The Making of (Modern) Banks*

Zhao Li† Kebin Ma‡ Lucy White§

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Abstract

Banks are made of contracts. For a bank to finance productive investment by issuing riskless, money-like claims, its organizational structure (e.g., sole proprietorship, partnership, or public ownership), capital structure, and its bankers' compensation contracts must be jointly designed to induce banker 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 banker risk-taking. Outside shareholders, contributing book equity, are useful despite introducing another layer of agency problems. It is efficient for shareholders to create a 'big' bank with multiple bankers and their respective projects and finance those projects with joint liabilities. When bankers' incentive contracts are opaque, each banker's pay should depend on the entire bank's performance even though he exerts control only on his own project.

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†Capital University of Economics and Business, Email: *lizhao16@gmail.com*

‡The University of Warwick, Email: *kebin.ma@wbs.ac.uk*

§Boston University, Email: *lwhite81@bu.edu.*

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, their creditors (depositors), and the borrowers to whom they lend. 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 that, in practice, determine the nature of the bank's investments. How a bank's financing and employment contracts interact with one another – how the capital structure of the bank affects the way 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 the risk-taking having the potential to result in significant losses and even insolvency of an 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 banker effort 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 sole proprietor 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 cannot be sustained using only the 'market' value of inside equity, and actual paid-in

[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 microfoundations 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.

‘book’, or ’outside,’ equity is needed. 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 and 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 external 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. The impact of deleveraging the bank is indirect in that it eases the budget constraint out of which bank compensation can be paid when the state is unfavorable, and changes the shareholder’s incentives in writing incentive contracts controlling bankers’ actions in that state. The key issue facing the depositors and the viability of the bank is that depositors do not directly observe the compensation contracts between the bank and its bankers, nor the latters’ investment choices (safe or risky). If they were able to observe these, we can show that no equity capital would be needed. Instead, we allow only project returns to be verifiable, so if one of the bankers’ investments returns zero, then depositors can infer that risks were taken and prevent any compensation or dividends from being paid in this case. Successful risk taking will go undetected, however, as it is indistinguishable from investment in a safe project. This means that an outside shareholder with insufficient ‘skin in the game’ will be tempted to renege on any (cheap-talk) promises made to depositors to write incentive contracts which induce bankers to eschew risky investments, instead putting in place compensation contracts to encourage banker risk-taking, since much of the cost of this risk-taking falls on depositors.

The shareholder's gain from allowing risk-taking in a bank does not only arise for standard risk-shifting reasons (the fact that the equity holder's claim is junior to the depositors'). There is a further factor which has been largely overlooked by the literature. The shareholder gains from allowing risk-taking because it allows her to reduce the expected cost of banker compensation. It is more expensive to induce safe behavior than risky behavior from bankers. To be more specific, a banker with incentives to pass up risky opportunities must receive a higher level of expected pay, as a result of his pay structure being more concave. To see why, note first that an agent (banker) must receive more from a successful investment than from simply doing nothing, (and sitting on his hands and returning the money to investors 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 be paid more than zero for sitting on their hands and doing nothing than for taking the risky investment. Otherwise, when a risky investment arises, the banker will take it, rather than ignore it and not invest 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 earn a rent from 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 is no resource available to pay the banker for mediocre performance (no excess returns are generated and yet deposits must be paid in full).

The combination of the need for effort and safety at the same time creates a role for outside equity in the form of paid-in capital, because the outside equity injected up-front delevers the bank, freeing up funds to pay the banker a premium in the situation where he finds only a risky project but refrain from taking it. If the only source of value available in this state were the other banker's similarly-levered project, this would be insufficient to discourage risk-taking as that project would also have no surplus to pay either banker in case the risky project arose. Hence a bank with cash paid in by outside equity-holders (shareholders) can operate where one with only inside equity-holders (partners) cannot.

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 ring-fenced from each other. Each small bank has the same parent shareholder, but is run by an individual banker and issues debt separately to its own depositors (i.e., no joint liabilities). This case can be thought of as either a bank holding company owning equity claims in two subsidiaries, with all of the group's debt issued at the subsidiary level, or, equivalently, as having two separate banks similar to sole proprietors but each with an outside equity injection which delevers the banks. The outside equity injection allows each banker to receive higher compensation in the case where 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 banks possible.

In the 'small banks' case, the two banks remain insulated from one another's risk-taking, because they issue separate liabilities and issue separate equity claims to the shareholder. An alternative arrangement is what we call the 'large bank' case, where debt claims are issued at the bank holding company level. If the liabilities are directly issued by the holding company, that creates the risk that gambling in one division (or subsidiary) of the bank can bring the entire bank down, as the failing subsidiary's liabilities will have a claim against the successful assets of the other subsidiary. This potential for 'risk contamination' (Banal-Estañol et al. (2013)) 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. This effect is similar to the cross-pledging of projects previously seen in the literature but it is not the same. That is because previous cross-pledging is done by *agents* taking a moral hazard (effort) action, whereas in our case, it is the shareholder who cross-pledges the assets, and not the bankers doing so, even though the bankers are the ones taking the moral hazard actions.[2] Cross-pledging assets commits the shareholder to designing compensation contracts to control bankers' risk-taking action.

[2] Similarly, the benefit of a partnership over a sole proprietorship is different to the classical cross-pledging in the literature (e.g. Tirole (2006), Chapter 4) because there a single agent pledges returns from multiple projects he operates, whereas in our case, returns are pledged across two different agents independently operating different projects.

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 banker's incentives are determined not by the capital structure of the bank, but by the incentive contracts offered to them by the shareholder. 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.

It would be natural for the shareholder to tie each banker's compensation to the performance of his own division or subsidiary (i.e. pay his bonus in divisional equity) and not to the performance of the whole banking group, since each banker controls only the risk and return of his own division. But since bankers are risk neutral and the limited liability constraint does not bind as long as no banker takes risk on the equilibrium path, exposing a banker to the performance of the other division in addition does no harm (but equally, offers no benefit) in the case of a large banks with incentive contracts that are visible to all bankers within an institution.** On the other hand, when bankers cannot see each others' incentive contracts, the joint liability structure of a big bank becomes less advantageous. We call this the 'private contracts' case. In this case, it is not only the depositors but also the bankers who fear that the shareholder will allow risk-taking by (the other division of) the bank. Recall that bankers receive an expected rent from contracts which induce safe choices. The shareholder can partially expropriate this rent from a banker who plays safe by writing a contract with the other banker which induces him to take risk. If that risk fails, part of the loss is borne by depositors, as before, but now, if contracting is not transparent between bankers, then part will also be borne by the safe banker who accepts a contract and plays safe when he would not do so if he knew the other division were taking risk. To reassure each banker that the shareholder will not 'defect' and write a contract inducing risk-taking with the other banker, the shareholder has to contribute more equity and issue fewer deposits than in the case when contracting within the bank was transparent. In this sense, internal contracting difficulties within the bank affect and are affected by the external contracting between the shareholder and the depositors. We investigate the case where bankers do not see the incentive contracts of their counterparts in other divisions, so have to make inferences about whether the shareholder has incentivized them to play safe or risky. In this case, it does matter whether bankers' compensation depends on their own performance only, or on the performance of the entire bank, but in an unexpected way. Counter-intuitively, we show that when contracts are private, it is strictly better to compensate bankers according to the performance of the whole bank rather than according to the performance of their individual division. This exposes bankers to the potential risk-taking of their colleagues, but precisely because they will share in the upside (and the shareholder and all the bankers have limited liability on the downside), the shareholder has strictly less incentive to take risk in this case. The reason the shareholder has less to gain from inducing one banker to take a risk is that she cannot pocket all of the gains from a successful risk, but must share them with the bankers from the other divisions of the bank. Therefore with private contracting, required equity is smaller if internal contracts depend on whole bank performance and not on individual division performance (except insofar as it affects whole bank performance). In other words, while paid-in equity helps the shareholder to refrain from inducing bankers to take risk with the potential loss of equity, compensation contracts conditional on the whole bank performance helps the shareholder commit to no risk-taking by reducing the upside from such opportunistic actions and can reduce the need of paid-in equity.

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 common 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 to study various recent policy issues surrounding banker pay, bank capital, and ring-fencing.

Related literature: Bankers in our model need to be motivated to both take efforts and 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 case where multiple such bankers can form a coalition to run a bank or be contracted by a shareholder so that the inter-dependence of their compensation contracts needs to be analyzed. Furthermore, the compensation contracts to the bankers need to be aligned with the bank's capital structure to provide correct incentives to both bankers and the shareholder.

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). Our theoretical model provides 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 a greater scale of a bank reduce agency cost of contracting, such as mitigating costly state verification in Diamond (1984). Interestingly, while it is observed in the literature that diversification has a downside of risk contamination, Banal-Estañol et al. (2013), the very fact that one failed banking project can destroy value of a successful one provides incentives for the shareholder to contract bankers to avoid risk-taking in the first place.[3] This relaxed limited liability constraint in improving efficiency 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 two ways. First, a higher output does not necessarily imply efficient actions from the agent, so that the extremely convex compensation that arises in the literature will not prevail in our setting. Second, our model features a two-layer agency problem. Bankers have direct control over risk-taking but 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. Simulaneously, cross-pledging by the shareholder, who owns the assets but has no direct control over the moral hazard actions related to those assets, can nevertheless relax her incentive to set safety-inducing incentive contracts for the bankers, who do have such control.

The problem of private contracting was first analyzed in the industrial organization literature on vertical relationships, such as 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 which private contracting is analyzed is mostly exogenous in those contributions (e.g., one upstream monopoly contracting two downstream firms, or one principal contracting with two agents), the organizational structure where a shareholder

[3] 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, whereas the riskiness of cash flow is endogenous in our framework and the risk of contamination is only off the equilibrium path.

contracts with two bankers emerges endogenously in our model when a partnership bank of two bankers alone is infeasible, and a big' bank with an outside shareholder, providing capital and incentive contracts mitigates the agency problem vis-a-vis depositors despite the lack of transparency of the banking organization to bankers and depositors .

The introduction of private compensation contracts in our model makes it efficient to make a banker's compensation depend on the overall performance of the bank, instead of the performance of his individual project. Such firm-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 firm-performance-sensitive compensation in the banking sector and attribute the phenomena to capital market friction. In our model, the firm-performance-sensitive contracts are offered to keep the shareholder's incentive to implement a safe bank and emerge with the problem of private contracting.

The 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 can provide funds in unlimited supply if they receive 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 'depositors'.

