Regulatory capture and banking supervision reform[☆]

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Abstract

We analyze whether banking supervision responsibilities should be concentrated in the hands of a single supervisor. We find that splitting supervisory powers among different supervisors is a superior arrangement in terms of social welfare to concentrating them in a single supervisor when the capture of supervisors by bankers is a concern. This result has implications for the design of banking supervisory architecture and informs current reform efforts in this field.

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1. Introduction

A series of reform proposals that have been envisaged since the subprime crisis started aims to concentrate supervisory powers in the hands of single bank supervisors. For example, the Bank of England has received new responsibilities for guarding the overall system's stability, i.e. macro-prudential supervision. Yet, the Conservative Party, now in office, has adopted as policy the investiture of full responsibilities to the Bank of England for the prudential oversight of all individ-

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ual financial institutions, i.e. micro-prudential supervision (see The Conservative Party, 2009). Similarly, the United States' Federal Reserve System is accumulating centralized control over the economy and banks. The Restoring American Financial Stability Act of 2010 gives the Federal Reserve primary responsibility for supervising all firms that could pose a threat to financial stability in addition to its responsibilities of monitoring the operations of holding companies —including traditional banks— and of protecting consumers. The financial crisis has also brought the division of powers between home and host supervisors of cross-border banks into question. In the European Union, for instance, the fact that the effective supervision of the off-shore branches of banks is conducted by the home supervisor, i.e. the supervisory authority of the country where their head offices are located, while the authorities of the host countries have a limited supervisory role is under debate (see, for example, UK House of Lords, 2009, Chapter 7).

In this paper, we argue that some of the current efforts to reform banking supervision systems by concentrating supervisory powers in the hands of a single supervisor could make them more prone to being captured by bankers. Certain features of banking supervision —e.g. the very specialized skills and the vast amount of data that are necessary to conduct banking supervision, and the maintenance of confidentiality— may facilitate the capture of supervisors by bankers. Additionally, the regulated industry may be more willing to capture supervisors that are powerful.[1] Indeed, capture has already been a concern during the Savings & Loans debacle (see Kane, 1990a,b, 2001), and in past regulatory debates in the United States and in Europe (see, for instance, Abrams and Settle, 1993; Benink and Schmidt, 2004; Gabillon and Martimort, 2004; Heinemann and Schüler, 2004).

[1] In an article in *Bloomberg* we read "With power from Congress to oversee the previously unregulated $615 trillion market for over-the-counter derivatives, it [the Commodity Futures Trading Commission] has become one of the hottest lobbying spots in town." ("Wall Street Lobbyists Besiege CFTC to Shape Derivatives Rules", October 14, 2010.)

We use a formal model to analyze the case where supervisors may use their powers to benefit favored banks instead of improving the well-being of the society, i.e. the case where supervisors may be captured by banks.[2] We focus on the incentives that self-interested bank supervisors may have to use supervisory information for their own benefit and examine the implications of these incentives for the design of supervisory institutions.[3] We show that concentrating supervisory authority in the hands of a single supervisor, e.g. a central bank or a home supervisor, may have a potential drawback: it may make the capture of the supervisor by banks more likely. Considering the allocation of bank supervisory powers as a contracting variable, we find that it is socially optimal that the oversight of different dimensions of the riskiness of banks be conducted by different bank supervisors.

In our basic model, each banker has private information about her bank's riskiness. The total riskiness of a bank can be decomposed into two additive and independent components.[4] A benevolent financial stability committee does not observe the riskiness of banks but uses one or two supervisors to attempt to bridge its informational gap. One can think of the financial stability committee as a legislature designing banking regulation and supervisory arrangements, and of the supervisors as two governmental agencies, e.g. the Bank of England and the Financial Services Authority in the case of the United Kingdom, supervising and enforcing regulations on banks. Alternatively, one can think of the former as a supranational institution, e.g. the Commission, the Council and the Parliament

[2] In this paper we focus on supervisors' capture by banks. However, political influence on supervisors by the government may also be a concern. See Quintyn and Taylor (2002), Quintyn et al. (2007), and Ponce (2010b) for studies on the convenience and the effects of having politically independent supervisors.

[3] Hardy (2006) argues that the possibility of regulatory capture needs to be taken into account in designing governance arrangements for bank supervisors.

[4] In Section 5, we show that the results are robust to considering the case of correlation between the two components of bank's riskiness.

in the case of the European Union, and of the latter as the supervisory authorities of two member states. The supervisors are endowed with imperfect informational technologies that allow them to get verifiable information on each dimension of the riskiness of a bank with some positive probabilities.[5]

If supervisors were benevolent, then the allocation of supervisory power would be of no consequence. Bank supervisors always truthfully reveal their supervisory information about the riskiness of the bank to the financial stability committee. In turn, the latter can implement a socially optimal regulatory contract.

However, bank supervisors may pursue self interest rather than social welfare. In fact, supervision creates particular links between supervisors and the banking sector which increase the likelihood that supervisors deviate from socially optimal objectives. We model the pursuit of self interest by allowing supervisors to hide supervisory information, so that the financial stability committee remains uninformed. Supervisory information gathered through audits and *in situ* inspections is difficult to manipulate but can be easily concealed. Supervisors may have many reasons not to inform the financial stability committee about the riskiness of the bank.[6] We use the following modeling short-cut: a supervisor may be willing to hide supervisory information in exchange for some monetary bribes from the bank.

If supervisors are self-interested agents, then the allocation of supervisory powers may be a useful mechanism to improve social welfare. First, we consider the case where there is only one supervisor gathering information about the two dimensions of a bank's riskiness. Second, we study the arrangement where there

[5]Verifiability has a weak meaning as we do not require that the information can be verified by a jury, but only that the financial stability committee can be convinced about it.

[6]For example, bank supervisors may prefer to conceal information in order to protect their reputation like in Boot and Thakor (1993), or in exchange of favors and post-career concerns like in Laffont and Tirole (1993).

are two supervisors endowed with separate supervisory technologies; i.e. each supervisor only gathers information about one dimension of a bank's riskiness. We restrict our attention to cases in which bank supervisors request bribes that can always be provided by the bank,[7] and show that the separation of supervisory powers can improve social welfare relative to the situation in which there is only one bank supervisor assessing both dimensions of risk.

Intuitively, splitting supervisory powers into two different supervisors reduces their discretion by limiting the information at their disposal. Under separation, each supervisor does not observe the information gathered nor the bribe requested by the other supervisor. Hence, each supervisor is constrained to request bribes based only on the piece of information he has gathered. Moreover, each supervisor is constrained to request bribes that can always be paid by the banker whatever her riskiness and whatever the bribe requested by the other supervisor. As a result, the sum of the bribes requested by both supervisors is at most as large as the bribe requested by a single supervisor who is endowed with the two supervisory technologies. Since the financial stability committee has to offer wages greater than possible bribes, splitting supervisory powers reduces the costs for the financial stability committee to provide incentives to bank supervisors and get information.

Splitting supervisory powers among different bank supervisors is a superior arrangement in terms of social welfare to concentrating supervisory powers in a single supervisor when the capture of supervisors by bankers is a concern. From an *ex ante* perspective, the design of separated supervisory entities with precise objectives and specific supervisory technologies leads to more rules and less discretion in banking supervision. The move from discretion to rules is indeed a

[7] This is a natural assumption when a bank supervisor is afraid of being sued for requesting bribes that cannot be accepted by the bank.

constitutional response to the threat of capture. Each supervisor then receives a single mission, i.e. to monitor a single dimension of risk, and follows stringent rules.

