, BC in the state $R + I$ (41) can be set as slack

$$0 > \left[B^*_{\{s,s\}}(I) + \frac{p}{(1-p)q^2}\tau\right] - (R - I).$$

Note that we have $(R - I) - \frac{2p}{(1-p)q^2}\tau > 0$ when $\tau < \frac{\mu-p}{2p}\widehat{\tau}^{FB}$. By continuity there exists a $B^*_{\{s,s\}}(I)$ such that $B^*_{\{s,s\}}(I) \geq C^*_{\{s,s\}}(R) = \frac{p}{(1-p)q^2}\tau$ satisfying the above inequality.

When $\frac{\mu-p}{2p}\widehat{\tau}_{FB} \leq \tau \leq \widehat{\tau}_s$, the shareholder with paid-in equity $A = 0$ is unable to reduce $C^*_{\{s,s\}}(I)$ down to 0 to finance the bank. The minimum $C^*_{\{s,s\}}(I)$ and A are obtained

[31] Notice that $\frac{\mu-p}{2p}\widehat{\tau}^{FB} < \widehat{\tau}_s$ because $2p > p + (1-p)q = \mu$.

by the binding BCs (42), (41) and the monotonicity condition $B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R)$. The cheapest compensation contract $\left\{B^*_{\{s,s\}}(R), B^*_{\{s,s\}}(I), C^*_{\{s,s\}}(R), C^*_{\{s,s\}}(I)\right\}$ and the cutoff A then jointly solve

$$\begin{cases} qB^*_{\{s,s\}}(R) + (1-q)B^*_{\{s,s\}}(I) = \frac{1}{\mu-p}\tau \\ qC^*_{\{s,s\}}(R) + (1-q)C^*_{\{s,s\}}(I) = \frac{p}{\mu-p}\tau \\ B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R) \\ B^*_{\{s,s\}}(I) + C^*_{\{s,s\}}(R)] - (R-I) = A \\ 2C^*_{\{s,s\}}(I) = A. \end{cases}$$

We obtain the minium $C^*_{\{s,s\}}(I)$ and paid-in equity A as $C^*_{\{s,s\}}(I) = A = \frac{2p}{\mu-p}\tau - \widehat{\tau}^{FB}$ when $\frac{\mu-p}{2p}\widehat{\tau}_{FB} < \tau \leq \widehat{\tau}^{T}$ is achieved by the compensation contract $B^*_{\{s,s\}}(R) = \frac{1-(1-q)p}{(1-p)q^2}\tau - \frac{(1-q)^2}{2q^2}\widehat{\tau}_{FB}$, $B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R) = \frac{p}{(1-p)q}\tau + \frac{1-q}{2q}\widehat{\tau}_{FB}$ and $C^*_{\{s,s\}}(I) = \frac{p}{(1-p)q}\tau - \frac{1}{2}\widehat{\tau}_{FB}$, and the maximum amount of safe deposits $2I - \left[\frac{2p}{\mu-p}\tau - \widehat{\tau}^{FB}\right]$.[32] In particular, when $\tau = \frac{\mu-p}{2p}\widehat{\tau}^{FB}$, we have the minium required paid-in equity $A = 0$ achieved by the compensation contract $B^*_{\{s,s\}}(R) = \frac{q-(1-q)p}{(1-p)q^3} \cdot \frac{\mu-p}{2p}\widehat{\tau}^{FB}$, $B^*_{\{s,s\}}(I) = C^*_{\{s,s\}}(R) = \frac{p}{(1-p)q^2} \cdot \frac{\mu-p}{2p}\widehat{\tau}^{FB}$ and $C^*_{\{s,s\}}(I) = 0$, and the maximum amount of safe deposits $2I$. [33]

□

A.6 Proof of Proposition 5

Proof. We establish the relationship between the minimum possible tweaking δ^*_B and δ^*_C of the compensation contract and the shareholder's paid-in equity A.

First, there exists a upper bound $2C^*_{\{s\}} = 2\frac{p}{\mu-p}\tau$ of A such that a shareholder with $A \geq 2C^*_{\{s\}}$ can optimally offer each banker the individual-performance contract $B^*_{\{s\}}$ and

[32] Again, it can be verified $B^*_{\{s,s\}}(R) > B^*_{\{s,s\}}(I)$ when $q > p$.

[33] It can be easily verified that $B^*_{\{s,s\}}(R) > B^*_{\{s,s\}}(I)$ when $q > p$.

$C^*_{\{s\}}$ with no tweaking $\delta^*_B = \delta^*_C = 0$, and finance the bank with safe deposits $2I - A$. In this case, creating two 'small' banks and financing them separately is equivalent to creating a 'big' bank and financing the two divisions with joint liabilities. Once the shareholder can inject high equity $A/2 > C^*_{\{s\}}$ into each 'small' bank or $A > 2C^*_{\{s\}}$ into a 'big' bank, both the organizational structure design and the compensation design are irrelevant.

Second, there exists a lower bound A^{pub}_2 of A such that a shareholder with $A \leq A^{pub}_2$ can not create either one 'big' bank or two 'small' banks. From Proposition 4, the lower bound of A is $A^{pub}_2 = 0$ when $\tau \leq \frac{\mu-p}{2p}\widehat{\tau}_{FB}$ and $A^{pub}_2 = 2C^*_{\{s\}} - \widehat{\tau}_{FB}$ when $\frac{\mu-p}{2p}\widehat{\tau}_{FB} < \tau \leq \widehat{\tau}_s$. It can be seen that $A^{pub}_2(\tau) < 2C^*_{\{s\}} = 2A^{pub}_1(\tau)$. We then analyze the case for $A^{pub}_2 \leq A < 2C^*_{\{s\}}$.