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 proper 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 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:

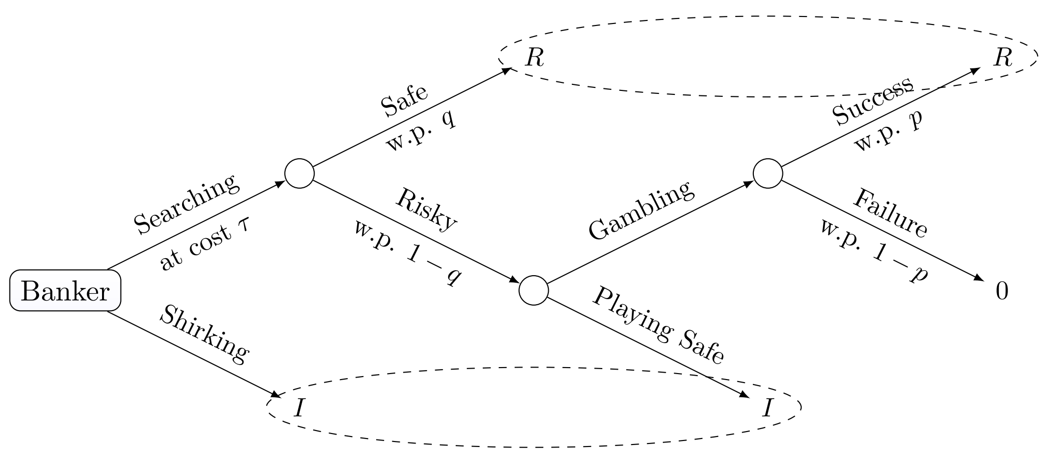
$$\tau \leq q(R-I) \equiv \widehat{\tau}_{FB}. \tag{1}$$

And the risk-taking is inefficient:

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

We summarize the bankers' investment technology in Figure 1.

Figure 1: Agency problems in the banking technology



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 facing only 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.

We assume all risks are independent when the two bankers manage their respective investments. 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 initial 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 that this risk-bearing capital is limited so that the shareholder cannot finance both bankers' investments entirely with her endowment, i.e., $A < 2I$. 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.[4]

[4] 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. 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), and Gennaioli et al. (2012). Safe claims are money-like and therefore yield lower returns than risky claims, reducing the bank's funding cost. 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 resources). A bank can emerge as an organization created by financing and compensation contracts linking the different economic agents. Such a bank in our model 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 creation 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 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.[5]

We assume that the loss-absorbing buffer provided by the shareholder is limited relative to the potential loss from risk-taking: when a banker gambles and his project returns 0, his 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,

$$R + 0 \leq 2I - A \qquad \text{or} \qquad A \leq 2I - R. \tag{3}$$

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

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

case of a bank failure, all available funds will go to the depositors. Both the shareholder or the bankers will receive zero payoffs in that contingency.[6]

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 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 equity capital when actions and states are not verifiable. We first show that, due to bankers' inability to commit to no risk-taking to depositors, a sole proprietorship bank without paid-in equity is unable issue any risk-free claims. By contrast, two bankers acting together, can form a partnership bank to issue risk-free claims, but only if risk-taking opportunities are sufficiently unattractive (Section 3.1). Otherwise, the involvement of the shareholder is necessary. For a bank with shareholder

[6]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.

ownership, we consider three scenarios to highlight how informational frictions shape the bank's organizational structure and its financing and compensation contracts.

1. We start with an illustrative 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, since when the banker chooses not to invest, there is only I available for distribution, giving the banker any positive payoff, in this case, will reduce the value available to pay depositors below I. Therefore, deposits are not risk-free, and a sole banker cannot be financed without an external shareholder providing risk-bearing equity. We summarize this result in Proposition 1.

Proposition 1. *A safe sole proprietorship bank cannot be established by a banker with no endowment.*

3.1.2 A partnership bank of two bankers

We now allow the two penniless bankers to form a partnership together, 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 payoff equally. When the bank generates $R+I$, the banker who returns R obtains a β share of the residual payoff, 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 residual payoffs to the bankers will be 0 under our assumption $R < 2I$. We prove the following proposition.

Proposition 2. *When $p < 1/2$, a symmetric profit-sharing rule with $\beta \in \left[\frac{\tau}{\widehat{\tau}_{FB}}, \frac{\mu-p}{\mu}\right]$ can implement a safe partnership bank as 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,[7] 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 rather that risk is endogenous, and imperfect correlation between the charter value of the two banking units reduces each partner's incentives to gamble.[8]. 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

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

[8] A classic paper that highlights the role of diversification in reducing agency cost is Diamond (1984), which also features a two-layer agency problem like the current model

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 the two bankers and the depositors and will make them take-it-or-leave-it offers. While the banker's moral hazard problems prevail in such a setting, we first assume that the bankers' compensation contracts are observable to all other parties so 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 can have only one project managed by a single banker. We will use the subscript s to denote the endogenous contracts in this case. 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 $B_{\{s\}}$ a banker's compensation if his bank returns R (small bank bonus) and by $C_{\{s\}}$

a banker's compensation when his bank returns I (small bank compensation). The shareholder solves the following program when making the 'small' bank a safe one.

$$\max_{\{B_{\{s\}},C_{\{s\}}\}} \quad \Pi = q \cdot \left[R - (I - A/2) - B_{\{s\}}\right] + (1-q) \cdot \left[I - (I - A/2) - C_{\{s\}}\right] - A/2$$

$$A/2 \geq C_{\{s\}} \tag{4}$$

$$A/2 \geq B_{\{s\}} - (R - I) \tag{5}$$

$$C_{\{s\}} \geq pB_{\{s\}} \tag{6}$$

$$qB_{\{s\}} + (1-q)C_{\{s\}} - \tau \geq C_{\{s\}} \tag{7}$$

$$\Pi \geq 0. \tag{8}$$

Inequalities (4) and (5) are the budget constraints in state I and R respectively, whereas Inequalities (6) and (7) represent the banker's (ex-post) incentive constraint for no gambling and the (ex-ante) incentive constraint for exerting effort.[9] Inequality (8) is the shareholder's participation constraint. The solution of the program entails both incentive constraints binding as the shareholder tries to minimize the bankers' compensation. Lemma 2 characterizes the optimal compensation contract.

Lemma 2. *To induce effort and avoid risk-taking when hiring a single banker to run a bank, the shareholder will offer $B_{\{s\}} = \frac{1}{\mu - p}\tau$ and $C_{\{s\}} = \frac{p}{\mu - p}\tau$ to the banker. The banker gains a rent $X = C_{\{s\}}$.*

Our model highlights an intrinsic conflict between generating returns and controlling for risk in a setting of delegated investment: increasing a banker's compensation when he returns R both induces effort and creates incentives for risk-taking. More importantly,

[9] 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 (7).

with $C_{\{s\}} > 0$, Lemma 2 emphasizes that, to avoid risk-taking, a banker's compensation must not be compressed even if he generates a zero net return.[10] 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 $C_{\{s\}}$ implies that $B_{\{s\}}$ 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

$$X \equiv qB_{\{s\}} + (1-q)C_{\{s\}} - \tau = C_{\{s\}}, \tag{9}$$

which exactly equals his compensation when generating a zero net return. The risk-shifting problem in our model suggests that part of the cash flow of the investment cannot be pledged to external financiers in the middle state I. 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 compensation contract $\left(B_{\{s\}}, C_{\{s\}}\right)$, a safe bank can be established by the shareholder when the budget constraints (4) and (5) are satisfied, and the shareholder's participation constraint (8) is met. 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, and when the shareholder can commit to their compensation contracts, shareholder paid-in equity is needed only to deleverage the bank sufficiently to pay the banker's compensation in state I, i.e., $A/2 \geq C_{\{s\}}$. The insufficient funds in this state are why a sole proprietorship

[10] It should be noted that, in our setting, the positive compensation $C_{\{s\}}$ 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.

cannot survive, whereas the shareholder can provide funds up front, so that there will be funds available to pay the banker not to take risk when the opportunity arises. On the other hand, because the shareholder concedes an agency rent to the bankers, the shareholder cannot obtain the full NPV of the project. The shareholder's participation constraint is 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 $\tau \in (\widehat{\tau}_s, \widehat{\tau}_{FB}]$.

Lemma 3. *When the shareholder can commit to no risk-shifting, she only needs to provide paid-in equity in excess of the bankers' compensation when both of them return* I*. Two safe banks can be established when* $\tau \leq \widehat{\tau}_s < \widehat{\tau}_{FB}$*, with each bank receiving paid-in equity* $A/2 \geq C_{\{s\}}$ *and the maximum money creation being* $2I - A = 2(I - X)$*.*

Proof. See Appendix A.2. □

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. 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. 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. For a banker's compensation to (weakly) monotonically increase both in his own performance and the other banker's project performance, we assume that $C_{\{s,s\}}(I) \leq C_{\{s,s\}}(R)$, $B_{\{s,s\}}(I) \leq B_{\{s,s\}}(R)$, and $C_{\{s,s\}}(R) \leq B_{\{s,s\}}(I)$.[11]

[11] The monotonicity constraint $C_{\{s,s\}}(R) \leq B_{\{s,s\}}(I)$ mimics the requirement of $\beta \geq 1/2$ in the case of a partnership bank. We show in Appendix B.2 that these monotonicity constraints suggest that a banker's compensation is *not negatively correlated* with the bank's overall performance.

As in the case of a partnership, a banker's incentive to behave can be preserved by his skin-in-the-game in the other banker's project. In particular, the shareholder can reduce the use of paid-in equity by minimizing the bankers' compensation when both of their projects return I. For example, if a banker's incentive not to gamble can be preserved when $C_{\{s,s\}}(I) = 0$ and $C_{\{s,s\}}(R) = C_s/q$, no paid-in equity will be needed. Lemma 4 pins down the required amount of paid-in equity for this 'big' bank case.

Lemma 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*

$$A \geq A_2^{pub}(\tau) = \begin{cases} 0 & \tau \in \left[0, \frac{q(1-p)}{2p}\widehat{\tau}_{FB}\right] \\ 2C_{\{s\}} - q(R-I) & \tau \in \left(\frac{q(1-p)}{2p}\widehat{\tau}_{FB}, \widehat{\tau}_s\right], \end{cases} \tag{10}$$

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

Proof. See Appendix A.3. □

A safe bank is feasible for the same $\tau \leq \widehat{\tau}_s$ as in the case of a partnership, since we have allowed 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 risk 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 which retains the gain from risk-taking rather than selling it to a third party.

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.[12]

3.2.3 Making banks with public contracts: a summary

Figure 2 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 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 $\tau \leq \widehat{\tau}_s$ even if $A = 0$.

