Monitoring the Supervisors: Optimal Regulatory Architecture in a Banking Union*

Jean-Edouard Colliard†

First version: March 2013

This version: December 16, 2013

Abstract

I study the optimal architecture of bank supervision in a federal system. A central supervisor gets information about a bank, for instance through stress-testing, and decides whether an on-site examination should be performed by a local or a central authority. Local supervisors have lower inspection costs, but do not internalize cross-border externalities. The optimal degree of centralization depends on the severity of these externalities, the opacity of the supervised bank and the specificity of its assets. The market reacts to the chosen architecture, so that a centralized supervision endogenously increases market integration and cross-border externalities, strengthening the need for centralized supervision. The economy can be trapped in an equilibrium with low supervision and integration, while a forward-looking design of the supervisory architecture would coordinate economic agents on a superior equilibrium.

JEL Classification Number: D53, G21, G28, G33, G38, L51.

Keywords: banking union, single supervisory mechanism, bank supervision, financial integration, regulatory federalism.

---

*I am grateful to Elena Carletti, Dean Corbae, Hans Degryse, Giovanni Di Iasio, Co-Pierre Georg, Charles Kahn, Julian Kolm, Myron Kwast, Perrin Lefebvre, David Marques-Ibanez, Marcelo Rezende, Roberto Savona, Bernd Schwaab, Alexandros Vardoulakis, Larry Wall, seminar participants at the European Central Bank, the Deutsche Bundesbank, the Paris School of Economics and the University of Mannheim, and participants to the 5th Financial Stability Conference in Tilburg, the 2013 Bocconi-Carefin Conference, the 2013 CREDIT Conference, the 2013 Conference on Banks and Governments in Globalised Financial Markets and the 2013 EEA Congress for helpful comments and suggestions. The views expressed in this paper are the author's and do not necessarily reflect those of the European Central Bank or the Eurosystem.

†European Central Bank, Financial Research. Address: ECB, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany. E-mail: Jean-Edouard.Colliard@ecb.int. Phone: (49) 69 1344 5313.

1 Introduction

As a consequence of the increasing integration of banking systems in the past decades, the boundaries of a bank's activity can stretch significantly further than the mandate of its supervisor. The problem has been particularly acute in Europe, where "supervisory failings"[1] such as the inability of national supervisors to take into account cross-border externalities led the European Commission to propose the creation of a "Single Supervisory Mechanism" (SSM) for European banks in September 2012. The possibility that the objectives national or local supervisory agencies may not be aligned with the general interest is of course more general: a similar problem is documented for instance in the United States, where banks regulated by State and Federal regulators alternatively appear to face regulatory forbearance by the former (see Agarwal *et al.* (2012)).

The goal of this paper is to offer a theoretical framework with a rationale for banking supervision, the possibility of "supervisory failings" by local supervisors, and thus a scope for centralized supervision and the possibility to study how best to organize it. Banks lend to entrepreneurs with risky projects, whose probability of success is revealed to the banks after one period. If it is low, it is socially optimal to liquidate the projects. Due to limited liability the banks will tend to "evergreen" loans. The supervisor has to step in, inspect the banks and force liquidation if necessary. But due to the externalities of a bank's liquidation, the local supervisor may be too forbearant. This is anticipated by a bank's creditors, who ask for a higher interest rate. Inadequate supervision thus leads to a friction in the allocation of capital, in particular cross-border.

Supervisory forbearance justifies the need for integrated supervision, offering a framework to analyze the optimal supervisory architecture, taking into account that the banks and their creditors will react endogenously to the chosen architecture. The trade-off is between the biased incentives of local supervisors and their better knowledge of domestic banks. I assume that through on-site examinations a supervisor can learn the probability that loans are repaid. Due to the informational advantage of the local supervisor, on-site inspections are more costly

[1] Term used in the *Proposal for a Council regulation conferring specific tasks on the European Central Bank concerning policies relating to the prudential supervision of credit institutions*, European Commission, 12.09.12, p.2. The actual regulation was adopted on 15.10.13. Both texts are available on the Commission's website: http://ec.europa.eu/internal_market/finances/banking-union/.

for the central supervisor. The central supervisor also monitors key balance sheet items off-site. Based on the information she receives[2], the central supervisor can choose to inspect the bank and potentially force its liquidation, or to leave the inspection to the local level. Moreover, it is costly to monitor the banks and how much is invested in this activity is a choice variable of the central supervisor.