The previous result has implications for the design of the banking supervisory architecture and thereby informs current reform efforts in this field. If the two dimensions of the riskiness of banks are associated with micro-prudential and macro-prudential supervision, then the threat of supervisory capture provides a rationale for splitting the two supervisory responsibilities between different supervisors. If in addition to that we think that macro-prudential supervision should be conducted by central banks,[8] then the threat of supervisory capture provides a rationale for allocating micro-prudential supervision to a supervisor outside the central bank. If instead the two dimensions of the riskiness of banks are associated with activities in two different countries, then the threat of supervisory capture provides a rationale for an active supervisory role of both the home and the host country supervisors. In the case of the European Union, for instance, this result provides a rationale for giving rather more oversight powers to host country supervisors.[9]

[8] In practice, central banks are being given more responsibilities for macro-prudential supervision. This trend may be justified by many reasons (see, for instance, Blinder, 2010; Goodhart and Schoenmaker, 1995; Vives, 2001). First, central banks are the natural source of liquidity. As lenders of last resort they play a crucial role in preventing and managing banking crises. So, having access to timely supervisory information would help them to better perform these activities. Second, financial instability affects the macroeconomic environment—with substantial consequences for price stability and the monetary policy transmission process—to the point that even central bankers now recognize that they have previously ignored macro financial stability at their peril. Third, the conduction of monetary policy provides central banks with an ideal position to monitor macroeconomic developments and better anticipate threats to the stability of the whole financial system.

[9] In these two examples, the final allocation of supervisory powers will also depend on other factors like the possible addition to supervisory burden occasioned by multiplying the number of supervisors into a single jurisdiction or the potential loss of efficiency originated in the fact that banks (both in a single jurisdiction and across borders) would need to deal with more than one supervisory authority. See Section 5 for a discussion of these issues.

Our finding that separating supervisory powers into different supervisors is a superior institutional arrangement to concentrating them in a single supervisor is robust to relaxing some of the assumptions of our basic model. First, assuming a positive correlation between the two components of risk does not change the qualitative results. Moreover, in the case where two independent supervisors are used, it is possible to make the remuneration scheme of one of the bank supervisors contingent on the report by the other. The utilization of this kind of mechanism, known as "yardstick competition" in the industrial organization literature (see, for instance, Shleifer, 1985), would reduce the cost of providing appropriate incentives to each individual supervisor and therefore reinforce our result.

Second, in the basic model supervisors do not exchange information. Supervisors may exchange some information because it may be too costly to duplicate supervisory structures or because one supervisor may be under the authority of another supervisor. We consider a situation where one supervisor observes the information gathered by the other one but not *vice versa*. The informational advantage of one of the supervisors implies that this arrangement does strictly worse than the arrangement with two independent supervisors. However, the lack of an informational advantage by the other supervisor implies that social welfare improves with respect to the case in which only one supervisor is used.

Third, the use of the two supervisory technologies by one supervisor may imply informational advantages and efficiency gains. If this is the case, concentrating supervisory powers implies access to better information but, at the same time, increases the stake for collusion. The main result of this paper would hold as long as the latter effect is larger than the former one.

Finally, we discuss some of the implications of considering repeated interactions between the financial stability committee, supervisors and banks. A repeated version of our basic model opens the possibility of using new tools, i.e. tools other

than the separation of supervisory powers, in order to reduce the possibility of collusion between a bank and the supervisors. Nevertheless, our result that separation of supervisory authority improves social welfare is likely to hold. Indeed, to keep each supervisor partially informed about the condition of the bank in each single period reduces the scope for capture and hence reduces the social cost of obtaining informative signals.

The rest of the paper is organized as follows. In the following section we present the related literature. In Section 3 we present the model. In Section 4 we compare the implications of having one or two bank supervisors in terms of social welfare. In Section 5 we discuss some extensions to the model. Finally, in Section 6 we offer some concluding remarks.

2. Related literature

This paper contributes to the literature on the allocation of bank supervisory and regulatory powers. One strand of this literature focuses on economies of scope, synergies and potential conflicts among multiple responsibilities as reasons to allocate all supervisory powers to central banks or to other agencies. Goodhart and Schoenmaker (1995) present a detailed analysis of the reasons for and against allocating supervisory responsibilities to central banks and find that the main argument in favor is to preserve financial stability (see also Masciandaro (1995) and Vives (2001) for overviews of the literature). In general, there are economies of scope in the acquisition of information between the function of providing emergency liquidity assistance and that of supervising banks. Moreover, it can be argued that there are synergies between the conduction of monetary policy and the collection of supervisory information; Peek et al. (1999) provide evidence that having access to supervisory information may improve the efficiency of monetary policy because it helps central bankers to better forecast economic variables. The main opposition to combining the functions of monetary policy and

supervision is a potential conflict between the various objectives, and its effects on the reputation of the central bank. Cukierman (2011) argues that the trade-off between price and financial stability may compromise central bank independence. Di Giorgio and Di Noia (1999) show that the inflation rate is higher and more volatile in countries in which the central bank has a monopoly on supervision. Claeys and Schoors (2007) present empirical evidence of conflicts between micro- and macro-prudential objectives in the Central Bank of Russia. We provide an additional argument against the concentration of supervisory powers in the hands of a single supervisor: his monopoly on information acquisition makes his capture by the industry more likely.

Another strand of the literature on the allocation of banking supervision and regulation focuses on the incentives of self-interested agencies and the implications for the design of supervisory and regulatory arrangements. Masciandaro (2009) studies conditions under which politicians prefer to implement a unified supervisor outside the central bank. Boot and Thakor (1993) model the pursuit of self interest by introducing uncertainty about the supervisor's ability to gather supervisory information. They show that the desire of the supervisor to appear as a capable monitor may lead to excessive regulatory forbearance. The separation between the conflicting tasks, i.e. supervision and intervention, may mitigate this problem. We model the pursuit of self interest by allowing bank supervisors to hide supervisory information in exchange for monetary bribes, and consider a richer environment where more than one supervisor can be appointed. We show that allocating the responsibilities for supervising different dimensions of risk to different supervisors reduces the scope for capture and improves social welfare. Kahn and Santos (2005, 2006), Ponce (2010a) and Repullo (2000) study the optimal allocation of lender of last resort, deposit insurance and supervision responsibilities among several self-interested agencies. Their guiding question is who should perform each of

these activities. In this paper, we focus on banking supervision and analyze whether or not more than one supervisor should be responsible for conducting such an activity. Hence, we contribute new results about the optimal architecture of banking supervision.

This paper borrows extensively from the insights of the regulatory literature on collusion. Laffont and Tirole (1993) formally study issues such as the capture of regulators, favoritism in auctions and collusion in cost auditing. The general problem is that bureaucrats may fall under the influence of the industry and then fail to reduce the informational gap between uninformed policy makers and the privately informed industry. Revolving doors and post-career concerns[10] can lead the bureaucrats to manipulate their information in favor of the industry's interest. Policy makers may avoid regulatory capture by reducing the discretion of the regulatory agencies. The closest paper to ours is by Laffont and Martimort (1999). They are also interested in the possibility that the separation of powers in regulation acts as a commitment device against the threat of capture. We adapt their framework to analyze the implications of capture on the optimal allocation of responsibilities for supervising different components of the riskiness of banks.

3. The model

We consider the three-tier hierarchy, benevolent financial stability committee—bank supervisors—bank, in a model inspired by Laffont and Martimort (1999).

3.1. Agents, preferences and information

A banker has private information about her bank's riskiness, r. The riskiness of the bank can be decomposed into two components. We assume that these two components are additive. Hence, r has the following structure:

$$r = \underline{r} + r_m + r_M,$$

[10] On career-concerns and behavior of government agencies see Dewatripont et al. (1999a,b).

where $\underline{r}$ is the minimal level of risk, and r_m and r_M are two binary random variables with support in $\{0, \Delta r\}$ representing the two components of risk. The structure of r is common knowledge. The random variables r_m and r_M are independently drawn from the same probability distribution function with $P(0) = \alpha$ and $P(\Delta r) = 1 - \alpha$. We denote $\widehat{r} \equiv \underline{r} + \Delta r$ and $\overline{r} \equiv \underline{r} + 2\Delta r$. Hence, the bank can have three levels of risk $\underline{r}$, $\hat{r}$, and $\overline{r}$, with associated probabilities $P(\underline{r}) = \alpha^2$, $P(\widehat{r}) = 2\alpha(1-\alpha)$, and $P(\overline{r}) = (1-\alpha)^2$, respectively.