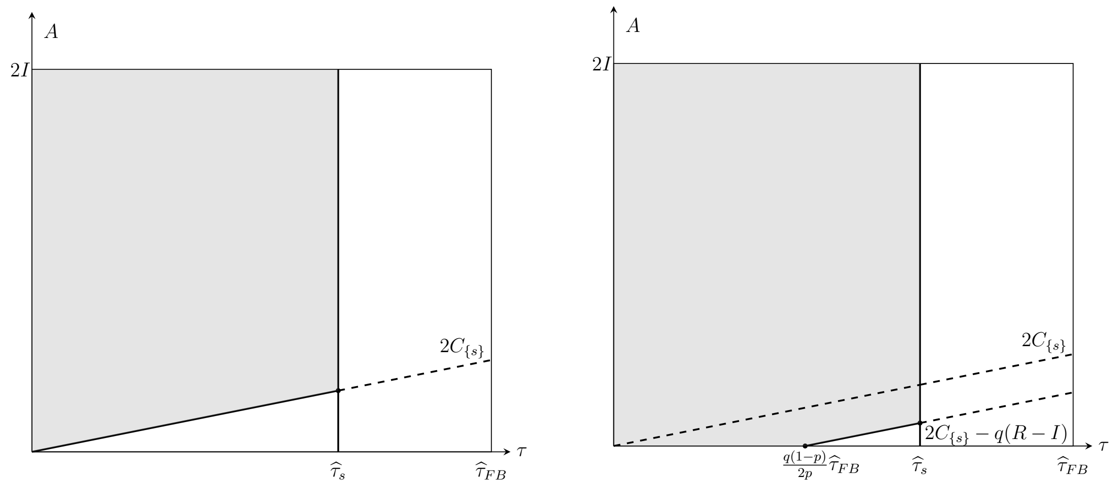
To an extent, transparency and paid-in (book) equity are substitutes: full transparency of contracting to depositors allows outside equity holders to commit to no risk-taking and operate with little (small bank) or no (big bank) equity.[13]

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

[12]One can impose monotonicity constraints such as $C_{\{s,s\}}(I) \leq C_{\{s,s\}}(R)$ and $B_{\{s,s\}}(I) \leq B_{\{s,s\}}(R)$. In such a case, the required amount of paid-in equity will remain zero for relatively low levels of τ, positive but still lower than $2X$ for relatively high levels of τ.

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

Figure 2: Money Creation when the Shareholder Can Commit to No Risk-shifting



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

in the banker's own unit cannot. Therefore, firm-performance sensitive compensation is useful: it eases the budget constraint.

3.3 Making banks with semi-public contracts

We now move onto the case where the compensation contract that the shareholder signs with a banker cannot be observed by the outside depositors but remains observable to the other banker if a 'big' bank is created to hire both bankers. We call such compensation contracts semi-public. This introduces an incentive problem for the shareholder, who is now able to shift risks to depositors by changing the bankers' incentive contracts unobserved by the depositors.

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 of them.[14] Then for each bank, the shareholder raises additional funding from depositors and hires one banker to manage the bank's investment. 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. The two banks are 'small' or independent banks in the sense that 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. For each bank, the shareholder has two possible defections from establishing a safe bank with effort: to offer the banker a compensation contract that induces gambling, or one that induces no effort from the banker (equivalently, not hiring the banker at all). When allowing the banker to pursue a risky investment opportunity, the shareholder will offer compensation $B_{\{r\}}$ if the banker returns R and $C_{\{r\}} = 0$ if the banker returns I. Recall that $\mu \equiv q + (1-q)p$ denotes the probability of obtaining a return R when the banker receives a contract inducing such risk-shifting. The lowest possible compensation entails

$$B_{\{r\}} = \frac{\tau}{\mu}$$

[14] We assume that the bank holds no cash and all the funds raised by the issuance of deposits and outside equity is 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.

to cover just the banker's cost of effort. Note that allowing risk-taking significantly reduces the burden of bank compensation to the shareholder 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

$$\Pi_{\{r\}}(A) = \mu(R - I) - \tau - (1 - \mu)\frac{A}{2}, \tag{11}$$

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

$$\Pi_{\{s\}} = q(R - I) - \tau - X \tag{12}$$

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 3. *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*

$$\frac{A_1}{2} = \frac{1}{1 - \mu}\Big[(1 - q)p(R - I) + X\Big] > C_{\{s\}} = X. \tag{13}$$

Proof. See Appendix A.4. □

Proposition 3 gives a necessary condition for a safe bank to be feasible. The critical level of paid-in equity to prevent risk-shifting to depositors has two components: (1) the expression involving $(R - I)$ reflects the direct gain from risk-shifting, for which reason A_1 increases in $(R - I)$, and (2) the presence of banker's rent X reflects the impact of internal contracting problem on the external contracting problem — 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.[15] It also worth noticing that as A_1 increases in X, the condition reveals that any friction in the (internal) contracting with the banker will aggravate the shareholder's (external) contracting problem with depositors.

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 can fail to hold for $\tau > \widehat{\tau}_s$ even if the incentive constraint in Proposition 3 is satisfied. We depict in Panel (a) of Figure 3 such a case, which arises when the return of the project is not too high:

$$\frac{R}{I} < 1 + \frac{1-p}{p}\frac{\mu(1-q)}{\mu(1-q)+q}. \tag{14}$$

[15]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.

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 3.

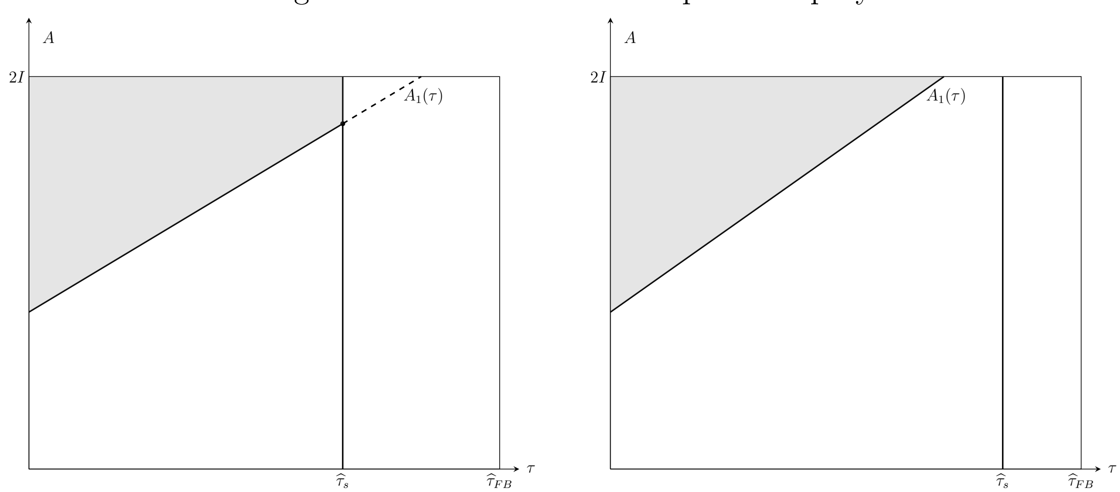
Assumption 2. *For the remainder of the paper, we assume that inequality (14) holds.*

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

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

Proof. See Appendix A.5 □

Figure 3: 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.

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. Hence compensation contracts are externally opaque.

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 $\{s, s\}$. Suppose that depositors expect the shareholder to implement a 'big' safe bank and are willing to contribute $2I - A$. Analagously to Lemma 2, we derive the cheapest equilibrium compensation contracts that can implement a safe bank. Without loss of generality, we consider individual-performance sensitive contracts as defined below and show at the end of this section (Proposition 6) that more flexible compensation contracts cannot improve the allocation.

Definition 1. *Individual-performance-sensitive compensation: a banker's compensation 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. In particular, the banker obtains the same payoff $B_{\{s,s\}}$ ($C_{\{s,s\}}$ respectively) when its project produces R (I respectively) independently of the other banker's investment outcome, which is indicated by R and I in the parentheses. That is,*

$$C_{\{s,s\}}(R) = C_{\{s,s\}}(I) = C_{\{s,s\}} \qquad \textit{and} \qquad B_{\{s,s\}}(R) = B_{\{s,s\}}(I) = B_{\{s,s\}}. \tag{15}$$

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.

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

$$C_{\{s,s\}} \geq p \cdot B_{\{s,s\}} \tag{16}$$

$$q \cdot B_{\{s,s\}} + (1-q) \cdot C_{\{s,s\}} - \tau \geq C_{\{s,s\}}. \tag{17}$$

For bankers' incentive constraints to avoid risk-taking (16) and exert effort (17), 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

$$B_{\{s,s\}} = B_{\{s\}} = \frac{1}{q(1-p)}\tau \quad C_{\{s,s\}} = C_{\{s\}} = \frac{p}{q(1-p)}\tau. \tag{18}$$

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

$$\Pi^{pub}_{\{s,s\}} = 2q(R-I) - 2X - 2\tau. \tag{19}$$

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). Lemma 5 summarizes the equilibrium compensation contract and also the cheapest compensation for all 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 both bankers exert effort and take no risk, the shareholder will offer* $B_{\{s,s\}} = B_{\{s\}} = \frac{1}{\mu - p}\tau$ *and* $C_{\{s,s\}} = C_{\{s\}} = \frac{p}{\mu - p}\tau$*. Each banker gains a rent* X*.*
- *To create an* $\{s, r\}$ *bank where Banker* i *exerts effort and takes no risk but Banker* j *exerts effort and can gamble, the shareholder will offer Banker* i *compensation* $B^i_{\{s,r\}} = B_{\{s\}}/\mu$ *and* $C^i_{\{s,r\}} = C_{\{s\}}/\mu$ *when he generates* R *and* I *respectively, and offer Banker* j *compensation* $B^j_{\{s,r\}} = B_{\{r\}} = \tau/\mu$ *when he generates* R *and* $C^j_{\{s,r\}} = 0$ *when he generates* I*. Only banker* i *earns positive rent* X*.*
- *To create a* $\{r, r\}$ *bank where both bankers exert effort and can gamble, the shareholder will offer* $B_{\{r,r\}} = B_{\{r\}}/\mu$ *when a banker generates* R *and* $C_{\{r,r\}} = 0$ *when he generates* I*. Both bankers obtain zero rent.*
- *To create an* $\{s, n\}$ *bank where Banker* i *exerts effort and takes no risk but Banker* j *shirks, the shareholder will offer Banker* i *compensation* $B_{\{s,n\}} = B_{\{s\}}$ *and* $C_{\{s,n\}} = C_{\{s\}}$ *when he generates* R *and* I*, and offer Banker* j $B^j_{\{r,n\}} = C^j_{\{r,n\}} = 0$ *(or not hire Banker* j *at all). Only Banker* i *earns the positive rent* X*.*
- *To create a* $\{r, n\}$ *bank where Banker* i *exerts effort and can gamble and Banker* j *shirks, the shareholder will offer Banker* i *compensation* $B^i_{\{r,n\}} = B_{\{r\}}$ *and* $C^i_{\{r,n\}} = 0$*, and offer Banker* j $B^j_{\{r,n\}} = C^j_{\{r,n\}} = 0$ *(or not to hire Banker* j *at all). Both bankers obtain zero rent.*

Proof. See Appendix A.6. ∎

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

$$\Pi^{semi}_{\{s,r\}}(A) = \mu(1+q)(R-I) - X - 2\tau - (1-\mu)A \tag{20}$$

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

$$\Pi^{semi}_{\{r,r\}}(A) = 2\mu^2(R-I) - 2\tau - (1-\mu^2)A \tag{21}$$

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

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

from implementing a $\{r,n\}$ bank; and will never find it profitable to implement an $\{s,n\}$ bank as that is dominated by the profit from an $\{s,s\}$ bank. We prove in Appendix A.7 that there exist 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 $\tau > \widehat{\tau}_{\{r,r\}}$. The interval $\tau \in \left(\widehat{\tau}_{\{s,r\}}, \widehat{\tau}_{\{r,r\}}\right]$ is non-empty if and only if

$$p \cdot q \geq (1-q)\mu. \tag{23}$$

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 (23) holds.