When $0 \leq \tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB} = \widehat{\tau}_s$, the shareholder with a paid-in equity $A \in \left[A^{pub}_2, 2C^*_{\{s\}}\right)$ can offer

$$C^*_{\{s,s\}}(I) = \frac{A}{2} \quad \text{and} \quad C^*_{\{s,s\}}(R) = \frac{1}{q}\left[C^*_{\{s\}} - (1-q)\frac{A}{2}]\right]$$

to issue an amount $2I - A$ of safe deposits.[34] Note that when $0 \leq \tau \leq \frac{\mu-p}{2p}\widehat{\tau}_{FB}$, a shareholder with $A = 0$ has to set $C^*_{\{s,s\}}(I) = 0$ and $C^*_{\{s,s\}}(R) = \frac{p}{(1-p)q^2}\tau$; and when $0 \leq \tau \leq \frac{\mu-p}{2p}\widehat{\tau}_{FB}$, a shareholder with $A = 2C^*_{\{s\}} - \widehat{\tau}_{FB}$ has to set $C^*_{\{s,s\}}(I) = C^*_{\{s\}} - \frac{1}{2}\widehat{\tau}_{FB} > 0$ and $C^*_{\{s,s\}}(R) = \frac{1}{q}\left[C^*_{\{s\}} - (1-q)\left(C^*_{\{s\}} - \frac{1}{2}\widehat{\tau}_{FB}\right)\right]$, as showed in Lemma 4. According to the definition (32), we can solve the tweak on $C^*_{\{s,s\}}(I)$ and $C^*_{\{s,s\}}(R)$ as

$$\delta^*_C = \frac{1-q}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] > 0.$$

[34] It is not optimal for the shareholder to issue a safe deposits more than $2I - A$ and keep some cash in her own pocket because she can only invest that money in a risk free technology and obtain zero.

It can be seen that

$$\frac{\partial \delta_C^*}{\partial A} = -\frac{q}{2(1-q)} < 0.$$

A higher value of δ_C^* represents a higher degree of the 'sharing' feature of a banker's compensation on other banker's performance when the banker's project produces I. Moreover, a higher value of paid-in equity A reduces this dependence of a banker's pay on the other banker's performance when his project produces I. In particular, the highest degree of tweaking $\delta_C^* = \frac{(1-q)p}{(1-p)q^2}\tau$ on $C_{\{s,s\}}^*(I)$ and $C_{\{s,s\}}^*(R)$ is needed when $0 \leq \tau \leq \frac{\mu-p}{2p}\widehat{\tau}_{FB}$ and for a shareholder with $A = 0$ to secure external financing $2I$.

On the other hand, there exists another cutoff $A_2^{\delta_B^*=0}(\tau) \in \left[A_2^{pub}, 2C_{\{s\}}^*\right)$ such that the shareholder can make a banker's compensation depend on his own performance when the banker's project produces R, i.e., $B_{\{s,s\}}^*(R) = B_{\{s,s\}}^*(I) = B_{\{s\}}^*$ with $\delta_B^* = 0$ if $A \geq A_2^{\delta_B^*=0}(\tau)$.

To see this, insert $B_{\{s,s\}}^*(I) = B_{\{s\}}^*$ into the budget constraints in the state $R + I$, and the constraint is non-binding if

$$A \geq \left\{\frac{1}{q}\left[\frac{p}{(1-p)q}\tau - (1-q)\frac{A}{2}\right] + \frac{1}{(1-p)q}\tau\right\} - (R-I) \Leftrightarrow A \geq \frac{2}{1+q}\left[\frac{p+q}{(1-p)q}\tau - q(R-I)\right].$$

One can easily check that $\frac{2}{1+q}\left[\frac{p+q}{(1-p)q}\tau - q(R-I)\right] \geq 0 \Leftrightarrow \tau \geq \frac{\mu-p}{p+q}\widehat{\tau}_{FB}$,[35] and verify the following

$$\frac{2}{1+q}\left[\frac{p+q}{(1-p)q}\tau - q(R-I)\right] < 2\frac{p}{\mu-p} = 2C_{\{s\}}^* \Leftrightarrow \tau < q(R-I) = \widehat{\tau}_{FB}$$

and

$$\frac{2}{1+q}\left[\frac{p+q}{(1-p)q}\tau - q(R-I)\right] \geq 2\frac{p}{\mu-p}\tau - q(R-I) = 2C_{\{s\}}^* - \widehat{\tau}_{FB} \Leftrightarrow \tau \geq \frac{1-q}{2}\widehat{\tau}_{FB}.$$

[35] We have $\frac{\mu-p}{p+q}\widehat{\tau}_{FB} < \frac{\mu-p}{2p}\widehat{\tau}_{FB}$ if $q > p$.

Furthermore, note that $\frac{1-q}{2}\widehat{\tau}_{FB} < \frac{\mu-p}{p+q}\widehat{\tau}_{FB}$. Therefore, we have $A_2^{\delta_B^*=0}(\tau)$ as

$$A_2^{\delta_B^*=0}(\tau) = \begin{cases} 0 & 0 \leq \tau \leq \frac{\mu-p}{p+q}\widehat{\tau}_{FB} \\ \frac{2}{1+q}\left[\frac{p+q}{(1-p)q}\tau - q(R-I)\right] & \frac{\mu-p}{p+q}\widehat{\tau}_{FB} < \tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB}. \end{cases}$$

The above analyses then show that $A_2^{pub}(\tau) \leq A_2^{\delta_B^*=0}(\tau) < 2C^*_{\{s\}}$ for $\tau \in \left[0, \frac{\mu-p}{\mu}\widehat{\tau}_{FB}\right]$, and $A_2^{\delta_B^*=0}(\tau) = A_2^{pub}(\tau)$ for $\tau \in \left[0, \frac{\mu-p}{p+q}\widehat{\tau}_{FB}\right]$.

When $0 \leq \tau \leq \frac{\mu-p}{p+q}\widehat{\tau}_{FB}$, a shareholder with $A \geq A_2^{\delta_B^*=0}(\tau)$ needs not tweak $B^*_{\{s,s\}}(I)$ and $B^*_{\{s,s\}}(R)$ because $A_2^{\delta_B^*=0}(\tau) = 0$. Therefore, we have $\delta_C^* = \frac{1-q}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] > 0$ and $\delta_B^* = 0$. For this contract with the least possible tweaks, one can check that the monotonicity condition is satisfied because $B^*_{\{s,s\}}(R) = B^*_{\{s,s\}}(I) = B^*_{\{s\}} = \frac{1}{(1-p)q}\tau > \frac{p}{(1-p)q^2}\tau = C^*_{\{s,s\}}(R) > C^*_{\{s,s\}}(I)$, and the inequality holds when $q > p$. Notice that we have $B^*_{\{s,s\}}(I) > C^*_{\{s,s\}}(I)$ for this range of small τs.