For simplicity, we normalize to zero the amount of deposits in the bank. Hence, the size of the bank's balance sheet is equal to the level of capital, k, put at risk by the banker. If the (net) profit of the bank is denoted by π, then the utility function of the banker is given by

$$B = \pi - rk.$$

The reservation utility of the banker is such that $B \geq 0$.

A benevolent financial stability committee is responsible for the design of banking regulation and supervisory arrangements. It does not observe the riskiness of the bank but uses one or two supervisors in order to bridge its lack of information. Bank supervisors are self-interested agencies that need to be motivated in order to inform the financial stability committee about the bank's riskiness. More precisely, supervisors receive a wage, w_i for $i \in \{1, 2\}$, which is based on verifiable measures of their performance. Since the information gathered from the bank by supervisors can be verified by the financial stability committee (see Section 3.3), then the wage of bank supervisors will be contingent on the information that they effectively provide to the latter.[11] If the financial stability committee uses only

[11] See Tirole (1994) for a discussion of different ways in which self-interested governmental agencies can be motivated.

one supervisor, then that supervisor's utility level is

$$S = w,$$

with the individual rationality constraint $w \geq 0$. If the financial stability committee uses two supervisors, then we similarly have

$$S_i = w_i \geq 0 \qquad \text{for} \qquad i \in \{1, 2\}.$$

Figure 1 summarizes the structure of the three-tier hierarchy in our model.

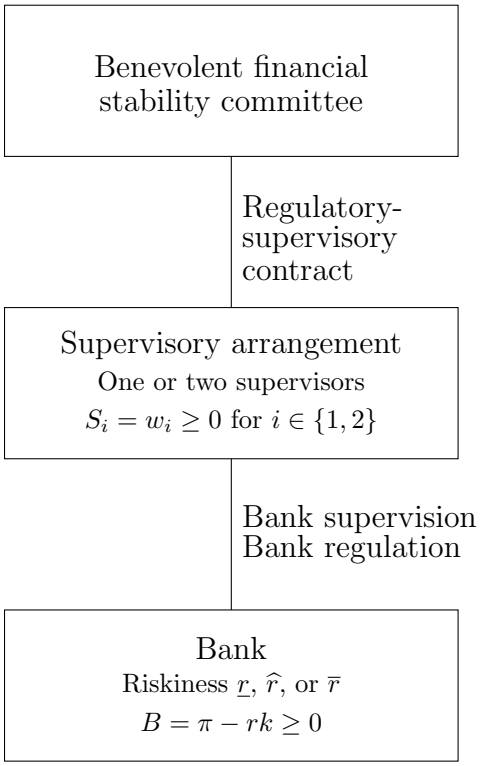

Figure 1: The three-tier hierarchy

3.2. Bank regulation

The benevolent financial stability committee regulates banks using a set of regulatory instruments. First, the financial stability committee regulates the size

of the bank's balance sheet, k, using capital regulations, mergers and acquisition regulations, and downsizing policies, among other tools. For example, the Restoring American Financial Stability Act of 2010 introduces new capital and leverage requirements with the aim of making it undesirable for banks to get too big, i.e. too systemic, to fail.[12] Second, the financial stability committee uses instruments like fees, taxes, provisioning for expected and unexpected loses, and monetary penalties that directly or indirectly affect the profit of the bank, π.[13]

Bank regulation, as well as bank supervision, entails some costs due to the bureaucratic structures that are needed to enact regulations and to collect public funds in order to pay wages, w, to bank supervisors. For simplicity, we assume that these costs are equal to $\lambda(\pi + w)$ with $\lambda > 0$. The term $\lambda\pi$ measures the bureaucratic costs of enacting regulations affecting the profit of banks, while the term λw measures the costs of collecting public funds to pay bank supervisors.[14]

3.3. Supervisory technologies

There are two supervisory technologies denoted by T_j for $j \in \{m, M\}$. A bank supervisor using technology T_j obtains hard information on the random variable r_j with probability $\epsilon \in (0, 1)$ when the realization of the variable is 0; nothing is learned otherwise. The information gathered by supervisors is hard in the sense that it can be justified by evidences. Let σ_j denote the signal provided by technology T_j. Hence, we have that the signal σ_j is informative with probability $\alpha\epsilon$ and that it is not informative with probability $1 - \alpha\epsilon$.

[12] In practice, many macro-prudential policies use traditional micro-prudential instruments, e.g. capital requirements, which are recalibrated to assess different dimensions of the riskiness of banks. In this model, regulations are contingent on the two components of the riskiness of banks. Hence, if we think that these components are associated with micro- and macro-prudential supervision, then our model allows for both micro- and macro-prudential regulations.

[13] See Perotti and Suarez (2009) and Shin (2010) for proposals of bank regulation that use taxes and charges as prudential tools.

[14] The qualitative results of this paper are robust to considering different costs of regulation such that $\lambda(\pi + w)$ is replaced by $\lambda_\pi \pi + \lambda_w w$ with $\lambda_\pi > 0$, $\lambda_w > 0$ and $\lambda_\pi \neq \lambda_w$.

We denote by $s \in \{0, 1, 2\}$ the number of informative signals. Let $P_s(r)$ be the probability that the riskiness of the bank is $r \in \{\underline{r}, \widehat{r}, \overline{r}\}$ conditional on the number of the signals that are informative, s. Hence, if none of the technologies provides an informative signal, i.e. $\sigma_m = \sigma_M = \emptyset$, we have

$$P_0(\underline{r}) = \frac{\alpha^2(1-\epsilon)^2}{(1-\alpha\epsilon)^2}, \quad P_0(\widehat{r}) = \frac{2\alpha(1-\alpha)(1-\epsilon)}{(1-\alpha\epsilon)^2}, \quad \text{and} \quad P_0(\overline{r}) = \frac{(1-\alpha)^2}{(1-\alpha\epsilon)^2}.$$

If only one of the supervisory technologies provides an informative signal, i.e. $\sigma_m = \emptyset$ and $\sigma_M = 0$, or $\sigma_m = 0$ and $\sigma_M = \emptyset$, then the riskiness of the bank cannot be equal to $\overline{r}$. In this case we have

$$P_1(\underline{r}) = \frac{\alpha(1-\epsilon)}{1-\alpha\epsilon}, \quad \text{and} \quad P_1(\widehat{r}) = \frac{1-\alpha}{1-\alpha\epsilon}.$$

If both signals are informative, i.e. $\sigma_m = 0$ and $\sigma_M = 0$, it is necessarily the case that $r = \underline{r}$.

3.4. Social welfare

The benevolent financial stability committee maximizes the expected value of the following welfare function

$$W = \Psi(k) + B + S - (1+\lambda)(\pi + w),$$

where $\Psi(k)$, with $\Psi' > 0$ and $\Psi'' < 0$, is the utility that the customers of the bank derive from using its services. The surplus of customers, $\Psi(k)$, is assumed to be increasing in the size of the bank, which is measured by its capital k, but with decreasing returns to scale. Indeed, larger banks generally offer more complete sets of products, which may better satisfy the preferences of customers. However, the marginal utility derived by customers from the introduction of a new product tends to zero when the current offer of products by the bank is large enough. Moreover, better capitalized banks offer better protection to their depositors whereas the marginal utility of extra protection tends to zero when the

bank is well capitalized. Recall that B and S are the utility functions of the banker and of bank supervisors respectively. Finally, the term $(1+\lambda)(\pi+w)$ represents the total costs of regulating and supervising banks. The welfare function can be restated as follows

$$W = \Psi(k) - (1+\lambda)rk - \lambda B - \lambda S.$$

3.5. The structure of the regulatory-supervisory contract

A regulatory-supervisory contract designed by the financial stability committee is a triplet $\left\{k(\widetilde{\sigma}_m, \widetilde{\sigma}_M, \widetilde{r}), B(\widetilde{\sigma}_m, \widetilde{\sigma}_M, \widetilde{r}), w(\widetilde{\sigma}_m, \widetilde{\sigma}_M)\right\}$, where $k(.)$, $B(.)$, and $w(.)$ denote respectively the capital (size), the profit of the bank, and the wage(s) of supervisor(s) as functions of both the report(s) of the supervisor(s), $\widetilde{\sigma}_j$ with $j \in \{m, M\}$, and the report of the banker about her bank's riskiness, $\widetilde{r}$.