Assumption 3. *We assume inequality (23) 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 4, with the required amount of paid-in equity plotted in Figure 4.

Proposition 4. *When the shareholder sets up one 'big' bank with two bankers, each managing one investment, a safe 'big' bank can be established only if the shareholder provides paid-in equity*

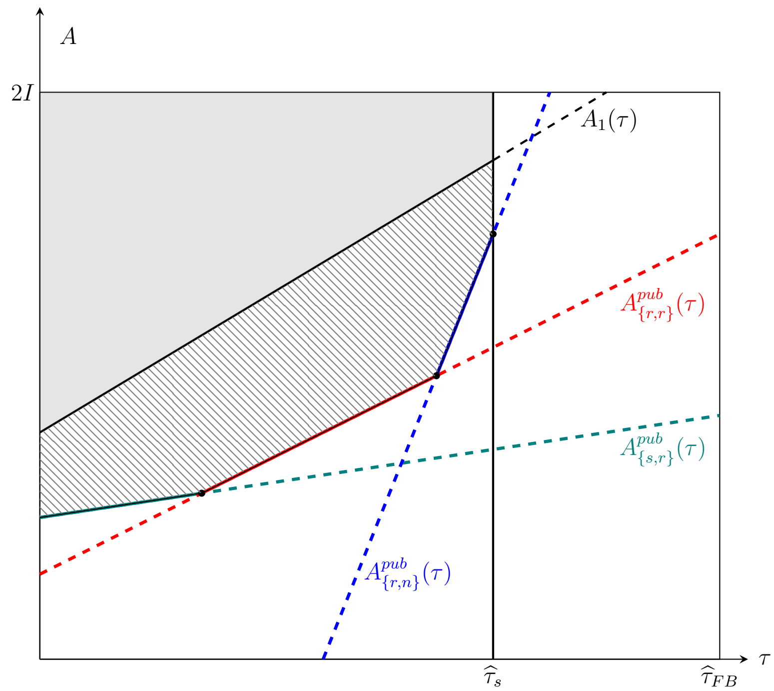
$$A \geq A_2^{semi}(\tau) = \begin{cases} A_{\{s,r\}}^{semi}(\tau) = \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R - I) + X\Big] & \tau \in \big[0, \widehat{\tau}_{\{s,r\}}\big] \\ A_{\{r,r\}}^{semi}(\tau) = \frac{1}{1-\mu^2}\big[(\mu^2 - q)2(R - I) + 2X\big] & \tau \in \big(\widehat{\tau}_{\{s,r\}}, \widehat{\tau}_{\{r,r\}}\big] \\ A_{\{r,n\}}^{semi}(\tau) = \frac{1}{1-\mu}\big[(\mu - 2q)(R - I) + \tau + 2X\big] & \tau > \widehat{\tau}_{\{r,r\}}, \end{cases} \tag{24}$$

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.7. □

A few comments are due regarding the critical paid-in equity $A_2^{semi}(\tau)$ and the 'big' bank's organizational structure. First, this setting of one bank with two bankers is equivalent to a case where the shareholder creates a bank holding company (BHC) with

Figure 4: 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 $A_1(\tau)$ to $A_2^{semi}(\tau)$, with the latter given by the maximum of $A^{pub}_{\{s,r\}}(\tau)$ (in green), $A^{semi}_{\{r,r\}}(\tau)$ (in red), and $A^{semi}_{\{r,n\}}(\tau)$ (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.

a parent company and two subsidiary banks, with the two bankers each running one subsidiary, the parent company issuing all the debt, and the subsidiaries being equity financed by the parent. The shareholder's incentive constraint will not change under alternative capital structures (e.g., some – or even all – debt issued by subsidiaries) if the subsidiaries and the parent company can commit to saving a failed subsidiary ex post by transferring shareholder value from the surviving subsidiary to the depositors of the failed one. If the BHC cannot make this commitment (either due to a lack of incentives from the shareholder or due to regulatory constraints), then some equity value will be preserved in the surviving subsidiary even if the other subsidiary fails. This will increase the shareholder's defection payoff and will tighten the shareholder incentive constraint. In this sense, the critical paid-in equity $A_2^{semi}(\tau)$ represents a lower bound or the most favorable result for the big bank or BHC structure. To the extent that the big bank issues more debt liabilities at the subsidiary level, more equity may be necessary.

It is worth noticing that, even when the structure of liabilities makes full commitment difficult, some degree of commitment is possible as the BHC's reputation is at stake from a private perspective (see Segura (2018)), and regulators can force certain transfers of capital from surviving subsidiaries to the failed one. For example, the FDIC, under the Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA), is allowed to shift the losses of a failed subsidiary onto the capital of surviving subsidiaries, and the Federal Reserve follows the doctrine that a BHC should act as a 'source of strength' to its subsidiaries (see Ashcraft (2008)).

Similar to our analysis in Section 3.3.1, Proposition 4 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 5. *When the shareholder hires two bankers to run a 'big' bank of two divisions with joint liabilities, the bank's maximum money creation is* $2I - A_2^{pub}(\tau)$ *and is always positive for* $\forall \tau \leq \widehat{\tau}_s$*. In fact,* $2X < A_2^{pub}(\tau) < A_1(\tau)$ *holds for all* $\tau < \widehat{\tau}_s$ *so that the maximum money creation increases as compared to the 'small' bank setting.*

Proof. See Appendix A.8. □

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 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.[16]

Finally, we prove in Proposition 6 that the compensation and financing contracts of the bank are independent of each other with internally-transparent compensation. Indeed, the individual-performance-sensitive compensation discussed is the cheapest but not uniquely so. There exist other compensation contracts that can implement a $\{s, s\}$ bank with equal rent.[17] However, the shareholder needs to provide the same amount of equity $A_2^{pub}(\tau)$ whether she offers the individual-performance-sensitive compensation or any alternative compensation contract. Proposition 6, therefore, establishes an irrelevance result: the design of (internal) compensation contracts does not affect the bank's (external) financing. We show that this will no longer hold once the compensation contracts are only privately observed by individual bankers, in which case, the bank's capital structure—the required amount of paid-in equity—will depend on bankers' compensation contracts.

[16] 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 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.

[17] With transparent compensation, there is no particular reason to consider alternative compensation contracts, because they support the same allocation and are more complicated, relying on the observability of each project's returns, and expose the bankers to increased risk (since bankers are risk-neutral, this has no cost here, but would be costly with small risk aversion). Therefore, we focus on the individual-performance sensitive contract as the equilibrium compensation contract with internally-transparent compensation.

Proposition 6. *When compensation contracts are internally-transparent to bankers, the 'big' bank's capital structure is independent of the compensation contracts offered to its bankers.*

Proof. See Appendix A.9. □

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 sufficeintly 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 ensures 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.[18] To illustrate the impact this friction, we consider a setting where the shareholder signs compensation contracts with the two bankers i and j sequentially. 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. When contracting with Banker i, the shareholder cannot directly commit to inducing a safe strategy from Banker j. This can be problematic 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.

In this section, we show how this additional friction reduces the efficiency of a large bank, and how the shareholder should adapt compensation to regain some of the lost efficiency by tweaking the bankers' compensation contracts. In particular, when a banker cannot see the other banker's contracts, the shareholder must make that banker's com-

[18] 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.

pensation of bankers depend not only on his own return but also on the returns generated by the other banker. This is 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. It works, however, 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.

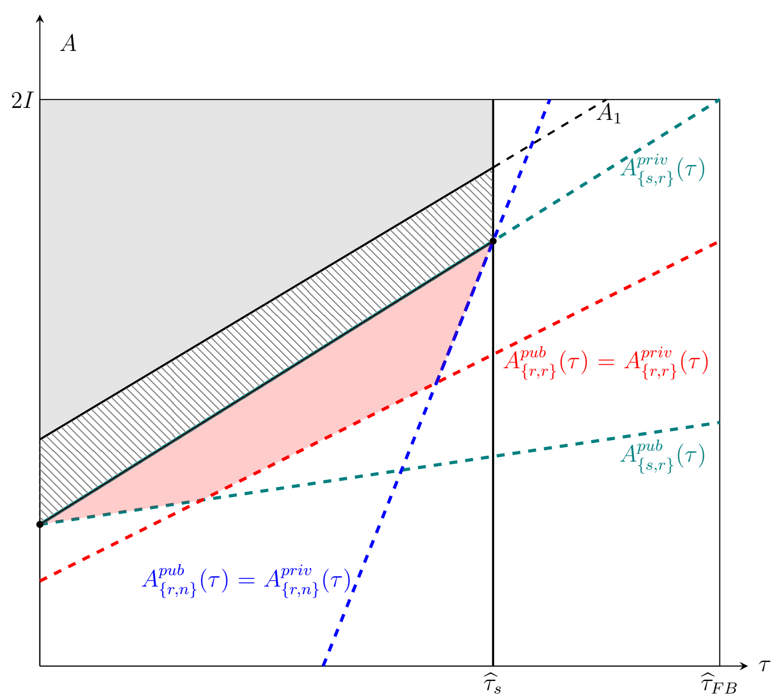
3.4.1 Individual performance sensitive contracts

To identify the efficiency loss from private contracting, we start by analyzing what happens if the shareholder continues to offer bankers individual-performance-sensitive compensation under private contracting between the shareholder and Banker j. 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:

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

Comparing the expression of $A^{priv}_{\{s,r\}}(\tau)$ with that of $A^{pub}_{\{s,r\}}(\tau)$, one can identify the additional term $(1-\mu)(X+\tau)$ which captures the shareholder's temptation to expropriate Banker i. Figure 5 illustrates the tightening of the incentive constraint which leads $A^{pub}_{\{s,r\}}(\tau)$ 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 5: 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.[19]

To take the defection $\{r,n\}$ defection, the shareholder should first offer 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 as with internally-transparent contracting.