Instead, when $\frac{\mu-p}{p+q}\widehat{\tau}_{FB} < \tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB}$, the set $\left[A_2^{pub}, A_2^{\delta_B^*=0}(\tau)\right)$ is non-empty. For a shareholder with $A \in \left[A_2^{pub}, A_2^{\delta_B^*=0}(\tau)\right)$, she must also tweak $B^*_{\{s,s\}}(I)$ and $B^*_{\{s,s\}}(R)$: $B^*_{\{s,s\}}(I)$ ($B^*_{\{s,s\}}(R)$) must be smaller (higher) than $B^*_{\{s\}}$ because of the binding budget constraint in the state $R+I$.

We show that the least tweak δ_B^* has to be strictly positive and determined by the binding budget constraint in the state $R+I$.

In this case, the highest possible $B^*_{\{s,s\}}(I)$ (δ_B^* will be the least) is given by

$$A = \left\{\frac{1}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] + B^*_{\{s,s\}}(I)\right\} - (R-I) \Leftrightarrow B^*_{\{s,s\}}(I) = (R-I) - \frac{p}{(1-p)q^2}\tau + \frac{1+q}{2q}A.$$

One can check that $B^*_{\{s,s\}}(I) = (R-I) - \frac{p}{(1-p)q^2}\tau + \frac{1+q}{2q}A < \frac{p}{(1-p)q}\tau = B^*_{\{s\}}$ if $A < A_2^{\delta^*_B=0}(\tau)$. We can solve the minimum tweak on $B^*_{\{s,s\}}(I)$ and $B^*_{\{s,s\}}(R)$ according to the the definition (31) as

$$\delta^*_B = \frac{1-q}{q^2}\left[\frac{q+p}{(1-p)q}\tau - q(R-I) - \frac{1+q}{2}A\right] > 0.$$

It can be seen that

$$\frac{\partial \delta^*_B}{\partial A} = -\frac{1-q^2}{2q^2} < 0.$$

Similar to the case of δ^*_C, a higher value of δ^*_B also represents a higher degree of the 'sharing' feature of a banker's compensation on other banker's performance when the banker's project produces R. And a higher value of paid-in equity A also reduces this dependence of a banker's pay on the other banker's performance when his project produces R. For this contract with $\delta^*_B > 0$ and $\delta^*_C > 0$, the monotonicity condition $B^*_{\{s,s\}}(R) > B^*_{\{s,s\}}(I)$ and $C^*_{\{s,s\}}(R) > C^*_{\{s,s\}}(I)$ must be satisfied. The only thing needs to be guaranteed is

$$\begin{aligned}
&B^*_{\{s,s\}}(I) = (R-I) - \frac{p}{(1-p)q^2}\tau + \frac{1+q}{2q}A > \frac{1}{q}\left[C^*_{\{s\}} - (1-q)\frac{A}{2}\right] = C^*_{\{s,s\}}(R) \\
\Leftrightarrow\, &A \geq \frac{2p}{(1-p)q}\tau - q(R-I) = 2C^*_{\{s\}} - \widehat{\tau}_{FB},
\end{aligned}$$

which is of course true because we are considering $A \geq A_2^{pub}(\tau) \geq 2C^*_{\{s\}} - \widehat{\tau}_{FB}$ for $\frac{\mu-p}{p+q}\widehat{\tau}_{FB} < \tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB}$. Therefore, the monotonicity condition $B^*_{\{s,s\}}(I) \geq C^*_{\{s,s\}}(R)$ is satisfied, and the '=' occurs when $A = A_2^{pub}(\tau)$ for $\frac{\mu-p}{2p}\widehat{\tau}_{FB} < \tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB}$.

Lastly, one can show that $\delta_B^* < \delta_C^*$ for all $A \in \left[A_2^{pub}(\tau), 2C^*_{\{s\}}\right]$ and $\tau \in \left[0, \frac{\mu-p}{\mu}\widehat{\tau}_{FB}\right]$. Indeed, for $A \in \left[A_2^{\delta_B^*=0}(\tau), 2C^*_{\{s\}}\right]$ and $\tau \in \left[0, \frac{\mu-p}{\mu}\widehat{\tau}_{FB}\right]$, we have $\delta_C^* > 0 = \delta_B^*$. For $A \in \left[A_2^{pub}(\tau), A_2^{\delta_B^*=0}(\tau)\right)$ and $\tau \in \left[\frac{\mu-p}{p+q}\widehat{\tau}_{FB}, \frac{\mu-p}{\mu}\widehat{\tau}_{FB}\right]$, we have

$$\begin{aligned}
&\delta_C^* = \frac{1-q}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] > \frac{1-q}{q^2}\left[\frac{q+p}{(1-p)q}\tau - q(R-I) - \frac{1+q}{2}A\right] = \delta_B^* \\
\Leftrightarrow &\frac{1}{2}A > \frac{\mu}{\mu-p}\tau - q(R-I),
\end{aligned}$$

which is true because $\tau \leq \frac{\mu-p}{\mu}q(R-I) = \frac{\mu-p}{\mu}\widehat{\tau}_{FB} = \widehat{\tau}_s$.

In sum, when $0 \leq \tau \leq \frac{\mu-p}{p+q}\widehat{\tau}_{FB}$, a shareholder with $A \in \left[A_2^{\delta_B^*=0}(\tau), 2C^*_{\{s\}}\right) = \left[A_2^{pub}, 2C^*_{\{s\}}\right)$ can minimize the tweak on the compensation contract by setting $\delta_B^* = 0$ and $\delta_C^* = \frac{1-q}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] > 0$, and $\frac{\partial\delta_C^*}{\partial A} < 0$. When $\frac{\mu-p}{p+q}\widehat{\tau}_{FB} < \tau \leq \frac{\mu-p}{\mu}\widehat{\tau}_{FB}$, a shareholder with $A \in \left[A_2^{\delta_B^*=0}(\tau), 2C^*_{\{s\}}\right)$ can still minimize the tweak on the compensation contract by setting $\delta_B^* = 0$ and $\delta_C^* = \frac{1-q}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] > 0$ while a shareholder with $A \in \left[A_2^{pub}(\tau), A_2^{\delta_B^*=0}(\tau)\right)$ must set $\delta_B^* = \frac{1-q}{q^2}\left[\frac{q+p}{(1-p)q}\tau - q(R-I) - \frac{1+q}{2}A\right] > 0$ and $\delta_C^* = \frac{1-q}{q}\left[\frac{p}{(1-p)q}\tau - \frac{A}{2}\right] > 0$, where $A^c = \frac{2}{1+q}\left[\frac{p+q}{(1-p)q}\tau - q(R-I)\right] > 0$. Both $\frac{\partial\delta_B^*}{\partial A} < 0$ and $\frac{\partial\delta_C^*}{\partial A} < 0$ We always have $\delta_C^* > \delta_B^*$.