3.6. Timing

The timing of the model is as follows:

(i) The financial stability committee defines the supervisory structure, i.e. either to use one or two bank supervisors.

(ii) The bank learns r_m and r_M. Simultaneously, the supervisor(s) learn(s) his (their) signals σ_m and σ_M.

(iii) The financial stability committee offers a regulatory-supervisory contract, i.e. a set of regulations to the bank and wage(s) to the supervisor(s) which are contingent on the report(s) of the supervisors(s) and the banker about the riskiness of the bank. The banker and the supervisor(s) decide whether or not to agree to participate. If anyone refuses, the game ends.

(iv) Non-benevolent supervisor(s) that observe(s) informative signal(s) request(s) bribes from the banker in exchange for hiding supervisory information.

(v) The supervisor(s) report(s) his (their) signal(s) and, if uninformative, the banker makes her report about the riskiness of her bank to the financial stability committee. A regulatory-supervisory contract is implemented according to these reports.

3.7. Benchmark: benevolent supervision

We solve for a benchmark case in which bank supervisors' objectives are aligned with the financial stability committee's objectives, i.e. supervisors are benevolent. Benevolent supervisors truthfully report their supervisory information to the financial stability committee for zero reward. Hence, having one or two supervisors is irrelevant from the perspective of the financial stability committee.[15]

Let us denote by $\underline{k}_s$, $\widehat{k}_s$ and $\overline{k}_s$ the capital (size) regulations imposed on a bank of risk equal to $\underline{r}$, $\widehat{r}$ and $\overline{r}$ respectively, and by $\underline{B}_s$, $\widehat{B}_s$ and $\overline{B}_s$ the respective utility levels of the banker when $s \in \{0, 1, 2\}$ informative signals are observed.

When no informative signal is observed, i.e. $s = 0$, the welfare function is

$$\begin{aligned} W_0 &= P_0(\underline{r})[\Psi(\underline{k}_0) - (1+\lambda)\underline{r}\underline{k}_0 - \lambda\underline{B}_0] + P_0(\widehat{r})[\Psi(\widehat{k}_0) - (1+\lambda)\widehat{r}\widehat{k}_0 - \lambda\widehat{B}_0] \\ &\quad + P_0(\overline{r})[\Psi(\overline{k}_0) - (1+\lambda)\overline{r}\overline{k}_0 - \lambda\overline{B}_0]. \end{aligned}$$

When only one informative signal is observed, i.e. $s = 1$, the welfare function is

$$W_1 = P_1(\underline{r})[\Psi(\underline{k}_1) - (1+\lambda)\underline{r}\underline{k}_1 - \lambda\underline{B}_1] + P_1(\widehat{r})[\Psi(\widehat{k}_1) - (1+\lambda)\widehat{r}\widehat{k}_1 - \lambda\widehat{B}_1].$$

When both signals are informative, i.e. $s = 2$, the welfare function is

$$W_2 = \Psi(\underline{k}_2) - (1+\lambda)\underline{r}\underline{k}_2 - \lambda\underline{B}_2.$$

From an *ex ante* perspective, social welfare under benevolent supervision, denoted by W^B, is

$$W^B = (1-\alpha\epsilon)^2 W_0 + 2\alpha\epsilon(1-\alpha\epsilon)W_1 + (\alpha\epsilon)^2 W_2. \tag{1}$$

[15] As we discuss in Section 5, this conclusion would be different when appointing a second supervisor entails the duplication of some costs or when the accuracy of supervisory technologies is larger under concentration than under separation of supervisory powers.

In the case with benevolent supervision, the financial stability committee maximizes the expected value of social welfare, which is given in Equation (1), under the banker's participation and incentive compatibility constraints. These constraints depend on the number of signals that are informative.

If both signals are informative, i.e. $s = 2$, the financial stability committee has perfect information so that it knows that the riskiness of the bank is $r = \underline{r}$. In this case, maximizing W^B yields the same results as maximizing W_2: all the banker's informational rent should be extracted, $\underline{B}_2^B = 0$, and the capital (size) regulations, $\underline{k}_2^B$, should be such that $\Psi'(\underline{k}_2^B) = (1+\lambda)\underline{r}$. In this case, the riskiness of the bank is observed by supervisors and thus by the financial stability committee. Hence, the bank directly falls into a particular regulatory scheme. Indeed, as the information gathered by supervisors is hard in the sense that it can be justified by evidences, the financial stability committee knows that the riskiness of the bank is $\underline{r}$ and applies the complete information regulation that leads to a profit $\underline{B}_2^B$ for the bank with the associated capital $\underline{k}_2^B$.

However, as soon as at least one of the signals is not informative, i.e. when $s = 0$ or $s = 1$, the riskiness of the bank is the banker's private information and the financial stability committee is not able to assign the bank to a particular regulatory scheme. In this case, the banker chooses the regulatory scheme that better fits her needs. Hence, the financial stability committee, in designing banking regulation, has to ensure that the banker chooses the regulatory scheme that is socially optimal for the bank's level of risk. This introduces some self-selection or incentive compatibility constraints to the problem of the financial stability committee. These constraints ensure that the banker finds it optimal to truthfully report her riskiness rather than reporting a different level of risk and accepting the regulations associated with that risk. Under asymmetric information, i.e. $s = 0$

and $s = 1$, the single-crossing property[16] ensures that it is enough to consider only upward incentive constraints. Hence, the relevant incentive compatibility constraints are

$$\underline{B}_0 \geq \widehat{B}_0 + \Delta r \widehat{k}_0, \tag{IC_1}$$

$$\widehat{B}_0 \geq \overline{B}_0 + \Delta r \overline{k}_0, \quad \text{and} \tag{IC_2}$$

$$\underline{B}_1 \geq \widehat{B}_1 + \Delta r \widehat{k}_1. \tag{IC_3}$$

Constraints (IC_1) and (IC_3) ensure that a banker of riskiness $\underline{r}$ is not willing to mimic a banker of riskiness $\widehat{r}$ when both signals are not informative and when only one signal is informative respectively. Constraint (IC_2) says that a banker of riskiness $\widehat{r}$ is not willing to mimic a banker of riskiness $\overline{r}$ when no signal is informative.

The single-crossing property also ensures that it is enough to consider the most risky banker's participation constraints.[17] These constraints are

$$\overline{B}_0 \geq 0, \quad \text{and} \tag{PC_1}$$

$$\widehat{B}_1 \geq 0. \tag{PC_2}$$

These constraints ensure the break-even condition of the bank under the different regulatory schemes. Since the incentive compatibility constraints and the participation constraints of the banker are binding at the optimum, we have that $\overline{B}_0^B = 0$, $\widehat{B}_0^B = \Delta r \overline{k}_0^B$, $\underline{B}_0^B = \Delta r(\overline{k}_0^B + \widehat{k}_0^B)$, $\widehat{B}_1^B = 0$, and $\underline{B}_1^B = \Delta r \widehat{k}_1^B$.

[16] The single-crossing property, or Spence-Mirrlees property, refers to a situation in which the isoutility curves of different types cross only once. See Laffont and Martimort (2002, Chapter 2), and the references therein for detailed analyzes of the single-crossing property.

[17] The participation constraints that are not presented in the text are strictly satisfied.

Maximizing the expected value of social welfare, W^B, under the previous constraints we find that $\underline{k}_0^B = \underline{k}_1^B = \underline{k}_2^B$, and that $\widehat{k}_0^B$, $\overline{k}_0^B$, and $\widehat{k}_1^B$ are such that

$$\begin{aligned}
\Psi'(\widehat{k}_0^B) &= (1+\lambda)\widehat{r} + \lambda\tfrac{P_0(\underline{r})}{P_0(\widehat{r})}\Delta r, \\
\Psi'(\overline{k}_0^B) &= (1+\lambda)\overline{r} + \lambda\tfrac{P_0(\underline{r})+P_0(\widehat{r})}{P_0(\overline{r})}\Delta r, \quad \text{and} \\
\Psi'(\widehat{k}_1^B) &= (1+\lambda)\widehat{r} + \lambda\tfrac{P_1(\underline{r})}{P_1(\widehat{r})}\Delta r.
\end{aligned}$$

The previous results imply the following Proposition.