We show in Proposition 7 below that, when confined to individual-performance-sensitive compensation contracts, 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 a rather profitable defection 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 transparent compensation.

Proposition 7. *When the shareholder's contract with Banker j is private and the shareholder offers only individual-performance-sensitive compensation to the bankers,*

[19] 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. To see this, note that the shareholder's profit from the $\{r,r\}$ defection equals that under internally-transparent compensation contracts, because both bankers hold correct beliefs regarding the other banker's action.

the shareholder prefers to establish a safe bank only if she puts in paid-in equity no less than $A_2^{priv}(\tau) = A_{\{s,r\}}^{priv}(\tau)$.

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 the limit of 'cross-pledging': 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.[20]

Corollary 2. *A 'big' bank's money creation capacity is compromised under private contracting when the shareholder can only use individual-performance-sensitive compensation, 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.10. □

3.4.2 Institution-performance sensitive contracts

Contrary to the transparent compensation case where there is no efficiency gain from more flexible compensation contracts (Proposition 6), we now show that the shareholder can improve allocation with institution-performance sensitive compensation. We will call these 'tweaked' contracts, for reasons that will become clear below.

[20]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. We hope to investigate this issue in future research.

Definition 2. *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.*

$$C_{\{s,s\}}(R) \geq C_{\{s,s\}}(I) \qquad\qquad B_{\{s,s\}}(R) \geq B_{\{s,s\}}(I) \tag{25}$$

$$B_{\{s,s\}}(I) \geq C_{\{s,s\}}(R) \tag{26}$$

The tweaked compensation contracts allow for a banker's compensation to depend on the outcome of the other banker's project, but maintain monotonicity in two dimensions. First, Banker i's compensation (weakly) increases in Banker j's performance holding Banker i's own performance constant. Second, Banker i's compensation (weakly) increases in his own performance, independent of Banker j's performance. In the absence of this second monotonicity constraint, a banker would have incentives to sabotage his own investment project or mis-report its return, Innes (1990).

There is no loss of generality to considering tweaked contracts with

$$B_{\{s,s\}}(R) = B_{\{s\}} + \delta \qquad B_{\{s,s\}}(I) = B_{\{s\}} - \tfrac{q}{1-q}\delta, \tag{27}$$

$$C_{\{s,s\}}(R) = C_{\{s\}} + \delta \qquad C_{\{s,s\}}(I) = C_{\{s\}} - \tfrac{q}{1-q}\delta, \tag{28}$$

where $\delta \geq 0$ so that a banker's compensation is non-decreasing in the other banker's performance. Such tweaked contracts guarantee that a banker's expected payoff from generating I (R) equals his payoff from generating I (R) under the individual-performance-sensitive contract. That is,

$$qB_{\{s,s\}}(R) + (1-q)B_{\{s,s\}}(I) = B_{\{s\}} \qquad \text{and} \qquad qC_{\{s,s\}}(R) + (1-q)C_{\{s,s\}}(I) = C_{\{s\}}.$$

Intuitively, the (expected) compensation from generating I cannot be reduced. Otherwise, the banker would take risks. Since the shareholder will try to minimize the total (expected) compensation while still inducing efforts, the expected compensation when a banker generates R will be kept at $B_{\{s\}}$: any higher expected compensation will concede to a banker a rent greater than X, reducing the shareholder's equilibrium payoff and making it more difficult to prevent shareholder defection, whereas any lower expected compensation would fail to induce bankers' efforts. For the set of tweaked contracts given by (27) and (28), monotonicity condition (26) is equivalent to

$$\delta \leq \frac{1-q}{q}\tau.$$

The institution performance sensitive contracts are "tweaked" versions of the individual performance sensitive contracts considered in the previous section in the sense that they offer the same expected pay for individual performance, but will pay a larger absolute bonus when the bank as a whole performs well, and a smaller absolute bonus when the bank as a whole performs less well. This type of contract is consistent with the actual practice of bank compensation, which is to create bonus pools dependent on bank performance, and then divide bonus pools according to divisional and individual performance.

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 $\delta^* \in [0, (1-q)/q\tau]$. Using Nash implementation as above, 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 $\delta < \delta^*$ (e.g., the individual-performance-sensitive compensation where $\delta = 0$) 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 an equilibrium tweaked compensation contract of $\delta = \delta^*$, and contract Banker j to play risky with a compensation contract $B_{\{r\}} = \tau/\mu$ 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 8 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. We illustrate how this (tweaked) institution-performance-sensitive compensation differs from individual-performance-sensitive compensation in Figure 6.

Proposition 8. *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*

$$A \geq A^{tweak}_{\{s,r\}}(\tau, \delta) = \frac{1}{1-\mu}\Big[\big(\mu(1+q) - 2q\big)(R - I) + X + (1-\mu)(X+\tau) - \mu\delta\Big]. \quad (29)$$

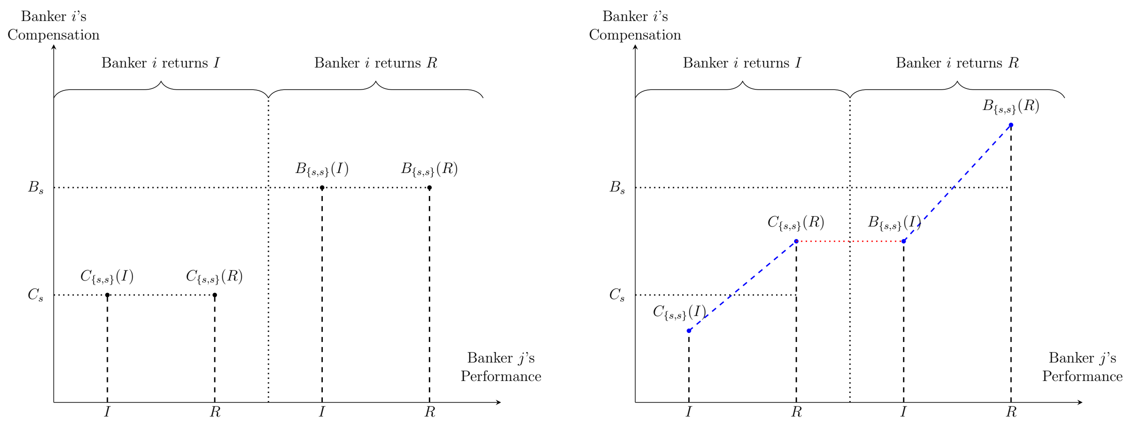
In particular, when δ is set to its upper bound $(1-q)\tau/q$ so that $C_{\{s,s\}}(R) = B_{\{s,s\}}(I)$, the inefficiency caused by private contracting under individual-performance-sensitive compensation will be completely eliminated, and a safe bank can be established if and only if the shareholder's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

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 (26).[21] 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 $A \geq A^{pub}_{\{r,r\}}(\tau)$ and $A \geq A^{pub}_{\{r,n\}}(\tau)$ 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 $\delta \in (\delta^*, (1-q)\tau/q)$*

[21] 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.

Figure 6: Individual- v.s. Institution-performance-sensitive Compensation



(a) Individual-performance-sensitive Pay (b) Institution-performance-sensitive Pay

Panel (a) illustrates the individual-performance-based compensation as defined in Definition 1: whereby a Banker i's compensation only depends the return of his own project and is not affected by Banker j's performance. Panel (b) provides an example of the institution-performance-based compensation as defined in Definition 2, whereby a Banker i's compensation not only increases in his own performance but also in Banker j's performance. At the 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 $C_{\{s,s\}}(R) = B_{\{s,s\}}(I)$ so that the maximum efficiency gain can be achieved with the tweaked compensation (Proposition 8).

can implement a safe bank too. For a paid-in equity level $A \in \left[A_2^{pub}(\tau), A_2^{priv}(\tau)\right]$, *the minimum 'tweak' required to implement a safe bank is*

$$\underline{\delta}(A) = \frac{1}{\mu}\Big[\big(\mu(1+q) - 2q\big)(R-I) + X + (1-\mu)(X+\tau)\Big] - \frac{1-\mu}{\mu}A, \qquad (30)$$

with $\underline{\delta}(A) = 0$ *when* $A = A_2^{priv}(\tau)$ *and* $\underline{\delta}(A) = (1-q)\tau/q$ *when* $A = A_2^{pub}(\tau)$.

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 the it expropriates depositors through risk-shifting in the usual way.

Introducing firm-performance-sensitive pay helps slacken the shareholder's incentive constraints. With such a compensation contract, the banker who plays safe can claim some of the return from risk-taking should that be allowed to happen by the shareholder. This reduces the upside of risk-taking and discourage the shareholder from risk-shifting. To an extent, the firm-performance-sensitive provides an alternative commitment device other than paid-in equity and facilitate the creation of safe claims.

4 Discussion and Policy Implications

Our model allows us to analyze 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.

Academics are inclined to emphasize the importance of market value over 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 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.[22] When the bank is in an ex-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.

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.[23]

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 liabil-

[22] 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 a poor indicator of the soundness of banks.

[23] 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.

ities, 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.[24]

While there was public outrage over uncompressed bankers' compensation during crisis (low-return) periods, our model points out that some remuneration in such states can be 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.

Finally, while compensation contract features such as bonus pools may appear theoretically puzzling,[25] we show that when compensation contracts are opaque within the bank (which can be for reasons beyond this agency model), one way to counter the inefficiency due to private contracting is for shareholders to offer bankers institution-performance-sensitive compensation, since such on-equilibrium-path compensation contracts will distribute the gain from successful risk-taking by one banker to the other bankers, and limit the shareholder's incentive to shift risks to depositors.

[24] 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

[25] One may even suspect such compensation contracts indicates some failure in corporate governance as some employees can be rewarded for good performance of the others.

5 Conclusion

In a unified yet simple framework of an agency model, our paper studies how a bank should be organized and created by a collection of jointly-designed financing and compensation contracts to enable it to transform risky investments into safe deposits effectively. We find that bankers, who need to both make effort to locate investment opportunities and avoid inefficient risk-taking in conducting investment, must receive high compensation even if they produce only mediocre outcomes because of the unobservable nature of their actions and the friction of limited liability. When capital is raised from risk-averse depositors, allocating a positive payoff to the banker in these low-return states, however, conflicts with the depositors' desire for risk-free claims. A partnership between two bankers helps to solve the problem, because a successful project by one banker offers some financial slack to pay the other banker when his returns are mediocre because he resisted taking a risky project. But we show that partnership as a whole will still be incentives to shift risks to depositors when the chance of paying off is moderately high and the partners themselves have no cash to pay into the bank. Therefore, when extent there is a separation of skilled labor and capital endowments in the economy, it is important to introduce paid-in equity from external shareholders. The market value, or the prospect of positive NPV projects, that the bankers bring to the table do 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 state, 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 can discourage shareholders from allowing for risk-taking with any individual banker, for the failure of such risk-taking may endanger safe projects run by other bankers. To put it another way, when it is recognized that risk-taking is endogenous, a financial conglomerate will have 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. And the bankers themselves may be concerned that if 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 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, but it is very common in practice. 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 from the ground up, starting with individual bankers who must find and finance potentially risky projects, who can form coalitions with each other and with a 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 is likely to promote financial stability.