The optimal architecture for supervising a given bank can be either centralized, in which case local knowledge is not used, delegated to the local level, which can lead to forbearance, or joint, in which case inspections are realized either by the local or the central supervisor, depending on the information revealed to the central supervisor through off-site monitoring.

Which arrangement is optimal depends on three dimensions: the severity of the conflict of objectives, the opacity of the bank, the specificity of its assets. Delegating the supervision to the local level is a better solution when the costs of inspecting the bank are much higher for the central than for the local supervisor (Proposition 1), which is typically the case when its assets are very specific (local knowledge is more necessary), and when the conflict of objectives between the central and the local level is mild. Centralizing the supervision by always having the central supervisor's staff inspecting the bank is on the contrary better when assets are not too specific and the conflict of objectives high. In both cases, a joint architecture will be preferable if off-site monitoring gives enough information and is not too costly, that is if the bank is not too opaque: then the central supervisor can save on inspection costs by inspecting only if the observed figures point towards a situation where the local supervisor is likely to be too forbearant (Proposition 2 and Corollary 1).

I then endogenize how much banks lend to local entrepreneurs and borrow from foreign investors. The introduction of a supra-national/federal supervisory system is an important change, and its impact on market conditions must be taken into account. Such a supervisory reform makes it safer to lend to the banks, thus reducing the market fragmentation implied by supervisory forbearance. But it also implies that a higher proportion of banks' losses are borne by foreign investors, which worsens the local supervisor's incentives, making it necessary to reinforce central supervision. The optimal architecture should thus be flexible in

[2] It will be convenient to refer to the central supervisor with the female pronoun "she" and to the local supervisor with the male pronoun "he".

order to respond to endogenous changes in the banking sector. This complementarity between foreign lending and centralized supervision also implies the possibility of multiple equilibria: a bank with few foreign creditors may be left to local supervisors, and for this reason few foreign investors will lend to the bank (Proposition 4). Centralizing the supervision of this bank may imply more lending by foreigners, making central supervision necessary. Failing this, the economy may be trapped in a suboptimal equilibrium with both too little central supervision and too little market integration.

While the paper derives a number of normative implications about the organization of bank supervision, this second part also delivers empirical implications on the impact of changes in supervisory architecture on banks, such as the rates at which they can borrow on the interbank market, the structure of their balance sheet, or their profitability. I discuss in more details in section 3.3 how these implications could be tested on European or on U.S. data.

The optimal supervisory architecture derived in the first part of the paper takes supervisor incentives as given, which makes it easy to enrich the model with alternative microfoundations for these incentives. A simple variation is to consider banks with foreign equity holders or foreign assets instead of foreign creditors, which leads to a similar complementarity between centralized supervision and market integration. The banking sector could be modeled as having a core-periphery structure, in which case due to second-round effects of defaults, even banks indebted towards local agents only may be inadequately supervised. I then look at the local supervisor's behavior when common deposit insurance is introduced in the model, and when resolution rules change, both having implications for the future course of the European Banking union.

The end of this section reviews the related literature. Section 2 determines the optimal delegation of supervision to local supervisors in a general setup. Section 3 develops a particular case to study the interplay between supervision and market forces, followed by Section 4 which develops some extensions and by the Conclusion.

Links with the literature: this paper is related to the literature on the supervision of multinational banks. Beck, Todorov, and Wagner (2012) for instance use a similar modeling of banking supervision based on Mailath and Mester (1994) to study empirically the incentives faced by the local supervisor of such a bank. My paper is complementary as I derive the optimal regulatory answer to this problem and endogenize the supervisors' incentives. Calzolari and Loranth (2011) focus on the impact of the legal form of the multinational bank. Holthausen and Ronde (2004) study how different national supervisors of multinational banks can cooperate. My focus is different as I look at the optimal "vertical" regulatory architecture instead of the interaction between equal national supervisors.

This vertical dimension has been explored in several recent empirical papers that have studied the behavior of different bank supervisors at State and Federal level in the United States, and identified systematic differences in their behavior towards supervised banks. As will be discussed in the text, my findings are in line with these results and give additional implications that could be tested.