Since such a tweaked compensation can reduce the required amount of paid-in equity in case of public contracting (Proposition **??**), our model generates a testable prediction that the lower the bank's paid-in equity, the more the compensation contract needs to be firm-performance-sensitive. [More precise?]

□

A.7 Proof of Corollary 1

Proof. From **??**, the shareholder's incentive constraint for a safe bank is given by expression (**??**). The maximum money created in the two-bank economy is then

$$M = 2I - \frac{2}{1-\mu}\left[(1-q)p(R-I) + X\right] = 2I - A_1(\tau).$$

Observe that $A_1(\tau) = \frac{2}{1-\mu}\left[(1-q)p(R-I) + X\right]$ increases in τ as $X = X(\tau)$ increases in τ.

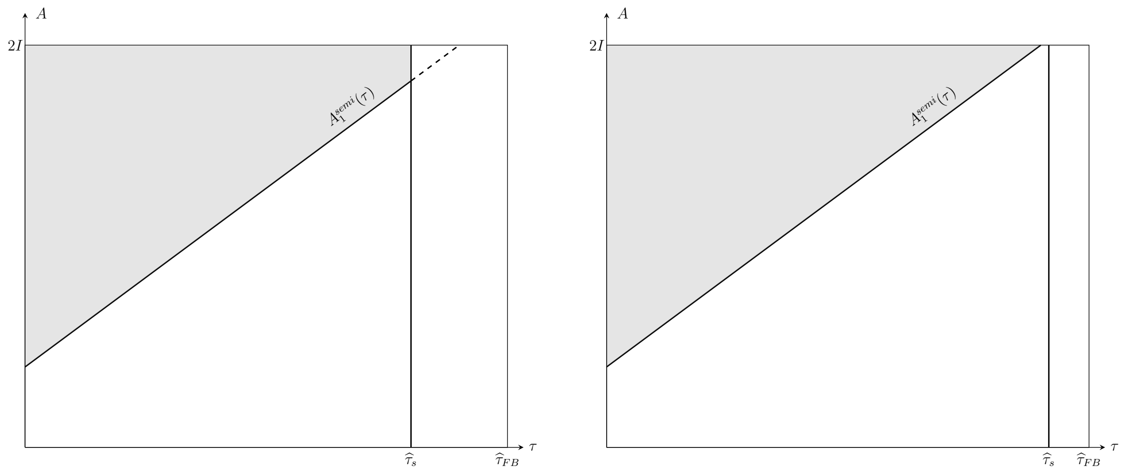
Providing the critical amount of paid-in equity, however, may not be a sufficient condition for the shareholder create a safe bank: the shareholder may find the payoff from running a safe bank to be negative after conceding the agency rent to the banker, which happens when the cost of effort exceeds a critical level $\widehat{\tau}_s$. That is, the shareholder's participation constraint fails to hold for $\tau > \widehat{\tau}_s$ even though the incentive constraint in Proposition 6 is satisfied. We depict in Panel (a) of Figure 7 such a case, which arises when the return of the project is not too high:

$$\frac{R}{I} < 1 + \frac{1-p}{p}\frac{\mu(1-q)}{\mu(1-q)+q}. \tag{48}$$

Otherwise, the shareholder's participation constraint $\tau \leq \widehat{\tau}_s$ will be redundant and implied by the incentive constraint. We illustrate this case in Panel (b) of Figure 7.

Assumption 2 reduces the number of cases we need to discuss, while keeping the more general case since the participation constraint is not always implied by the incentive constraint.

Figure 7: A 'small' bank with paid-in equity



(a) Illustration under Assumption 2

(b) Alternative assumption

Panel (a) illustrates a case where Assumption 2 is satisfied, so that the money creation of a 'small' bank is constrained both by its shareholder's incentive constraint and participation constraint. Panel (b) illustrates the alternative case where the shareholder's participation constraint is implied by her incentive constraint so that former does not place a restriction on the 'small' bank's money creation.

Note that the shareholder's participation requires $\tau \leq \widehat{\tau}_s = \frac{\mu - p}{\mu} q(R - I)$. Therefore, positive money creation can be achieved for $\forall \tau \leq \widehat{\tau}_s$ if and only if

$$2I - A_1(\widehat{\tau}_s) > 0.$$

After manipulation, the above inequality can be reformulated into

$$\frac{R}{I} < 1 + \frac{1-p}{p} \frac{\mu(1-q)}{\mu(1-q)+p}. \tag{49}$$

Therefore, both the shareholder's participation constraint and incentive constraint matter. On the other hand, suppose this inequality does not satisfied, then we have $2I - A_1(\widehat{\tau}_s) < 0$, the shareholder's participation constraint is implied by her incentive constraint. In this case, one can also check that $2I - A_1(0) > 0 \Leftrightarrow I > pR$. Therefore, if the inequality (49) does not hold, there exists a cutoff τ' such that $2I - A_1(\tau) > 0$ when $\tau < \tau'$ and $2I - A_1(\tau) \leq 0$ when $\tau' \leq \tau \leq \widehat{\tau}_s$, where τ' uniquely solves $2I - A_1(\tau') = 0$. $\square$

A.8 Proof of Lemma 5

Proof. First, consider the compensation needed to implement a safe bank. Without loss of generality, we consider compensation contracts under which a banker's pay depends only on the performance of the investment managed by him and is not affected by the performance of the investment managed by the other banker. That is,

$$C_{\{s,s\}}(R) = C_{\{s,s\}}(I) = C_{\{s,s\}} \qquad \text{and} \qquad B_{\{s,s\}}(R) = B_{\{s,s\}}(I) = B_{\{s,s\}}. \tag{50}$$

This is because, when the shareholder cannot commit to not shifting risks to depositors, her incentive constraints will bind before the budget constraint in the low-return state.