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A Proofs of Lemmas and Propositions

A.1 Proof of Proposition 2

Proof. Suppose that depositors have already supplied the initial outlay $2I$ to the partnership bank. We show that for $p < 1/2$, a safe partnership bank can emerge as the outcome of a Nash equilibrium. We examine a representative banker's incentive to defect given that his partner sticks to the equilibrium strategy that is to exert searching effort ex ante and avoid risk-taking ex post.

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 taking the risk, the banker expects an 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 bankers 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 in the project outcome, that is $\beta \geq 1/2$, 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 payoffs from exerting effort and letting go the gambling are:

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

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 summarized, provided with $p < \frac{1}{2}$, a partnership bank can be set up when

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

Note that the set about β is non-empty if and only if $\frac{\tau}{\widehat{\tau}_{FB}} \leq \frac{\mu-p}{\mu} \Leftrightarrow \tau \leq \frac{\mu}{\mu-p}\widehat{\tau}_{FB} \equiv \widehat{\tau}_s$. $\square$

A.2 Proof of Lemma 3

Proof. Consider a 'small' bank is financed by paid-in equity $A/2$ and deposits $I - A/2$. Given the cheapest compensation in Lemma 2, the shareholder's expected payoff from creating such a 'small' safe bank is $\Pi_1 = q \cdot [R - (I - A/2) - B_{\{s\}}] + (1 - q) \cdot [I - (I - A/2) - C_{\{s\}}] - A/2$. The paid-in equity must satisfy ex-post budged constraints (BCs)

$$A/2 \geq B_{\{s\}} - (R - I) \tag{31}$$

$$A/2 \geq C_{\{s\}}. \tag{32}$$

It can be shown that BC (32) implies BC (31) because $B_{\{s\}} - (R - I) \leq C_{\{s\}}$ holds for $\forall \tau < \widehat{\tau}_{FB}$. That is, the budget constraint tightens when the investment return is low. Therefore, the minimum amount of paid-in equity per bank is $A/2 = C_{\{s\}}$. The shareholder's ex-ante participation constraint (PC)

$$\Pi_1 \geq 0 \tag{33}$$

is satisfied when $\tau \leq \widehat{\tau}_s$. To see this, note $\Pi_1 = q(R - I) - [qB_{\{s\}} + (1 - q)C_{\{s\}}] = q(R - I) - X - \tau$, with $X = C_{\{s\}} = \frac{p}{\mu - p}\tau$ being the banker's information rent. From PC (33), we have

$$q(R - I) - X - \tau \geq 0 \Leftrightarrow \tau \leq \frac{\mu - p}{\mu} q(R - I) \equiv \widehat{\tau}_s < \widehat{\tau}_{FB}.$$

The maximum safe deposits (money) created by such a bank is given by the binding BC (32), i.e., $I - C_{\{s\}}$, and the maximum money creation in an economy with two of such 'small' banks is $M = 2I - 2C_{\{s\}}$.

$\square$

A.3 Proof of Lemma 4

We now show that the shareholder can reduce the need for paid-in equity by creating a 'big' bank that hires both bankers and provides the bankers with firm-performance-sensitive compensation. The shareholder needs to meet the following constraints when setting the bankers' compensation.

$$\begin{aligned}
2B_{\{s,s\}}(R) &\leq 2(R-I)+A && (34)\\
B_{\{s,s\}}(I)+C_{\{s,s\}}(R) &\leq (R-I)+A && (35)\\
2C_{\{s,s\}}(I) &\leq A && (36)\\
qB_{\{s,s\}}(R)+(1-q)B_{\{s,s\}}(I) &= B_{\{s\}} && (37)\\
qC_{\{s,s\}}(R)+(1-q)C_{\{s,s\}}(I) &= C_{\{s\}} && (38)\\
B_{\{s,s\}}(R)\geq B_{\{s,s\}}(I) &\geq C_{\{s,s\}}(R)\geq C_{\{s,s\}}(I) && (39)
\end{aligned}$$

Inequality (34), (35), and (36) are the budget constraints in the states $2R$, $R+I$, and $2I$ respectively. Constraints (37) and (38) are the incentive constraints for the bankers to 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, (39) 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.

We now derive the minimum paid-in equity needed to operate a safe bank. Note that the two incentive constraints 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 (34) 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 (37), $B_{\{s,s\}}(R)$ 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 (37), 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 (34) 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

$$2C_{\{s,s\}}(I) \quad < \quad A \tag{40}$$

$$B_{\{s,s\}}(I) + C_{\{s,s\}}(R) \quad = \quad (R - I) + A. \tag{41}$$

In this case, minimizing 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 $(1-q)\tau/q$ to reduce equity 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 (40), the shareholder can reduce equity A by decreasing $C_{\{s,s\}}(R)$ by ϵ and increasing $C_{\{s,s\}}(I)$ by $q\tau/(1-q)$.

Given $B_{\{s,s\}}(I) = C_{\{s,s\}}(R) = C_{\{s\}}$, the paid-in equity $A = 2C_{\{s\}} - (R-I)$ by presumption (41). This, however, contradicts presumption (40) 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 paid-in equity while the budget constraints bind in the $2I$ state.

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 binding in the $2I$ state and show that to economize on the paid-in equity, the budget constraint will bind in the $R+I$ state as well.

When the budget constraint is binding in the $2I$ state, we have $C_{\{s,s\}}(I) = A/2$, and by the binding incentive constraint (38),

$$C_{\{s,s\}}(R) = \frac{1}{q}\left[C_{\{s\}} - (1-q)\frac{A}{2}\right].$$

Inserting $C_{\{s,s\}}(R)$ into the budget constraint (35), we obtain

$$B_{\{s,s\}}(I)+\frac{1}{q}\left[C_{\{s\}}-(1-q)\frac{A}{2}\right]\leq(R-I)+A.$$

The constraint, after rearrangements of terms, becomes

$$\frac{1+q}{2}A\geq qB_{\{s,s\}}(I)+C_{\{s\}}-q(R-I),$$

which suggests that $B_{\{s,s\}}(I)$ needs to be set as low as possible to minimize the use of paid-in equity A. And the lowest possible value of $B_{\{s,s\}}(I)$ is $C_{\{s,s\}}(R)$ by the monotonicity constraint $B_{\{s,s\}}(I)\geq C_{\{s,s\}}(R)$. The budget constraint (35) can be further written as

$$\frac{1+q}{2}A\geq\left[C_{\{s\}}-(1-q)\frac{A}{2}\right]+C_{\{s\}}-q(R-I)\qquad\text{or}\qquad A\geq 2C_{\{s\}}-q(R-I).$$

Two cases emerge: (1) when $\tau\leq\frac{(1-p)q}{2p}q(R-I)$ such that $2C_{\{s\}}-q(R-I)\leq 0$, a safe bank can be established with zero paid-in equity. (2) When $\frac{(1-p)q}{2p}q(R-I)<\tau\leq\widehat{\tau}_s$, creating a safe bank requires paid-in equity$A=2C_{\{s\}}-q(R-I)$ at least.

A.4 Proof of Proposition 3

Proof. In a 'small' bank setting, we decompose the shareholder's contracting problems with a banker and depositors in two steps.

First, suppose that the shareholder has already raised $I-\frac{A}{2}$ as risk-free deposits. We derive her expected payoffs of contracting a safe bank $\Pi_{\{s\}}$ and a risky bank $\Pi_{\{r\}}$.

To induce the banker to exert effort and pursue a safe strategy, the shareholder optimally offers him the contract $\{B_{\{s\}}, C_{\{s\}}\}$. Her expected payoffs are

$$\Pi_{\{s\}} = q \cdot [R - (I - A) - B_{\{s\}}] + (1 - q) \cdot [I - (I - \frac{A}{2}) - C_{\{s\}}] - \frac{A}{2}.$$

As established in A.2, BC (32) and PC (33) are the relevant BC and the PC for contracting a safe bank. The shareholder's expected payoff can be reformulated as

$$\Pi_{\{s\}} = q(R - I) - X - \tau.$$

Instead, to induce the banker to exert effort and pursue a risky strategy, the shareholder optimally offers him the contract $\{B_{\{r\}}, C_{\{r\}}\}$. Her expected payoffs are

$$\Pi_{\{r\}} = [q + (1 - q)p] \cdot [R - (I - \frac{A}{2}) - B_{\{r\}}] - \frac{A}{2}.$$

When the shareholder's BC and PC are satisfied, $\Pi_{\{r\}}$ can be reformulated as

$$\Pi_{\{r\}} = \mu(R - I) - \tau - (1 - \mu)\frac{A}{2}.$$ [26]

Second, we derive the shareholder's IC constraint of contracting for a safe bank. So in equilibrium the depositors will indeed lend $I - A$ to the shareholder. To ensure shareholder has the incentive to contract for a safe bank, we have

$$\Pi_{\{s\}} = q(R - I) - X - \tau \geq \mu(R - I) - \tau - (1 - \mu)\frac{A}{2} = \Pi_{\{r\}},$$

[26] The shareholder's BC and PC for a risky bank are $\tau < \widehat{\tau}_r = \mu q(R - I)$ and $\frac{1}{\mu}\tau - (R - I) < \frac{A}{2} < \frac{1}{1-\mu}[\mu(R - I) - \tau]$. $\tau < \widehat{\tau}_r$ is implied by $\tau < \widehat{\tau}_s$ and one can check that $\frac{1}{\mu}\tau - (R - I) < \frac{p}{\mu - p}\tau < \frac{1}{1-\mu}[\mu(R - I) - \tau]$.

which can be further expressed as follows:

$$\frac{A}{2} \geq \frac{1}{1-\mu}\left[(1-q)p(R-I)+X\right] \equiv \frac{A_1}{2}. \tag{42}$$

It is clear that

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

Therefore, when $\tau < \widehat{\tau}_s$ and IC (42) is satisfied, it is both feasible and incentive compatible for the shareholder to contract for a safe bank.[27] $\square$

A.5 Proof of Corollary 1

Proof. From A.4, the shareholder's IC constraint for a safe bank is given by expression (42). 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.