Proposition 1. *Optimal regulation under benevolent supervision entails more severe regulations for the most risky banks such that*

(i) the most risky banks face more stringent capital (size) regulations than the less risky banks: $\underline{k}_0^B > \widehat{k}_0^B > \overline{k}_0^B$ *and* $\underline{k}_1^B > \widehat{k}_1^B$*; and*

(ii) the less risky banks make more profits: $\underline{B}_0^B > \widehat{B}_0^B > \overline{B}_0^B$ *and* $\underline{B}_1^B > \widehat{B}_1^B$*.*

Under the optimal regulatory scheme, the less risky banks face the less severe capital or size regulations. Moreover, the size that is allowed by regulation for the less risky banks does not depend on the information gathered by supervisors, i.e. $\underline{k}_0^B = \underline{k}_1^B = \underline{k}_2^B$.[18] However, the profit of the less risky banks depends on the supervisors' signals. In particular, the less risky banks gain more under asymmetric information, i.e. when $s = 0$ and $s = 1$, than under perfect information, i.e. when $s = 2$: $\underline{B}_0^B > \underline{B}_1^B > \underline{B}_2^B$ and $\widehat{B}_0^B > \widehat{B}_1^B$. Intuitively, when benevolent supervisors observe the riskiness of a bank, the financial stability committee can leave less profit to that bank and still implement the level of capital that is socially optimal. Stated differently, as soon as at least one supervisory signal is not informative, the financial stability committee has to leave some informational rent to the banker

[18] This is an expression of the classical "no distortion at the top" result of the theory of incentives; see, for example, Laffont and Martimort (2002).

in order for the latter to choose the regulatory scheme that is socially optimal for her bank's level of risk.

Intermediate and high-risk banks face more stringent regulations than low-risk banks. Under asymmetric information, i.e. when $s = 0$ and $s = 1$, and due to incentive reasons, the financial stability committee restricts further the size of the most risky banks and their profits accordingly. By so doing, the financial stability committee has to leave less informational rents to bankers to encourage self-selection into the regulatory scheme that is designed for their category of risk. As a result, optimal regulation entails an inverse relationship between riskiness and size of banks.

Since $\widehat{k}_0^B > \widehat{k}_1^B > \overline{k}_0^B$, the maximization of social welfare implies the following relationships among the utility levels of the banker.

Corollary 1. *Under benevolent supervision, the utility of the banker is such that*

$$\widehat{B}_0^B < \underline{B}_0^B - \underline{B}_1^B, \quad \textit{and} \tag{2}$$

$$\widehat{B}_0^B < \underline{B}_1^B. \tag{3}$$

The qualitative features of these conditions will still hold in the next section.

4. How many supervisors should be used?

In this section, we derive optimal regulations for the case in which bank supervisors are non-benevolent, i.e. self-interested. We also compute the distortions in terms of social welfare for the case in which only one supervisor is used and for the case in which two supervisors are used. Finally, we compare the results in order to answer the question of which supervisory arrangement is superior.

4.1. One non-benevolent supervisor

We first consider the case in which the financial stability committee uses one bank supervisor in order to bridge its informational gap on the riskiness of the bank. The single bank supervisor is endowed with both supervisory technologies T_j, $j \in \{m, M\}$. The bank supervisor is non-benevolent and has some discretion in performing his tasks. In particular, he may hide supervisory information in exchange for some monetary bribes from the bank. Hence, the financial stability committee has to reward the supervisor to incentivize him to truthfully reveal his information about the riskiness of the bank.

If the supervisor obtains hard information about the riskiness of the bank, it could be the case that the banker is better off when such information is not revealed to the financial stability committee. In such a case, there is scope for a collusive agreement between the banker and the supervisor. We assume that all the bargaining power belongs to the bank supervisor.[19] Hence, the supervisor requests a monetary bribe from the banker that is consistent with the information at his disposal and with the extra benefit accruing to the banker when the information is not revealed to the financial stability committee. This kind of bribe request is "safe" in the sense that it is always accepted by the banker. However, due to the illegal nature of bribes and the difficulties that arise when organizing such a collusive agreement, side-contracts between the banker and the supervisor are subject to transaction costs. These transaction costs imply that each unit of bribes paid by the banker increases the utility of the supervisor by only τ, with $\tau \in (0, 1)$.[20]

[19] Alternative assumptions are possible. The important point is that the financial stability committee can anticipate the outcome of the bargaining game.

[20] We assume that τ is exogenous and common knowledge. See Kofman and Lawarre (1993) for supervision models where the financial stability committee does not know τ. In Laffont and Martimort (1997, 2000) transaction costs are endogenously generated by asymmetric information among agents who want to enter into collusive agreements.

In this setting, the financial stability committee has to offer a reward to the bank supervisor which is at least equal to the stake of the bribes. There is not loss of generality in restricting the analysis to collusion-proof schemes, namely schemes that do not induce the bank and the supervisor to collude and motivate the latter to report truthfully to the financial stability committee.[21] The wage of the supervisor, w_s, is thus contingent on the number of informative signals, $s \in \{0, 1, 2\}$, reported to the financial stability committee. In particular, these wages must satisfy the following collusion-proof constraints

$$w_2 - w_1 \geq \tau \underline{B}_1, \tag{CP_1}$$

$$w_2 - w_0 \geq \tau \underline{B}_0, \quad \text{and} \tag{CP_2}$$

$$w_1 - w_0 \geq \tau \min\{\underline{B}_0 - \underline{B}_1, \widehat{B}_0\}. \tag{CP_3}$$

Constraint (CP_1) says that a fully informed supervisor prefers to report both signals rather than hiding one of them and getting a bribe from the banker. Constraint (CP_2) says that the supervisor prefers to report both signals rather than hiding both of them and getting the corresponding bribe from the banker. If the supervisor observes only one signal, he does not know whether or not the unobserved piece of information yields some rent to the banker. If it does, the maximum safe bribe that can be requested from the banker is equal to $\underline{B}_0 - \underline{B}_1$, while it is equal to $\widehat{B}_0$ otherwise. Hence, constraint (CP_3) says that the supervisor prefers to report the only signal he has gathered rather than hiding it and getting the bribe that can be provided by the banker whatever her riskiness.

[21] The collusion-proofness principle holds in our context. See Laffont and Tirole (1993) for a formal exposition of this principle.

The financial stability committee does not need to compensate the supervisor for a pair of uninformative signals, i.e. $\sigma_m = \emptyset$ and $\sigma_M = \emptyset$, hence $w_0^O = 0$. The expected social cost of hiring only one bank supervisor, denoted by C^O, is thus

$$C^O = \lambda[(\alpha\epsilon)^2 w_2 + 2\alpha\epsilon(1-\alpha\epsilon)w_1].$$

Therefore, the expected value of social welfare with only one non-benevolent supervisor, denoted by W^O, is

$$W^O = (1-\alpha\epsilon)^2 W_0 + 2\alpha\epsilon(1-\alpha\epsilon)W_1 + (\alpha\epsilon)^2 W_2 - \lambda[(\alpha\epsilon)^2 w_2 + 2\alpha(1-\alpha\epsilon)w_1].$$

The financial stability committee maximizes this objective function under collusion-proof constraints (CP_1) to (CP_3), incentive compatibility constraints (IC_1) to (IC_3), and the banker's participation constraints (PC_1) and (PC_2).