Now consider the shareholder's problem in contracting for a 'big' safe bank: to minimize the expected payments to bankers while inducing both bankers to exert effort and avoid risk taking. The cheapest compensation is to offer the two bankers each $B_{\{s,s\}}$ and $C_{\{s,s\}}$ that solve the following program.

$$\min_{\{B_{\{s,s\}}, C_{\{s,s\}}\}} q^2 \cdot 2B_{\{s,s\}} + 2q(1-q) \cdot (B_{\{s,s\}} + C_{\{s,s\}}) + (1-q)^2 \cdot 2C_{\{s,s\}}$$

$$C_{\{s,s\}} \geq p \cdot B_{\{s,s\}} \tag{51}$$

$$q \cdot B_{\{s,s\}} + (1-q) \cdot C_{\{s,s\}} - \tau \geq C_{\{s,s\}}. \tag{52}$$

For bankers' incentive constraints to avoid risk-taking (51) and exert effort (52), we take a Nash equilibrium point of view and consider that the contract should rule out a banker's defection (whether it is gambling or shirking) given that the other banker sticks to the equilibrium action. The cheapest compensation entails

$$B_{\{s,s\}} = B_{\{s\}} = \frac{1}{q(1-p)}\tau \quad C_{\{s,s\}} = C_{\{s\}} = \frac{p}{q(1-p)}\tau. \tag{53}$$

That is, each banker receives the same compensation scheme as in the 'small' bank case and still earns a rent X. Correspondingly, the shareholder earns a profit

$$\Pi^{pub}_{\{s,s\}} = 2q(R-I) - 2X - 2\tau. \tag{54}$$

Defection $\{s, r\}$

We now consider the shareholder's contracting problem for a bank with a safe division i and a risky division j. For division i, the shareholder solves the program $\min_{\left\{B^i_{\{s,r\}}, C^i_{\{s,r\}}\right\}} \mu \left[qB^i_{\{s,r\}} + (1-q)C^i_{\{s,r\}}\right]$ subjecting to the banker i's incentive constraints $\mu C^i_{\{s,s\}} \geq \mu p B^i_{\{s,s\}}$ and $\mu \left[qB^i_{\{s,s\}} + (1-q)C^i_{\{s,s\}}\right] - \tau \geq \mu C^i_{\{s,s\}}$. Instead, for division j, the shareholder solves $\min_{\left\{B^j_{\{s,r\}}, C^j_{\{s,r\}}\right\}} \mu B^j_{\{s,r\}}$ subjecting to the banker j's incentive constraints $\mu B^j_{\{s,r\}} - \tau \geq C^j_{\{s,r\}}$ and $pB^j_{\{s,r\}} \geq C^j_{\{s,r\}}$. In particular, in the public contracting, banker i can observe the contract offered to banker j. Therefore, he knows that he will receive compensation $B^i_{\{s,r\}}$ or $C^i_{\{s,r\}}$ only if division j's risk-taking succeeds (i.e., with a probability μ). The solution of the two bankers' programs give $\left\{B^i_{\{s,r\}}, C^i_{\{s,r\}}\right\} = \left\{\frac{1}{\mu}\frac{1}{\mu-p}\tau, \frac{1}{\mu}\frac{p}{\mu-p}\tau\right\}$ and $\left\{B^j_{\{s,r\}}, C^j_{\{s,r\}}\right\} = \left\{\frac{1}{\mu}\tau, 0\right\}$. Banker i obtains a rent $\mu C^i_{\{s,s\}} = X = \frac{p}{\mu-p}\tau$ and banker j obtains zero rent.

Defection $\{r, r\}$: we now consider the defection where the shareholder contracts both bankers to take effort and gamble upon a risky investment opportunity. Let a banker receives $B_{\{r,r\}}$ when he generates R and $C_{\{r,r\}}$ when he generates I.

The shareholder minimizes the expected compensation $\mu^2 B_{\{r,r\}}$ subject to the incentive constraints $\mu^2 B_{\{r,r\}} - \tau \geq \mu C_{\{r,r\}}$ to induce effort, and $\mu p B_{\{r,r\}} \geq \mu C_{\{r,r\}}$ to induce gambling. The solution is to set $C_{\{r,r\}} = 0$ and $B_{\{r,r\}} = \tau/\mu^2$, so a banker is paid with $B_{\{r,r\}}$ only if both bankers return R (which occurs with an ex-ante probability μ^2) and receives zero rent.

Defection $\{r, n\}$: Last, we consider the defection where the shareholder contracts Banker i to take effort and gamble and Banker j to take no effort.

To minimize bankers' expected compensation, the shareholder will always pay Banker j zero (or not hiring the banker at all) and will offer Banker i $C_{\{r,n\}} = 0$ when he returns 0 and $B_{\{r,n\}} = \tau/\mu$ when he returns R. The compensation induces effort from Banker i but allows him to receive zero rent. □

A.9 Proof of Proposition 7

Proof. We start by considering the feasibility and the profitability for the shareholder to create a 'big' bank where both bankers take effort and avoid gambling. We consider individual-performance-sensitive compensation.

$$B_{\{s,s\}} = B_{\{s\}} = \frac{1}{\mu - p}\tau \quad C_{\{s,s\}} = C_{\{s\}} = \frac{p}{\mu - p}\tau.$$

This is without losing generality because when bankers can observe each other's compensation contract, the benefit of firm-performance-sensitive compensation in implementing a safe 'big' is to relax the budget constraint in the low-income state (as shown in the public contracting case), whereas the budget constraint is slack and will be implied by the shareholder's incentive constraint as we will establish in below.

The shareholder faces the following budget constraints when the bank generates a total revenue of $2R$, $R+I$, and $2I$ respectively:

$$A \geq \frac{2}{\mu - p}\tau - 2(R - I) \tag{55}$$

$$A \geq \frac{1+p}{\mu - p}\tau - (R - I) \tag{56}$$

$$A \geq \frac{2p}{\mu - p}\tau. \tag{57}$$

It can be verified that, when $\tau < \widehat{\tau}_{FB} = q(R - I)$, constraint (57) implies both (55) and (56). That is, the budget constraint is most tight in the state where the overall income is the lowest at $2I$. In addition to the budget constraint (57), the shareholder faces a participation constraint

$$\begin{aligned}\Pi_{\{s,s\}} = {} & q^2[2R - 2B_{\{s,s\}} - (2I - A)] + 2q(1-q)[(R+I) - (B_{\{s,s\}} + C_{\{s,s\}}) - (2I - A)] \\ & + (1-q)^2[2I - 2C_{\{s,s\}} - (2I - A)] - A = 2q(R - I) - 2X - 2\tau \geq 0,\end{aligned}$$

which is satisfied if and only if $\tau \leq \widehat{\tau}_s$.