Note that the shareholder's PC 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

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

[27]Note that $\frac{1}{1-\mu}[(1-q)p(R-I)+X] < \frac{1}{1-\mu}[\mu(R-I)-\tau]$. So $\Pi_{\{s\}} > \Pi_{\{r\}}$ when $\frac{1}{1-\mu}\left[(1-q)p(R-I)+X\right] < \frac{A}{2} < \frac{1}{1-\mu}[\mu(R-I)-\tau]$. When $\frac{A}{2} \geq \frac{1}{1-\mu}[\mu(R-I)-\tau]$, $\Pi_{\{r\}} \leq 0$, only the safe bank is feasible.

After manipulation, the above inequality can be reformulated into

$$\frac{R}{I} < 1 + \frac{1-p}{p}\frac{\mu(1-q)}{\mu(1-q)+p}. \tag{43}$$

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 (43) does not hold, there exists a cutoff $\tau^{'}$ 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 $\tau^{'}$ uniquely solves $2I - A_1(\tau^{'}) = 0$. $\square$

A.6 Proof of Lemma 5

Proof. 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.

Consider next, the shareholder's contracting for a bank with a two risky divisions. We again focus on the symmetric contracts between the two bankers, i.e., $B^i_{\{r,r\}} =$

$B^j_{\{r,r\}} = B_{\{r,r\}}$ and $C^i_{\{r,r\}} = C^j_{\{r,r\}} = C_{\{r,r\}}$. The shareholder solves the program $\min_{\{B_{\{r,r\}}, C_{\{r,r\}}\}} \mu^2 B_{\{r,r\}}$ subjecting to the constraints $\mu^2 B_{\{r,r\}} - \tau \geq \mu C_{\{r,r\}}$ and $\mu p B_{\{r,r\}} \geq \mu C_{\{r,r\}}$. The solution is $\{B_{\{r,r\}}, C_{\{r,r\}}\} = \left\{\frac{1}{\mu^2}\tau, 0\right\} = \left\{\frac{B_{\{r\}}}{\mu}, 0\right\}$. Notice that both bankers know that they will be compensated with $B_{\{r,r\}}$ only if both divisions' risk-taking succeed (i.e., with a probability μ^2). Since $C_{\{r,r\}} = 0$, both bankers again obtain zero rent.

To create an $\{s, n\}$ bank where Banker i exerts effort and takes no risk but Banker j shirks, it is obvious that the shareholder will offer Banker i compensation $B_{\{s,n\}} = B_{\{s\}}$ and $C_{\{s,n\}} = C_{\{s\}}$ when he generates R and I, and offer Banker j $B^j_{\{r,n\}} = C^j_{\{r,n\}} = 0$ (or not to hire Banker j at all). Only Banker i earns the positive rent X.

Lastly, to contract for a bank with risk-taking in division i and no effort in division j, the shareholder simply offers $\left\{B^i_{\{r,n\}}, C^i_{\{r,n\}}\right\} = \{B_{\{r\}}, C_{\{r\}}\} = \left\{\frac{1}{\mu}\tau, 0\right\}$ to banker i and zero compensation to banker j. Banker i, again, obtains zero rent for the risk-taking. □

A.7 Proof of Proposition 4

Proof. In a 'big' bank setting, we still decompose the shareholder's contracting problems with two bankers and depositors in two steps.

First, suppose that the shareholder has already raised $2I - A$ as risk-free deposits. We derive her expected payoffs of contracting a big bank with, two safe divisions $\Pi^{pub}_{\{s,s\}}$, one safe division and one risky division $\Pi^{pub}_{\{s,r\}}$, two risky. divisions $\Pi^{pub}_{\{r,r\}}$, and one risky division only $\Pi^{pub}_{\{r,n\}}$. We also assume that the shareholder only offers the two bankers individual-performance-sensitive contracts derived in Lemma 5.

To contract for a bank with two safe divisions, the shareholder optimally offers each banker $\{B_{\{s,s\}}, C_{\{s,s\}}\}$. Her expected payoffs are

$$\Pi^{pub}_{\{s,s\}} = q^2[2R - 2B_{\{s,s\}} - (2I - A)] + 2q(1-q)[(R+I) - (B_{\{s,s\}} + C_{\{s,s\}}) - (2I - A)]$$
$$+ (1-q)^2[2I - 2C_{\{s,s\}} - (2I - A)] - A.$$

Since a safe bank cannot default ex-post, the shareholder now faces the following budget constraints (BCs)

$$A \geq \frac{2}{\mu - p}\tau - 2(R - I) \tag{44}$$
$$A \geq \frac{1+p}{\mu - p}\tau - (R - I) \tag{45}$$
$$A \geq \frac{2p}{\mu - p}\tau. \tag{46}$$

Like before, BC (46) implies BC (44) when $\tau < \widehat{\tau}_{FB}$. BC (46) also implies BC (45) as

$$\frac{2p}{\mu - p}\tau > \frac{1+p}{\mu - p}\tau - (R - I) \Leftrightarrow (R - I) > \frac{1-p}{\mu - p}\tau = \frac{\tau}{q} \Leftrightarrow \tau < q(R - I) = \widehat{\tau}_{FB}.$$

When BC (46) is satisfied, the shareholder also faces the participation constraint

$$\Pi^{pub}_{\{s,s\}} = 2q(R - I) - 2X - 2\tau \geq 0.$$

Like before, the PC constraint holds if and only if $\tau < \widehat{\tau}_s$. Therefore, to establish a safe bank, the feasible conditions are BC (46) and $\tau < \widehat{\tau}_s$.

To contract for a bank with a safe division i and a risky division j, the shareholder optimally offers banker i $\left\{B^i_{\{s,r\}}, C^i_{\{s,r\}}\right\}$ and banker j $\left\{B^j_{\{s,r\}}, C^j_{\{s,r\}}\right\}$. Her expected payoffs are

$$\Pi^{pub}_{\{s,r\}} = q\mu\left[2R - (B^i_{\{s,r\}} + B^j_{\{s,r\}}) - (2I - A)\right] + (1-q)\mu\left[(R+I) - (C^i_{\{s,r\}} + B^j_{\{s,r\}}) - (2I - A)\right] - A$$

When the shareholder's BC and PC are both satisfied, we can reformulate $\Pi^{pub}_{s,r}$ as

$$\Pi^{pub}_{\{s,r\}} = \mu(1+q)(R-I) - X_s - 2\tau - (1-\mu)A.$$ [28]

To contract for a bank with two risky divisions, the shareholder optimally offers both bankers $\left\{B_{\{r,r\}}, C_{\{r,r\}}\right\}$. Her expected payoffs are

$$\Pi^{pub}_{\{r,r\}} = \mu^2\left[2R - 2B_{\{r,r\}} - (2I - A)\right] - A = 2\mu^2(R-I) - 2\tau - (1-\mu^2)A.$$ [29]

Lastly, to contract for a bank with only one risky division, the shareholder offers banker i $\left\{B^i_{\{r,n\}}, C^i_{\{r,n\}}\right\}$. Her expected payoffs are

$$\Pi^{pub}_{\{r,n\}} = \mu[(R+I) - B^i_{\{r,n\}} - (2I - A)] - A = \mu(R-I) - \tau - (1-\mu)A.$$ [30]

[28] One can show that the shareholder's BC and PC are $\tau < \widehat{\tau}_{\{s,r\}} = \frac{1-p}{1+\mu-p}(1+q\mu)\widehat{\tau}_{FB}$ and $\frac{1}{\mu-p}\tau - (R-I) < A < \frac{1}{1-\mu}[(1+q)\mu(R-I) - \frac{2\mu-p}{\mu-p}\tau]$. Moreover, $\tau < \widehat{\tau}_{\{s,r\}}$ is also implied by $\tau < \widehat{\tau}_s$ as $\widehat{\tau}_{\{s,r\}} > \widehat{\tau}_s$ when $p > \frac{1}{2}$. And $\frac{1}{\mu-p}\tau - (R-I) < \frac{2p}{\mu-p}\tau < \frac{1}{1-\mu}[(1+q)\mu(R-I) - \frac{2\mu-p}{\mu-p}\tau]$ when $\tau < \widehat{\tau}_s$ and $p > \frac{1}{2}$.

[29] One can show that the shareholder's BC and PC are $\tau < \widehat{\tau}_{\{r,r\}} = \mu^2(R-I)$ and $\frac{1}{\mu^2}\tau - (R-I) < A < \frac{1}{1-\mu^2}[\mu^2(R-I) - \tau]$. $\tau < \widehat{\tau}_{\{r,r\}}$ is implied by $\tau < \widehat{\tau}_s$ as $\widehat{\tau}_{\{r,r\}} > \widehat{\tau}_s$ when $p > \frac{1}{2}$. And still, we have $\frac{1}{\mu^2}\tau - (R-I) < \frac{2p}{\mu-p}\tau < \frac{1}{1-\mu^2}[\mu^2(R-I) - \tau]$ when $p > \frac{1}{2}$.

[30] One can show the shareholder's BC and PC are $\tau < \widehat{\tau}_{\{r,n\}} = \widehat{\tau}_r$ and $\frac{1}{\mu}\tau - (R-I) < A < \frac{1}{1-\mu}[\mu(R-I) - \tau]$. And when $\tau < \widehat{\tau}_{FB}$, we always have $\tau < \widehat{\tau}_r$ is implied by $\tau < \widehat{\tau}_s$ and $\frac{1}{\mu}\tau - (R-I) < \frac{2p}{\mu-p}\tau < \frac{1}{1-\mu}[\mu(R-I) - \tau]$.

Second, we derive the shareholder's IC constraint of contracting for a bank with two safe divisions. So in equilibrium the depositors will indeed lend $2I - A$ to the bank.

To ensure the shareholder has no incentive to deviate to contract for a bank with one safe and one risky divisions, we have $\Pi^{pub}_{\{s,s\}} \geq \Pi^{pub}_{\{s,r\}}$. After manipulation, we have

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

One can show $A^{pub}_{\{s,r\}} > 2X = \frac{2p}{\mu-p}\tau$ because $(1+q)\mu > 2q \Leftrightarrow p > q(1-p)$ and $\frac{1}{1-\mu}X > 2X \Leftrightarrow 2\mu > 1$.

To ensure the shareholder has no incentive to deviate to contract for a bank with two risky divisions, we have $\Pi^{pub}_{\{s,s\}} \geq \Pi^{pub}_{\{r,r\}}$. After manipulation, we have

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

Similarly, one can show $A^{pub}_{\{r,r\}} > 2X = \frac{2p}{\mu-p}\tau$ because $\mu^2 > q$ and $\frac{2}{1-\mu^2}X > 2X$.