Since the incentive compatibility constraints and the participation constraints of the banker are binding at the optimum, we have $\overline{B}_0^O = 0$, $\widehat{B}_0^O = \Delta r \overline{k}_0^O$, $\underline{B}_0^O = \Delta r(\overline{k}_0^O + \widehat{k}_0^O)$, $\widehat{B_1^O} = 0$, and $\underline{B}_1^O = \Delta r \widehat{k}_1^O$. When conditions (2) and (3) hold,[22] equation (CP_3) can be rewritten as $w_1 \geq \tau \widehat{B}_0$. Since both ($CP_2$) and ($CP_3$) are binding at the optimum, condition (3) ensures that (CP_1) is slack. Using the binding collusion-proof constraints, social welfare can be rewritten as

$$W^O = (1-\alpha\epsilon)^2 W_0 + 2\alpha\epsilon(1-\alpha\epsilon)W_1 + (\alpha\epsilon)^2 W_2 - \lambda\tau[(\alpha\epsilon)^2 \underline{B}_0 + 2\alpha\epsilon(1-\alpha\epsilon)\widehat{B}_0].$$

Maximizing W^0 under the incentive compatibility constraints and the banker's participation constraints, we find that $\underline{k}_0^O = \underline{k}_1^O = \underline{k}_2^O$, and that $\widehat{k}_0^O$, $\overline{k}_0^O$, and $\widehat{k}_1^O$ are such that

$$\begin{aligned}
\Psi'(\widehat{k}_0^O) &= (1+\lambda)\widehat{r} + \lambda\big(\tfrac{P_0(\underline{r})}{P_0(\widehat{r})} + \tfrac{\tau(\alpha\epsilon)^2}{(1-\alpha\epsilon)^2 P_0(\widehat{r})}\big)\Delta r, \\
\Psi'(\overline{k}_0^O) &= (1+\lambda)\overline{r} + \lambda\big(\tfrac{P_0(\underline{r})+P_0(\widehat{r})}{P_0(\overline{r})} + \tfrac{\tau\alpha\epsilon(2-\alpha\epsilon)}{(1-\alpha\epsilon)^2 P_0(\overline{r})}\big)\Delta r, \quad \text{and} \\
\Psi'(\widehat{k}_1^O) &= (1+\lambda)\widehat{r} + \lambda\tfrac{P_1(\underline{r})}{P_1(\widehat{r})}\Delta r.
\end{aligned}$$

[22] As in Laffont and Martimort (1999), we assume that these conditions hold and check that it is indeed the case *ex post*.

The possibility that the bank supervisor colludes with the banker and hides supervisory information distorts the optimal regulatory policy presented in Proposition 1. The following proposition summarizes these distortions.

Proposition 2. *Optimal regulation with one non-benevolent bank supervisor entails more capital restrictions for the most risky banks and lower profits for the less risky banks with respect to the case of benevolent supervision. More precisely,* $\overline{k}_0^O < \overline{k}_0^B$, $\widehat{k}_0^O < \widehat{k}_0^B$, $\widehat{B}_0^O < \widehat{B}_0^B$, *and* $\underline{B}_0^O < \underline{B}_0^B$.

The threat of collusion between the supervisor and the bank leads to additional distortions on the optimal capital regulation for intermediate and high risk banks when no informative signal is reported, i.e. when $s = 0$. Indeed, no informative signals are more likely to be observed by the financial stability committee when collusion between the banker and the supervisor is a concern. Hence, the financial stability committee has to reward the supervisor for truthfully reporting in order to overcome his incentive to engage in collusive agreements with the banker. Since such a reward depends on the capacity of the banker to provide bribes to the bank supervisor, the financial stability committee reduces the social cost of being informed by decreasing the stake for collusion. This is achieved by reducing the profit of the banker in states where collusion is an issue and by introducing additional capital regulations such that the size of the most risky banks is smaller than in the case in which the supervisor is benevolent: $\overline{k}_0^O < \overline{k}_0^B$ and $\widehat{k}_0^O < \widehat{k}_0^B$.

It is worth noting that the regulatory distortions that are necessary to provide incentives to the bank supervisor depend on the transaction costs of side-contracting between the banker and the supervisor. In particular, when these costs are extremely large, i.e. $\tau \to 0$, the optimal regulation with a single non-benevolent supervisor tends to the optimal regulation under benevolent supervision. Increasing the transaction costs of side-contracting, e.g. via large scale

policies against corruption, is an effective policy to reduce the possibility of capture.

4.2. Two non-benevolent supervisors

We now consider the case in which the financial stability committee uses two bank supervisors in order to bridge its informational gap on the riskiness of the bank. Each supervisor is endowed with only one supervisory technology T_j with $j \in \{m, M\}$. Hence, each supervisor observes only the signal coming from his supervisory technology and remains ignorant about the other supervisor's signal. In order to simplify the analysis, we assume that supervisors do not exchange information about their signals.[23]

In this setting, we look for a Bayesian-Nash equilibrium in which the financial stability committee prevents collusive agreements between supervisors and the bank, and therefore supervisors truthfully report their information. If a bank supervisor observes an informative signal, then three cases are possible. First, if the second supervisor also observes an informative signal, then the bank's riskiness is $\underline{r}$. Provided that in a Bayesian-Nash equilibrium the first supervisor expects that the second supervisor is not deviating, and thus reporting his signal to the financial stability committee, the first supervisor can request a bribe equal to $\underline{B}_1$ from the bank. Second, the riskiness of the bank may be $\underline{r}$ even though the second supervisor does not observe an informative signal. In this case, the first supervisor can request a bribe equal to $\underline{B}_0 - \underline{B}_1$ from the bank. Third, if the second supervisor does not observe an informative signal, then the riskiness of the bank may be $\widehat{r}$. If this is the case, the first bank supervisor can request a

[23] In the absence of monetary bribes, central banks and bank supervisors do not have an incentive to voluntarily share supervisory information with each other (see, for example, Kahn and Santos, 2005, 2006; Ponce, 2010a). If monetary bribes were allowed, then it may be the case that one supervisor "sells" his information to the other. However, the financial stability committee is likely to be able to better control and prevent monetary bribes between supervisors than bribes between supervisors and banks.

bribe equal to $\widehat{B}_0$ from the bank. Each bank supervisor follows a safe behavior by requesting bribes that are accepted by the banker whatever her riskiness and whatever the information reported by the other supervisor. Hence, the following collusion-proof constraint guarantees that a bank supervisor truthfully reveals his supervisory information to the financial stability committee

$$w_1 - w_0 \geq \tau \min\{\widehat{B}_0, \underline{B}_0 - \underline{B}_1, \underline{B}_1\}. \qquad (CP_4)$$

The financial stability committee does not need to compensate a supervisor that provides a non-informative signal, hence $w_0^T = 0$. If conditions (2) and (3) hold, then each bank supervisor having an informative signal receives an incentive to report his signal to the financial stability committee when $w_1 \geq \tau \widehat{B}_0$. Hence, $w_1^T = \tau \widehat{B}_0$ at the equilibrium and the social cost of hiring two bank supervisors, denoted by C^T, is

$$C^T = 2\alpha\epsilon\lambda\tau\widehat{B}_0.$$

Therefore, social welfare with two non-benevolent supervisors, denoted by W^T, is

$$W^T = (1-\alpha\epsilon)^2 W_0 + 2\alpha\epsilon(1-\alpha\epsilon)W_1 + (\alpha\epsilon)^2 W_2 - 2\alpha\epsilon\lambda\tau\widehat{B}_0.$$

Maximizing W^T under the incentive compatibility constraints (IC_1) to (IC_3), and the banker's participation constraints (PC_1) and (PC_2), we find that $\underline{k}_0^T = \underline{k}_1^T = \underline{k}_2^T$, and that $\widehat{k}_0^T$, $\overline{k}_0^T$, and $\widehat{k}_1^T$ are such that

$$\begin{aligned}
\Psi'(\widehat{k}_0^T) &= (1+\lambda)\widehat{r} + \lambda\tfrac{P_0(\underline{r})}{P_0(\widehat{r})}\Delta r, \\
\Psi'(\overline{k}_0^T) &= (1+\lambda)\overline{r} + \lambda\big(\tfrac{P_0(\underline{r})+P_0(\widehat{r})}{P_0(\overline{r})} + \tfrac{2\tau\alpha\epsilon}{(1-\alpha\epsilon)^2 P_0(\overline{r})}\big)\Delta r, \quad \text{and} \\
\Psi'(\widehat{k}_1^T) &= (1+\lambda)\widehat{r} + \lambda\tfrac{P_1(\underline{r})}{P_1(\widehat{r})}\Delta r.
\end{aligned}$$

The following proposition summarizes the distortions introduced to the optimal regulatory policy when two non-benevolent bank supervisors are used.