Next, we derive shareholder's expected payoff from creating a 'big' bank with one safe division and one risky division (defection $\{s, r\}$), that from a 'big' bank with two risky divisions (defection $\{r, r\}$), and that from a bank with one risky division only (defection $\{r, n\}$). We first derive conditions that prevent such defections from happening when the shareholder offers only individual-performance-sensitive compensation off the equilibrium path. We then show that allowing a banker's compensation to depend on the other banker's performance off the equilibrium path does not lead to any change to those conditions.

Preventing defection $\{r,s\}$ with individual-performance-sensitive pay: By Lemma 5, the shareholder induce Banker i to play safe by offering him $B_{\{s\}}/\mu$ when he returns R and $C_{\{s\}}/\mu$ when he returns I. Banker j plays risky and receives τ/μ when returning R, 0 otherwise. The shareholder's expected payoffs is

$$\begin{aligned}\Pi_{\{s,r\}} &= q\mu\left[2R - B_{\{s\}}/\mu - \tau/\mu - (2I - A)\right] + (1-q)\mu\left[(R+I) - C_{\{s\}}/\mu - \tau/\mu - (2I - A)\right] - A \\ &= \mu(1+q)(R-I) - X - 2\tau - (1-\mu)A.\end{aligned}$$

The shareholder will pursue such a defection, if the budget constraint is met in the $2R$ state, $2R - B_{\{s\}}/\mu - \tau/\mu - (2I - A) \geq 0$, or

$$A \geq \max\left\{B_{\{s\}}/\mu + \tau/\mu - 2(R-I), 0\right\}$$

as well as in the $I + R$ state, $(R+I) - C_{\{s\}}/\mu - \tau/\mu - (2I - A) \geq 0$, or

$$A \geq \max\left\{C_{\{s\}}/\mu + \tau/\mu - (R-I), 0\right\};$$

the shareholder's participation constraint $\Pi_{\{s,r\}} \geq 0$ is met,

$$A \leq \frac{1}{1-\mu}\left[\mu(1+q)(R-I) - X - 2\tau\right]; \tag{58}$$

and the defection payoff exceeds that from a safe bank, $\Pi_{\{s,r\}} \geq \Pi_{\{s,s\}}$, or equivalently,

$$A \leq \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R-I) + X\Big]. \tag{59}$$

One can show that, for $p > 1/2$, the budget constraint in $2R$ state is implied by that in the $I + R$ state, and the latter is in turn guaranteed by $\tau < \widehat{\tau}_s$ even if $A = 0$. Therefore, the shareholder would not pursue the $\{s, r\}$ defection if

$$A > \min\left\{\frac{1}{1-\mu}\left[\mu(1+q)(R-I) - X - 2\tau\right], \ \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R-I) + X\Big]\right\}$$

It can be verified that $\mu(1+q)(R-I) - X - 2\tau \geq ((1+q)\mu - 2q)(R-I) + X$ for $\forall\tau \leq \widehat{\tau}_s$, so that the shareholder will not take the $\{s, r\}$ defection if

$$A > \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R-I) + X\Big] \equiv A^{semi}_{\{s,r\}}.$$

Preventing defection $\{r, r\}$ with individual-performance-sensitive pay: By Lemma 5, to create a bank with two risky divisions, the shareholder offers both bankers $B_{\{r,r\}} = \tau/\mu^2$ when they returns R and $C_{\{r,r\}} = 0$ when they return I. Her expected payoff from this defection is

$$\Pi_{\{r,r\}} = \mu^2\left[2R - 2\tau/\mu^2 - (2I - A)\right] - A = 2\mu^2(R-I) - 2\tau - (1-\mu^2)A. \qquad (60)$$

The shareholder will pursue such a defection, if the budget constraint $2R - 2\tau/\mu^2 - (2I - A) \geq 0$ is met,

$$A \geq \max\left\{2\tau/\mu^2 - 2(R-I), 0\right\};$$

the shareholder's participation constraint $\Pi_{\{r,r\}} \geq 0$ is met,

$$A \leq \frac{1}{1-\mu^2}\left[2\mu^2(R-I) - 2\tau\right]; \qquad (61)$$

and the defection payoff exceeds that from a safe bank, $\Pi_{\{r,r\}} \geq \Pi_{\{s,s\}}$, or equivalently,

$$A \leq \frac{1}{1-\mu^2}\left[\left(\mu^2 - q\right) 2(R-I) + 2X\right]. \tag{62}$$

One can show that, when $p > 1/2$ and $\tau \leq \widehat{\tau}_s$, the budget constraint always holds, even if $A = 0$.[36] Therefore, the shareholder would not pursue the $\{r, r\}$ defection if

$$A > \min\left\{\frac{1}{1-\mu^2}\left[2\mu^2(R-I) - 2\tau\right],\ \frac{1}{1-\mu^2}\left[\left(\mu^2 - q\right) 2(R-I) + 2X\right]\right\}$$

It can be verified that $\mu^2(R-I) - \tau \geq \left(\mu^2 - q\right)(R-I) + X$ for $\forall \tau \leq \widehat{\tau}_s$, so that the shareholder will not take the $\{r, r\}$ defection if

$$A > \frac{1}{1-\mu^2}\left[\left(\mu^2 - q\right) 2(R-I) + 2X\right] \equiv A^{semi}_{\{r,r\}}.$$

Preventing defection $\{r, n\}$ with individual-performance-sensitive pay: By Lemma 5, to create a bank where Banker i takes effort and gambles, whereas Banker j shirks, the shareholder pays Banker i τ/μ when he returns R, and 0 otherwise. Banker j, on the other hand, receives a zero payoff regardless. The shareholder's expected payoff from this defection is

$$\Pi_{\{r,n\}} = \mu[(R+I) - \tau/\mu - (2I - A)] - A = \mu(R-I) - \tau - (1-\mu)A.$$

[36] To see that $2\tau/\mu^2 - 2(R-I) < 0$ for $\tau < \widehat{\tau}_s$, note that the former inequality holds when $\tau \leq \mu^2(R-I)$, whereas the latter is $\tau \leq \frac{\mu-p}{\mu} q(R-I)$. To see that $\frac{\mu-p}{\mu} q < \mu^2$, or equivalently $pq > \mu(q-\mu^2)$, always holds, note that $q - \mu^2 = q(1-q) - 2q(1-q)p - (1-q)^2p^2 < 0$ for $p > 1/2$.