Lastly, to ensure the shareholder has no incentive to deviate to contract for a bank with only one risky division, we have $\Pi^{pub}_{\{s,s\}} \geq \Pi^{pub}_{\{r,n\}}$. We have

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

We still focus on the case $A^{pub}_{\{r,n\}} > 2X = \frac{2p}{\mu-p}\tau$.

After establishing $A^{pub}_{\{s,r\}}$, $A^{pub}_{\{r,r\}}$ and $A^{pub}_{\{s,n\}}$, we derive the shareholder's IC constraint as a function of τ for $0 < \tau < \widehat{\tau}_s$.

One can show that $A^{pub}_{\{s,r\}} \geq A^{pub}_{\{r,r\}}$ if and only if $\tau \leq \frac{\mu(1-q)(\mu-p)}{p}(R-I) = \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s$. Moreover, we have $\frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s < \mu\widehat{\tau}_s$ if and only if the parameters are such that

$$pq > \mu(1-q).$$

One can also show that $A^{pub}_{\{s,r\}} \geq A^{pub}_{\{r,n\}}$ if and only if $\tau < \mu\frac{\mu-p}{\mu}q(R-I) = \mu\widehat{\tau}_s$. Lastly, we have $A^{pub}_{\{r,r\}} \geq A^{pub}_{\{r,n\}}$ if and only if $\tau \leq \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s$. 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, $\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s > \mu\widehat{\tau}_s$. We further impose the parametric assumption

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

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

Because $X = \frac{p}{\mu-p}\tau$, $A^{pub}_{\{s,r\}}$, $A^{pub}_{\{s,r\}}$ and $A^{pub}_{\{s,r\}}$ are increasing and linear in τ. We have $A^{pub}_{\{s,r\}}(\tau) \geq A^{pub}_{\{r,r\}}(\tau) > A^{pub}_{\{r,n\}}(\tau)$ when $0 \leq \tau \leq \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s$, $A^{pub}_{\{r,r\}}(\tau) > A^{pub}_{\{s,r\}}(\tau) \geq A^{pub}_{\{r,n\}}(\tau)$ when $\frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s < \tau \leq \mu\widehat{\tau}_s$, $A^{pub}_{\{r,r\}}(\tau) > A^{pub}_{\{r,n\}}(\tau) > A^{pub}_{\{s,r\}}(\tau)$ when $\mu\widehat{\tau}_s < \tau < \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s$, and $A^{pub}_{\{r,n\}}(\tau) \geq A^{pub}_{\{r,r\}}(\tau) > A^{pub}_{\{s,r\}}(\tau)$ 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 $pq > \mu(1-q)$ and $\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu < 1$, the shareholder's IC can be expressed as

$$A > A^{pub}_2(\tau) = \begin{cases} A^{pub}_{\{s,r\}} & \tau \in \left[0, \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s\right] \\ A^{pub}_{\{r,r\}} & \tau \in \left(\frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s, \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s\right] \\ A^{pub}_{\{r,n\}} & \tau \in \left(\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s, \widehat{\tau}_s\right]. \end{cases} \tag{47}$$

When $\tau \leq \widehat{\tau}_s$ and $A \geq A_2^{pub}(\tau)$, it is both feasible and incentive compatible for the shareholder to contract for a bank with two safe divisions. The maximum money creation in the economy is given by

$$2I - A_2^{pub}(\tau).$$

□

A.8 Proof of Proposition 5

Proof. We have already shown in the proof of Proposition 4 that $A_2^{pub}(\tau) > 2X \ \forall \tau \in [0, \widehat{\tau}_s]$, we now show that $A_1(\tau) > A_2^{pub}(\tau)$ for $\forall \tau < \widehat{\tau}_s$.

When $\tau \leq \left[0, \frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s\right]$, $A_2^{pub}(\tau) = A_{\{s,r\}}^{pub}$, we have $A_1(\tau) > A_{\{s,r\}}^{pub}$ if and only if $\frac{2}{1-\mu}\left[(\mu-q)(R-I)+X\right] > \frac{1}{1-\mu}\left[\left((1+q)\mu-2q\right)(R-I)+X\right] \Leftrightarrow (1-q)(R-I)+X > 0.$

Instead, when $\tau \in \left(\frac{\mu(1-q)}{pq}\mu\widehat{\tau}_s, \frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s\right]$, $A_2^{pub}(\tau) = A_{\{r,r\}}^{pub}$, we have $A_1(\tau) > A_{\{r,r\}}^{pub}$ if and only if $\frac{2}{1-\mu}\left[(\mu-q)(R-I)+X\right] > \frac{1}{1-\mu^2}\left[(\mu^2-q)\,2(R-I)+2X\right]$, which is equivalent to $(\mu-q)(R-I)+X > \frac{1}{1+\mu}\left[(\mu^2-q)\,(R-I)+X\right]$, after manipulation. The inequality is true because $\mu - q > \mu^2 - q > \frac{1}{1+\mu}(\mu^2-q)$ and $1+\mu > 1$.

Lastly, when $\tau \in \left(\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu\widehat{\tau}_s, \widehat{\tau}_s\right]$, $A_2^{pub}(\tau) = A_{\{r,n\}}^{pub}$, we have $A_1(\tau) > A_{\{r,n\}}^{pub}$ if and only if $\frac{2}{1-\mu}\left[(\mu-q)(R-I)+X\right] > \frac{1}{1-\mu}\left[(\mu-2q)\,(R-I)+\tau+2X\right] \Leftrightarrow \tau < \frac{\mu}{q}q(R-I)$. The inequality is true $\forall \tau \leq \widehat{\tau}_s$ because $\widehat{\tau}_s = \frac{\mu-p}{\mu}q(R-I) < 1 < \frac{\mu}{\mu}q(R-I)$.

Also, when inequality

$$\frac{\mu^2+(2q-1)\mu}{q[\mu^2+(1+p)\mu-p]}\mu < 1, \tag{48}$$

holds, $A_{\{r,n\}}^{Pub}$ remains to the left of the participation constraint $\tau \leq \widehat{\tau}_s$ for $\forall A \leq 2I$. One can show that (48) always holds.

To summarize, we have proved that $A_1(\tau) > A_2^{pub}(\tau)$, $\forall \tau \in [0, \widehat{\tau}_s]$. $\square$

A.9 Proof of Proposition 6

Proof. Tweaking the equilibrium contracts, that is, setting $B_{\{s,s\}}(I) \neq B_{\{s,s\}}(R)$, and/or $C_{\{s,s\}}(I) \neq C_{\{s,s\}}(R)$, cannot improve efficiency under public contracting.

As shown in Proposition 4 and 5, the participation constraint $\tau \leq \widehat{\tau}_s$ and the shareholder's incentive constraint $A \geq A_2^{pub}(\tau)$ define the equilibrium set of (τ, A) where a safe bank can be created. We now examine whether the tweaked contracts can affect the two constraints.

Allowing tweaked contracts, the shareholder's equilibrium expected payoff in the public contracting case is still

$$\Pi_{\{s,s\}}^{pub,t} = 2q(R - I) - 2(X + \tau) = \Pi_{\{s,s\}}^{pub}.$$

Therefore, it is obvious that the PC $\tau < \widehat{\tau}_s$ is not affected by the tweaking.

Moreover, different from the previous contracting case, tweaking the equilibrium contract now cannot affect the shareholder's expected payoff to deviate to a type 's,r' bank. Indeed, banker i now perfectly observe the contract $\{\tau/\mu, 0\}$ the shareholder offered to banker j. Therefore, the banker knows perfectly the shareholder is defecting from the equilibrium contract and only accepts the previous contract $\left\{B_{\{s,r\}}^i, C_{\{s,r\}}^i\right\} = \left\{\frac{1}{\mu}\frac{1}{\mu-p}\tau, \frac{1}{\mu}\frac{p}{\mu-p}\tau\right\}$ depending on the outcome to be $R + R$ and $I + R$. The banker knows that there will never be the states $R+I$ and $I+I$. So there is no room for tweaking at all. We have

$$\Pi^{pub,t}_{\{s,r\}} = \mu(1+q)(R-I) - X - 2\tau - (1-\mu) = \Pi^{pub}_{\{s,r\}}.$$

In addition, the shareholder's deviation payoffs for a type '{r,r}' and '{r,n}' are, again, not affected by tweaking the equilibrium contract. We have the shareholder's IC $A_2^{pub}(\tau)$ is not affected by tweaking as well.

To summarize, both the PC and the IC in the public contracting case are not affected by tweaking the equilibrium contract. □

A.10 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 $A_2^{priv}(\tau) > A_2^{pub}(\tau)$ for $\forall\tau \in (0, \widehat{\tau}_s)$. We then show $A_1(\tau) > A_2^{priv}(\tau)$ for $\forall\tau < \widehat{\tau}_s$.

Note that $A_1(\tau) > A_2^{priv}(\tau)$ 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, $A_1(\tau) > A_2^{priv}(\tau)$ holds for $\forall\tau > 0$. □

B Online Appendix

B.1 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. □

B.2 On the Interpretation of the Monotonicity Constraints

To see that the monotonicity constraints suggest an individual banker's compensation is not negatively correlated with the bank's total revenue, one can decompose a banker's compensation into a (baseline) component tied to the performance of his own project, i.e., W_I and W_R when the banker's project returns I and R respectively, and a firm-level bonus depending on the revenue of the whole bank, $b(\cdot)$. Given the decomposition, a banker's firm-performance-sensitive compensation can be written as

$$\begin{aligned} C_{\{s,s\}}(I) &= W_I + b(I+I) \\ C_{\{s,s\}}(R) &= W_I + b(I+R) \\ B_{\{s,s\}}(I) &= W_R + b(I+R) \\ B_{\{s,s\}}(R) &= W_R + b(R+R). \end{aligned}$$

Note that it is reasonable to assume $W_I \leq W_R$. Otherwise, a banker would have incentives to sabotage his own investment project or misreport its returns, Innes (1990). Then it immediately follows that $C_{\{s,s\}}(R) \leq B_{\{s,s\}}(I)$. Furthermore, the monotonicity constraints $C_{\{s,s\}}(I) \leq C_{\{s,s\}}(R)$ and $B_{\{s,s\}}(I) \leq B_{\{s,s\}}(R)$ would hold as long as $b'(\cdot) \geq 0$. That is, the 'firm-level bonus' is not decreasing in the firm's total revenue and the banker's compensation is not negatively correlated with the bank's overall performance. Otherwise, the banker's compensation would include a put option on his own firm, which would be at odds with real-world practice. For this reason, we believe that the assumption $b'(\cdot) \geq 0$ is natural and empirically relevant. Efing et al. (2022), for example, documents positive correlation between bankers' pay and their bank's overall performance.