Proposition 3. *Optimal regulation with two non-benevolent bank supervisors entails more capital restrictions for the most risky banks and lower profits for the less risky banks with respect to the case of benevolent supervision. However, for banks of riskiness $\widehat{r}$ (respectively $\overline{r}$), optimal regulation is less (respectively more) distorted when two non-benevolent bank supervisors are used instead of using only one non-benevolent bank supervisor. More precisely, $\widehat{k}_0^T = \widehat{k}_0^B > \widehat{k}_0^O$, $\widehat{k}_1^T = \widehat{k}_1^B$, and $\overline{k}_0^T < \overline{k}_0^O < \overline{k}_0^B$.*

Proposition 3 shows that the use of two bank supervisors implies more severe regulation, i.e. more capital restrictions and less profits, for the most risky banks than the use of only one bank supervisor. Intuitively, if two supervisors are used, then a collusive agreement between one of the supervisors and the bank can only involve the non-report of one signal. Hence, the capacity of each supervisor to request bribes from the banker is reduced. As a consequence, the financial stability committee reduces the stake for collusion, and thus the social cost of being informed, by introducing additional capital regulations to only the most risky banks. However, there are now two bank supervisors rather than one. Hence, the distortion introduced to the optimal regulation for the most risky banks with respect to the case under benevolent supervision is larger when two supervisors are used than when one supervisor is used: $\overline{k}_0^T < \overline{k}_0^O < \overline{k}_0^B$. In contrast to the case in which only one bank supervisor is used, the financial stability committee does not need to distort the optimal regulation for other categories of risk. Indeed, it is enough to apply more stringent regulations to the most risky banks in order to ensure that bank supervisors truthfully report their information at the lowest social cost.

4.3. Comparison

The supervisory arrangements analyzed in the previous two sections lead to different distortions of the optimal regulatory policy. In particular, the single-

supervisor arrangement implies more capital restrictions for banks of riskiness $\overline{r}$ and $\widehat{r}$ with respect to the case of benevolent supervision. Meanwhile, the two-supervisor arrangement implies no distortion for banks of riskiness $\widehat{r}$ and further distortions for the most risky banks, i.e. banks of riskiness $\overline{r}$. Since the distortions generated go in opposite directions, the ranking of supervisory arrangements in terms of social welfare is ambiguous. However, we are able to prove the following result.

Proposition 4. *From an ex ante point of view, the gain in social welfare from using two non-benevolent bank supervisors instead of only one non-benevolent bank supervisor is at least equal to zero.*

The intuition for the proof of Proposition 4 is the following: by using two bank supervisors, the financial stability committee eliminates one constraint to its optimization problem while the other constraints remain unchanged. Indeed, by using two supervisors the financial stability committee gets rid of the collusion-proof constraint (CP_2), which is binding when only one supervisor is used. Meanwhile, simple algebra shows that collusion-proof constraint (CP_3), which is binding when only one supervisor is used, is equal to collusion-proof constraint (CP_4), which is binding when two supervisors are used.

Moreover, the cost of banking supervision in the case with one non-benevolent supervisor is equal to $C^T = 2\alpha\epsilon\lambda\tau\Delta r\overline{k}_0^T$, whereas it is equal to $C^O = \alpha\epsilon\lambda\tau\Delta r[\alpha\epsilon(\overline{k}_0^O + \widehat{k}_0^O) + 2(1-\alpha\epsilon)\overline{k}_0^O]$ under separation of supervisors. Simple algebra shows that $C^O - C^T = \alpha\epsilon\lambda\tau\Delta r[2(\overline{k}_0^O - \overline{k}_0^T) + \alpha\epsilon(\widehat{k}_0^O - \overline{k}_0^O)] > 0$. Hence, the financial stability committee achieves a higher value of its objective function, i.e. social welfare is higher, by using two bank supervisors instead of only one.

Splitting supervisory powers into two different bank supervisors reduces the social cost of obtaining two informative signals about the riskiness of the bank. Otherwise stated, it is less expensive for the financial stability committee to be

informed by two bank supervisors endowed with separate risk-specific supervisory technologies, than by only one bank supervisor endowed with both supervisory technologies. Under the two-supervisor arrangement, each bank supervisor is partially informed about the riskiness of the bank, whereas a single supervisor may be perfectly informed about the riskiness of the bank and may use such a piece of information to ask for bribes that could never be requested under separation of supervisory powers. Hence, the response to the threat of capture is the design of two separate supervisory entities with precise objectives and specific supervisory technologies. The separation of supervisory tasks introduces more rules to banking supervision and improves social welfare by reducing the discretion of bank supervisors. Each supervisor receives a single mission, i.e. to monitor a single dimension of risk, and follows stringent rules.

5. Extensions and discussion

In this section we analyze several extensions to the basic model and discuss their implications.

5.1. Correlation between risks and yardstick competition

In the basic model we assume that the two components of the bank's riskiness are independent, i.e. that r_m is independent from r_M. However, a positive correlation between these two components of risk is likely to exist. A simple way to introduce a positive correlation between the two components of risk is to assume that the probabilities associated with extreme levels of bank riskiness are higher than in the case of independence between these two components of risk. In particular, we can modify the basic model such that $P(\underline{r}) = \alpha^2 + \rho$, $P(\widehat{r}) = 2\left[\alpha(1-\alpha) - \rho\right]$, and $P(\overline{r}) = (1-\alpha)^2 + \rho$, where $\rho > 0$ measures the correlation between risks.

Introducing a positive correlation between the two components of risk into our model makes the algebra more complicated. Indeed, all the expressions for proba-

bilities will contain terms accounting for the correlation, ρ. However, introducing correlation does not change the qualitative results of the basic model.

Moreover, the positive correlation between the two components of risk would be exploited by the financial stability committee to better provide incentives to bank supervisors, reinforcing the result that separating supervisory powers into two supervisors implies welfare gains with respect to concentrating these powers in the hands of a single supervisor. Since risks are positively correlated, signals are positively correlated.[24] Hence, the financial stability committee would use the report of one supervisor to monitor the other supervisor. Otherwise stated, under correlation of signals the remuneration scheme of one bank supervisor may depend not only on the report by the incumbent supervisor but also on the report by the other supervisor. This introduces yardstick competition between bank supervisors. It is well-known in the industrial organization literature that this kind of competition helps the financial stability committee to reduce the social cost of providing incentives to bank supervisors (see, for instance, Shleifer, 1985).[25]

A potential limit to the use of yardstick competition is the presence of limited liability. For incentive reasons, the financial stability committee may want to heavily punish a bank supervisor that is caught misreporting. However, this may not possible when supervisors are protected by limited liability. Another potential limit to the use of yardstick competition is the possibility that supervisors engage in collusive agreements between themselves and decide together on their reports

[24] If risks are positively correlated, then the probabilities of getting two informative signals or no informative signal increase by $\rho\epsilon^2$ each, and the probability of getting only one informative signal decreases by $2\rho\epsilon^2$ with respect to the case in which risks are independent.

[25] The use of yardstick competition among bank supervisors may be extended further. If there were multiple agencies supervising each single dimension of risk, then the financial stability committee would use the information provided by each of them to punish or reward the other agencies. The utilization of this kind of monitoring device may reduce the cost of providing appropriate incentives to each individual agency. It would be worthwhile to extend our model in order to address the question of how many supervisors are optimal to use for each single dimension of a bank's riskiness.

to the financial stability committee.

5.2. Fixed costs and hierarchical supervision

In the basic model, we assume that the only cost associated with bank supervision is the wage paid in order to motivate bank supervisors. However, bank supervision may entail some fixed costs (e.g., buildings and bureaucracy) that need to be duplicated when supervisory powers are split. Formally, this can be modeled as a minimal fixed budget that has to be paid to each supervisor such that $w_i \geq \underline{w} > 0$. If two supervisors are used, the financial stability committee faces twice this constraint. Hence, the result that separating supervisory powers implies welfare gains with respect to concentrating these powers holds as long as the cost of settling a bank supervisor, i.e. $\underline{w}$, is not too large.