There is more generally a literature on coordination problems between different banking regulators and supervisors, either from different countries or with different objectives and functions. Acharya (2003) studies the competition between closure policies in two countries when capital adequacy regulation is already coordinated, and shows that this coordination worsens the regulatory race to the bottom. Hardy and Nieto (2011) show that common supervision alleviates the coordination problem between national deposit insurers. Kahn and Santos (2005) offer a different perspective by studying the interaction of regulators with different objectives (supervisor, deposit insurer, lender of last resort) depending on whether they are coordinated or not.

The model studied in this paper is static whereas the theoretical literature on supervision has mostly considered dynamic environments, in order to focus on the timing of supervisory interventions. See for instance Merton (1978), King and O'Brien (1991), Decamps, Rochet, and Roger (2004). Forbearance in my model can still be interpreted as delayed action, but the supervisor cannot use intertemporal effects on a bank's profit to achieve better outcomes.

The simplicity of the modeling makes it possible for future research to apply insights from recent theoretical papers. A first literature that delivers interesting insights is concerned with delegation games (Holmstrom (1977), Alonso and Matouschek (2008)), that is agency problems where it is legally infeasible for the principal (here, the central supervisor) to use monetary transfers to control the agent's (here, the local supervisor's) incentives. An interesting specificity in the delegation problem studied in this paper is the complementarity between centralization and foreign investment which can lead to multiple equilibria.

Another relevant strand of the literature studies regulatory design with lobbying. Supervisors in my model are assumed to maximize a measure of welfare, domestic or global. An alternative explanation of supervisory failings is capture by private interests. Particularly relevant papers in this literature are for instance Hiriart, Martimort, and Pouyet (2010) who show, with another application in mind, that separating ex-ante monitors of risk from ex-post monitors is a powerful tool against regulatory capture. Costa Lima, Moreira, and Verdier (2012) show on the contrary some benefits of centralization. See Boyer and Ponce (2011) for an application to bank supervision and a review of the relevant literature. Martimort (1999) shows that as a regulatory agency gains information over time, it becomes less and less robust to lobbying and should be given less discretion, which is to be traded off against Section 3, which shows that centralization may have to increase over time.

2 Optimal delegation of supervisory powers

This section analyzes a model with two levels of supervision and optimal delegation of supervisory powers, based on a model of supervision adapted from Mailath and Mester (1994).

2.1 A simple model of supervisory intervention

Market failure and supervision: consider a single bank and three periods. The bank in $t = 0$ makes a risky investment. There are two outcomes: "good", obtained with probability p, and "bad". p is drawn from a distribution Φ over $[0, 1]$, known to all players.

In $t = 1$ the true p is drawn from the distribution Φ and learnt by the bank. Through an on-site inspection, a supervisor can also learn p. For a low p it may be socially optimal to take a decision that the bank is unwilling to take due to limited liability (for instance filing for bankruptcy and liquidating the assets). The supervisor has the possibility to intervene and force this decision. The supervisor here exerts a form of "prompt corrective action". He may have intervention powers himself, or his report may trigger the intervention of a different player (for instance a resolution authority).

All payoffs are realized in $t = 2$. Total welfare in the economy is equal to W_I for sure if the supervisor intervenes. If he does not, with probability p the good outcome is realized and brings W_1, with probability $1-p$ the bad outcome is realized and brings W_0. To make the problem non trivial assume $W_1 > W_I > W_0$. A benevolent supervisor would choose to intervene or not in order to maximize expected total welfare (section 4 discusses the case of risk-averse supervisors). Without intervention, the expected global welfare would be $pW_1 + (1-p)W_0$, compared to a sure welfare of W_I with intervention. Intervention would happen for p lower than the *first-best intervention threshold* defined by:

$$p^{**} = \frac{W_I - W_0}{W_1 - W_0} \tag{1}$$

Cross-country externalities and supervisory failures: in the presence of cross-country externalities, in some states $s \in \{0, 1, I\}$ there is a discrepancy between total welfare W_S and *local welfare* $\hat{W}_S$. Assume a non trivial case where $\hat{W}_1 > \hat{W}_I > \hat{W}_0$. A local supervisor intervenes whenever p is higher than an intervention threshold defined by:

$$p^{*} = \frac{\hat{W}_I - \hat{W}_0}{\hat{W}_1 - \hat{W}_0} \tag{2}$$

In general we will have $p^* \neq p^{**}$. Depending on the externalities of the decision taken on foreign agents, the local supervisor may either intervene too often in the bank or not enough. I assume $p^{**} > p^*$ so that the local supervisor exerts supervisory forbearance[3]. This is with no loss of generality as adapting this section to the symmetric case $p^{**} < p^*$ is straightforward[4]. The quantity $p^{**} - p^*$ measures the intensity of the *conflict of objectives* between the local supervisor and the general interest.