The shareholder will pursue such a defection, if the budget constraint $(R+I)-\tau/\mu-(2I-A)\geq 0$ is met,

$$A \leq \max\left\{\frac{1}{\mu}\tau-(R-I),0\right\};$$

the shareholder's participation constraint $\Pi_{\{r,n\}}\geq 0$ is met,

$$A \leq \frac{1}{1-\mu}\left[\mu(R-I)-\tau\right]; \tag{63}$$

and the defection is profitable, $\Pi_{\{r,n\}}\geq\Pi_{\{s,s\}}$, or equivalently,

$$A \leq \frac{1}{1-\mu}\left[(\mu-2q)(R-I)+\tau+2X\right]. \tag{64}$$

Again, when $\tau\leq\widehat{\tau}_s$, the budget constraint always holds, even if $A=0$. Thus, the shareholder would not pursue the $\{r,n\}$ defection if

$$A > \min\left\{\frac{1}{1-\mu}\left[\mu(R-I)-\tau\right],\ \frac{1}{1-\mu}\left[(\mu-2q)(R-I)+\tau+2X\right]\right\}$$

One can show that $(\mu-2q)(R-I)+\tau+2X\leq\mu(R-I)-\tau$ for $\forall\tau\leq\widehat{\tau}_s$, so that the shareholder will not take the $\{r,n\}$ defection if

$$A \geq \frac{1}{1-\mu}\left[(\mu-2q)(R-I)+\tau+2X\right]\equiv A^{semi}_{\{r,n\}}.$$

Preventing defections with institution-performance-sensitive pay

To begin with, note that the shareholder can write institution-performance-sensitive contract only for the $\{r,s\}$ defection. For a banker instructed to take effort but play risky in the defection $\{r,r\}$ and $\{r,n\}$, the banker understands that when he gets paid, there is only one possible return generated by the other banker, that is, R in the $\{r,r\}$

defection and I in the $\{r, n\}$ defection. For instance, in the $\{r, r\}$ defection, a banker expects to be paid only if the other banker returns R – the bank fails and no banker is paid if the other banker otherwise returns 0. Therefore, the shareholder cannot design institution-performance-sensitive compensation contract in this defection.

Further note that in all three defections considered, the off-equilibrium-path budget constraints are always satisfied in dependent of the value of paid-in equity A. This is because, compared to the equilibrium where a low income $2I$ is possible, the states associated with defections have higher income and yet lower compensation cost. Indeed, all defections avoid the state of the lowest income $2I$, and the compensation to the banker(s) taking risks is also reduced – the shareholder pays no agency rent to a gambling banker. The higher income and lower compensation combined lead to the slack budget constraints. Therefore, setting institution-performance-sensitive pay would not make defections any more feasible by relaxing those budget constraints.

Finally, when the institution-performance-sensitive pay defections keeps the expected banker compensation unchanged, the shareholder's participation constraints associated with the defections, i.e., inequalities (58), (61), and (63), and his incentive constraints i.e., inequalities (59), (62), and (64), will not change. Thus, budget constraints are not altered by institution-performance-sensitive compensation off the equilibrium path; neither were the participation constraints, nor the incentive constraints. The conditions to prevent the $\{r, s\}$, $\{r, r\}$ and $\{r, n\}$ defections, are still to ask the shareholder to put in paid-in equity no less than $A^{semi}_{\{s,r\}}$, $A^{semi}_{\{r,r\}}$ and $A^{semi}_{\{s,n\}}$, respectively.

In addition, one can show the budget constraints are indeed also slack on the equilibrium path; they are implied by the incentive constraints. Intuitively, if the budget constraint is binding in the (low-income, $2I$) state, the shareholder will receive a zero payoff in such a state and will lose incentives to contract both bankers to play safe.

Mathematically, one can verify that $A^{semi}_{\{s,r\}} > 2X = \frac{2p}{\mu-p}\tau$ because $\mu(1+q) > 2q$ and $\frac{1}{1-\mu}X > 2X$; $A^{semi}_{\{r,r\}} > 2X$ because $\mu^2 > q$ and $\frac{2}{1-\mu^2} > 2$. $A^{semi}_{\{r,n\}} > 2X$ is also true because $\mu > 2q$. Therefore, the lack of shareholder commitment makes it possible to run a safe bank only with greater paid-in equity.

Incentive constraints that implement an $\{s,s\}$ bank: After deriving $A^{semi}_{\{s,r\}}$, $A^{semi}_{\{r,r\}}$ and $A^{semi}_{\{r,n\}}$, we express the shareholder's incentive constraint constraint as a function of τ for $\tau \in [0, \widehat{\tau}_s]$. Note that $A^{semi}_{\{s,r\}}$, $A^{semi}_{\{r,r\}}$ and $A^{semi}_{\{r,n\}}$ are all increasing and linear in τ. We can show that $A^{semi}_{\{s,r\}} \geq A^{semi}_{\{r,r\}}$ if and only if $\tau \leq \frac{\mu(1-q)(\mu-p)}{p}(R-I) = \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s \equiv \widehat{\tau}_{\{s,r\}}$. Moreover, $\frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s < \mu\widehat{\tau}_s$ if and only if $pq > \mu(1-q)$. One can also show that $A^{semi}_{\{s,r\}} \geq A^{semi}_{\{r,n\}}$ if and only if $\tau < \mu\frac{\mu-p}{\mu}q(R-I) = \mu\widehat{\tau}_s$. Lastly, we have $A^{semi}_{\{r,r\}} \geq A^{semi}_{\{r,n\}}$ if and only if $\tau \leq \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s \equiv \widehat{\tau}_{\{r,r\}}$. Furthermore, under the same condition $pq > \mu(1-q)$, we have $\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]} > 1$, therefore, $\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s > \mu\widehat{\tau}_s$. One can show that

$$\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu < 1.$$

Therefore, $A^{pub}_{\{r,n\}} \geq A^{pub}_{\{r,r\}}$ when $\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s \leq \tau < \widehat{\tau}_s$. We have