It is indeed possible that in some jurisdictions the costs of duplicating supervisory structures exceed the benefits of separating supervisory powers. Additionally, other efficiency reasons could imply that the concentration of all supervisory powers in a single agency is optimal (see Section 5.3). In these cases, policy makers would like to empower a single supervisor with the authority to supervise both dimensions of risk. Certain aspects of the internal governance of supervisory agencies, e.g. disputes in which different units seek to obtain increased influence, could ensure a high level of independence between units. If this is the case, policy makers would like to allocate supervisory technologies to two different units inside the single supervisor.

However, the concentration of all supervisory powers into a single supervisor could lead to a hierarchical structure where the unit that is responsible for supervising one dimension of risk is subordinated to the authority from the unit that is responsible for supervising the other dimension. In this case, the structure of information is slightly different with respect to the two cases that we have analyzed previously. More precisely, the subordinated supervisor cannot observe the

signal that has been gathered by the superior supervisor, as was the case when using two independent supervisors. However, the superior supervisor can observe the signal that has been gathered by his subordinate, as was the case when using only one supervisor. Under the assumption $\underline{w} = 0$ as in the basic model, the informational advantage of the superior supervisor implies that the hierarchical structure does strictly worse than having two independent supervisors. However, the lack of an informational advantage by the subordinated supervisor implies that social welfare improves with respect to the case in which only one supervisor is used. Summarizing, a hierarchical structure of banking supervision improves the social welfare with respect to using only one bank supervisor but does strictly worse than using two independent bank supervisors.

5.3. Different accuracy of supervisory technologies

The use of the two supervisory technologies by a single bank supervisor may imply informational advantages and efficiency gains. For example, by using one of the technologies, a bank supervisor would get skills, training and information that improve his accuracy and efficiency in the use of the other technology. Additionally, there would be overlap in the information needed to assess each dimension of risk, which would imply overlap in the supervisory technologies. Formally, we can extend the basic model by assuming that a single bank supervisor using the two supervisory technologies gets each informative signal with probability ϵ^O, whereas two independent bank supervisors get an informative signal with probability ϵ^T, where $\epsilon^O > \epsilon^T$.

The different accuracies of supervisory technologies introduce two conflicting effects. On the one hand, if bank supervisors truthfully reveal their signals to the financial stability committee, then the latter will get more accurate information by using a single bank supervisor than by splitting supervisory powers into two supervisors. In turn, having access to more accurate information allows the finan-

cial stability committee to leave less informational rent to the banker and then to improve social welfare. On the other hand, the access to more accurate information for a single supervisor increases the stake for collusion with the banker. Hence, the financial stability committee has to introduce larger distortions to the optimal regulatory scheme than in the basic model. Moreover, the committee has to leave more revenue to the bank supervisor in order to motivate the latter to truthfully reveal his signals, which reduces social welfare. Consequently, the result that separating supervisory powers implies welfare gains with respect to concentrating these powers holds as long as the latter effect is larger than the former one.

5.4. Repeated supervision

The interaction between the financial stability committee, supervisors and the bank that is described in our basic model may repeat over time. Repetition is likely to weaken the positive effects of separation of supervisory authority on social welfare. However, the qualitative result that separating supervisory powers into independent supervisors is a superior institutional arrangement with respect to concentrating them into a single supervisor is likely to hold in a repeated version of the model. Indeed, to keep each supervisor partially informed about the riskiness of the bank in each single period reduces his capacity for getting a bribe because of the same reasons in our basic model, and independently of the dynamic of the game. Hence, separation of supervisory powers reduces the social cost of obtaining informative signals.

Considering a repeated version of our model opens the possibility of using new tools, i.e. others than the separation of supervisory powers, in order to reduce the possibility of collusion between the bank and the supervisors. A rigorous treatment of these tools would require more sophistication and extra assumptions above and beyond those contained in our basic model; e.g. assumptions about

the correlation between risks and signals over time, and about the structure of the regulatory-supervisory contract would be necessary.

In what follows, we offer a brief discussion of some of the effects that could be present in a repeated version of our model. The financial stability committee could use the information from past periods to reward or to punish a supervisor, e.g. by replacing the supervisor and then cutting him off from future bribes. The term in office of supervisors could become a contracting variable. More precisely, the financial stability committee could commit to replace supervisors when the observed frequency of informative signals is considered too low with respect to the observed frequency of bank failures. This will increase the opportunity cost of bribing bank supervisors and reduce the social cost of obtaining informative signals about the riskiness of banks. At the same time, observing an excessively low frequency of informative signals does not perfectly reveal the existence of capture because supervisory technologies are imperfect, i.e. a bank supervisor may not get an informative signal even if the bank is excessively risky. This fact implies that even honest supervisors may be punished. Hence, the financial stability committee has to increase the wage of bank supervisors in order to satisfy their participation constraints, which increases the social cost of obtaining informative signals. Moreover, keeping a supervisor in office for long periods of time may significantly reduce the transaction costs of engaging into collusive agreements, i.e. τ may decrease over time. The reaction to an ease in the possibility of collusion would require more stringent rules to curb the pursuit of private interests. In turn, these more stringent rules would imply larger distortions to optimal regulation and then reduce social welfare. As a result, the convenience of using information from past periods to provide incentives to bank supervisors depends on the balance between these effects.

6. Concluding remarks

In this paper we use a formal model to analyze whether the same bank supervisor should supervise different components of the riskiness of banks when the supervisors' capture by the banking industry is a concern. Under the assumptions of our basic model, we find that the supervision of different dimensions of the riskiness of banks should be conducted by different supervisors. The concentration of supervisory powers in the hands of a single supervisor makes his capture more likely. Hence, it makes it more costly for a benevolent financial stability committee to provide incentives to the bank supervisor in order to be informed about the riskiness of banks. The separation of supervisory responsibilities appears as an optimal organizational response to the threat of capture. Separation reduces the information that each supervisor can obtain, and hence it also reduces the stake for capture and the social cost of providing incentives to self-interested supervisors. Otherwise stated, separation leads to more rules and reduces supervisory discretion to pursue their private agendas by limiting the information at their disposal.

The previous result is robust to relaxing some of the assumptions of the basic model. In particular, the result still holds if we consider a positive correlation between the two components of risk, that supervisors exchange supervisory information, and a repeated version of the model. However, the positive effects of the separation of supervisory powers on social welfare may not sufficiently compensate for the additional supervisory burden and the loss of efficiency in the supervisory technology introduced by multiplying the number of supervisors. In this case, supervisory powers should be concentrated into a single supervisor. If it is possible to ensure a high degree of independence between internal units of the single supervisor, then the insights of this paper applied to the internal organization of the supervisor provide a rationale for allocating different supervisory

responsibilities to different units inside the single supervisor.

The results of our formal model may have implications for the design of the banking supervisory architecture and thereby inform current reform efforts in this field. A series of reform proposals that have been envisaged in the aftermath of the subprime crisis aims to concentrate supervisory powers into single supervisors, notably central banks. Hence, our results provide a rationale for policy makers to reconsider the current trend toward the concentration of supervisory powers because the monopoly in information acquisition may be a curse when capture is a concern. Reconsidering the concentration trend of supervisory powers does not imply that central banks should have no role in banking supervision. There are good reasons (although outside the scope of our formal model) for central banks to oversee the stability of the whole financial system. Nowadays there appears to be a growing consensus among academics and policy makers on the need for central banks to conduct macro-prudential supervision. If central banks should conduct macro-prudential supervision, and if the two dimensions of riskiness in our model are associated with micro- and macro-prudential supervision respectively, then the threat of supervisory capture provides a rationale for allocating micro-prudential supervision to a different entity than the central bank supervisor.

The results of our analysis also inform the current debate on home-host supervision. In particular, our results provide a rationale for an active role of both the home and the host country authorities in the supervision of cross-border banks. In the case of the European Union, where the effective supervision of the offshore branches of banks is conducted by the home country supervisor, our results provide a rationale for giving rather more oversight powers to the host country supervisors.

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