- $A^{semi}_{\{s,r\}}(\tau) \geq A^{semi}_{\{r,r\}}(\tau) > A^{semi}_{\{r,n\}}(\tau)$ when $0 \leq \tau \leq \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s$,
- $A^{semi}_{\{r,r\}}(\tau) > A^{semi}_{\{s,r\}}(\tau) \geq A^{semi}_{\{r,n\}}(\tau)$ when $\frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s < \tau \leq \mu\widehat{\tau}_s$,
- $A^{semi}_{\{r,r\}}(\tau) > A^{semi}_{\{r,n\}}(\tau) > A^{semi}_{\{s,r\}}(\tau)$ when $\mu\widehat{\tau}_s < \tau < \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s$, and
- $A^{semi}_{\{r,n\}}(\tau) \geq A^{semi}_{\{r,r\}}(\tau) > A^{semi}_{\{s,r\}}(\tau)$ when $\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s \leq \tau \leq \widehat{\tau}_s$.

To conclude, when the parameters are such that $pq > \mu(1-q)$, the shareholder's IC can be expressed as (30). When $\tau \leq \widehat{\tau}_s$ and $A \geq A^{semi}_2(\tau)$, it is both feasible and incentive compatible for the shareholder to contract for a bank with two safe divisions. $\square$

A.10 Proof of Proposition 8

Proof. We have already shown in the proof of Proposition 7 that $A_2^{semi}(\tau) > 2X$ $\forall \tau \in [0, \widehat{\tau}_s]$, we now show that $A_1^{semi}(\tau) > A_2^{semi}(\tau)$ for $\forall \tau < \widehat{\tau}_s$.

When $\tau \leq \left[0, \widehat{\tau}_{\{s,r\}}\right]$, $A_2^{semi}(\tau) = A_{\{s,r\}}^{semi}(\tau)$, we have $A_1^{semi}(\tau) > A_{\{s,r\}}^{semi}(\tau)$ if and only if $\frac{2}{1-\mu}\left[(\mu - q)(R - I) + X\right] > \frac{1}{1-\mu}\left[\big(\mu(1+q) - 2q\big)(R - I) + X\right]$, which is guaranteed by $\mu(1-q)(R-I) + X > 0$.

Instead, when $\tau \in \left(\widehat{\tau}_{\{s,r\}}, \widehat{\tau}_{\{r,r\}}\right]$, $A_2^{semi}(\tau) = A_{\{r,r\}}^{semi}(\tau)$. We have $A_1^{semi}(\tau) > A_{\{r,r\}}^{semi}(\tau)$ if and only if $\frac{2}{1-\mu}\left[(\mu - q)(R - I) + X\right] > \frac{1}{1-\mu^2}\left[(\mu^2 - q)\, 2(R - I) + 2X\right]$, or equivalently $(\mu - q)(R - I) + X > \frac{1}{1+\mu}\left[\, (\mu^2 - q)\,(R - I) + X\right]$, which is true because $\mu - q > \mu^2 - q > \frac{1}{1+\mu}(\mu^2 - q)$ and $1 + \mu > 1$.

Finally, when $\tau \in \left(\widehat{\tau}_{\{r,r\}}, \widehat{\tau}_s\right]$, $A_2^{semi}(\tau) = A_{\{r,n\}}^{semi}(\tau)$. We have $A_1^{semi}(\tau) > A_{\{r,n\}}^{semi}(\tau)$ if and only if $\frac{2}{1-\mu}\left[(\mu - q)(R - I) + X\right] > \frac{1}{1-\mu}\left[(\mu - 2q)\,(R - I) + \tau + 2X\right]$ which is equivalent to $\tau < \mu(R - I)$. One can show that $\mu(R - I) < \widehat{\tau}_s$,[37] so that $A_1^{semi}(\tau) > A_{\{r,n\}}^{semi}(\tau)$ always holds whenever the shareholder's participation constraint is satisfied.

The maximum money creation in the economy is given by $2I - A_2^{semi}(\tau)$, greater than that by two 'small' banks given the shareholder's incentive for risk-shifting, but less than that by a 'big' bank under public contracting. □

[37] The inequality is equivalent to $\frac{\mu - p}{\mu} q < \mu$ and holds as $q^2(1-p) < q^2 + 2(1-q)pq + (1-q)^2p^2 = \mu^2$. It also shows that, for $\forall \tau < \widehat{\tau}_s$, from an ex-ante perspective, a banker's project still has a positive NPV if he takes effort but pursues a risky investment opportunity when one arises.

A.11 Proof of Corollary 2

Proof. In the previous proof, we showed $A^{priv}_{\{s,r\}}(\tau) > A^{pub}_{\{s,r\}}(\tau)$, $A^{priv}_{\{s,r\}}(\tau) > A^{priv}_{\{r,r\}}(\tau) > A^{pub}_{\{r,r\}}(\tau)$ and $A^{priv}_{\{s,r\}}(\tau) > A^{priv}_{\{r,n\}}(\tau) = A^{pub}_{\{r,n\}}(\tau)$ for $\forall\tau \in (0, \widehat{\tau}_s)$. Therefore, we have $A^{priv}_2(\tau) > A^{pub}_2(\tau)$ for $\forall\tau \in (0, \widehat{\tau}_s)$. We then show $A_1(\tau) > A^{priv}_2(\tau)$ for $\forall\tau < \widehat{\tau}_s$.

Note that $A_1(\tau) > A^{priv}_2(\tau)$ can be expressed as

$$\frac{2}{1-\mu}\left[(\mu-q)(R-I)+X\right] > \frac{1}{1-\mu}\left[\left(\mu(1+q)-2q\right)(R-I)+X+(1-\mu)(X+\tau)\right].$$

After manipulation, the inequality holds if and only if

$$\mu(1-q)(R-I) > \frac{\mu-\mu^2-p}{\mu}\tau$$

As showed in the previous proof, we have $\mu-\mu^2-p<0$. Therefore, $A_1(\tau) > A^{priv}_2(\tau)$ holds for $\forall\tau > 0$. $\square$