The results in this section do not depend on a particular microfoundation of p^* and p^{**}. Section 3 develops a particular example where p^* and p^{**} are endogenous: banks are indebted

[3]It should be emphasized that forbearance is always assumed to be suboptimal in this model, whereas Morrison and White (2010) show that forbearance can be an optimal answer to reputation concerns.

[4]Ongena, Popov, and Udell (2013) show that stricter regulation of multinational banks in Western Europe leads to lower their lending standards by their subsidiaries in Central and Eastern Europe. This would be a case where $\hat{W}_I > W_I$, leading to too much intervention by the home supervisor.

towards foreign investors whose payoffs are neglected by the local supervisor. A supervisory intervention consists in liquidating the loans made by a bank if their success probability is too low, a decision that the local supervisor will not take often enough as part of the liquidation proceeds go to the foreign investors. While it is helpful to have this example in mind, this section is kept general on purpose so that the properties of the optimal regulatory architecture do not depend on a particular theory of the political economy frictions that drive a wedge between the two levels of supervision.

2.2 A two-layered supervisory system

When local supervision is suboptimal, there is scope for introducing a central supervisor who would simply choose the first-best level of supervision p^{**}. A typical argument against centralized supervision however is the informational advantage of local supervisors (knowledge of local laws, products, language...). Centralizing thus involves a trade-off between better-aligned incentives and better information. Moreover, this trade-off may depend on the ex ante information the central supervisor has about a given bank.

There are two agency problems in this economy: one between the banks and the local supervisor, and one between the local supervisor and the central supervisor. It is unrealistic to use standard contracts based on side-payments to solve the second problem, as for legal as well as political reasons it is difficult to commit to imposing a penalty on a local supervisory agency that would have failed to adequately supervise its banks. The problem is thus one of "optimal delegation" (Holmstrom (1977)), which I model as follows.

Assumptions: the central supervisor can first invest in an off-site monitoring technology giving a noisy signal on p[5]. It could be based on simple balance sheet items and ratios, stress-tests, or quarterly call reports in the U.S. In order to get a signal with precision λ, the central supervisor needs to pay *monitoring costs* $C(\lambda)$, with $C(0) = C'(0) = 0$, $C' \geq 0, C'' \geq 0$ and $\lim_{x \to 1} C(x) = +\infty$.

Based on the signal received, the central supervisor decides whether the bank should be

[5] See Kick and Pfingsten (2011) for evidence that on-site supervision brings additional information compared to off-site monitoring.

inspected by the local supervisor at an inspection cost c_0, or by her own staff at a higher cost $c_0 + c$. c_0 is supposed to be high so that it is always suboptimal to duplicate inspections, and c measures the informational advantage of the local supervisor. The supervisor who inspects the bank learns the exact value of p and decides whether a supervisory intervention is necessary.

I consider a simple signal structure borrowed from Petriconi (2012). With some probability λ, the central supervisor receives a signal s signal is exactly equal to the true p. With probability $1-\lambda$, s is drawn from the prior distribution Φ. The signal thus sometimes gives perfect information about the soundness of the bank, and is sometimes uninformative. Denoting $\tilde{\Phi}_s$ the cumulative distribution function of p conditional on receiving signal s, and $\tilde{\phi}_s$ the corresponding density, we have:

$$\tilde{\Phi}_s(p) = \lambda \mathcal{H}(p-s) + (1-\lambda)\Phi(p) \quad (3)$$

$$\tilde{\phi}_s(p) = \lambda \delta(p-s) + (1-\lambda)\phi(p) \quad (4)$$

$$\mathbb{E}(p|\sigma = s) = (1-\lambda)\mathbb{E}(p) + \lambda s \quad (5)$$

where $\mathcal{H}(x)$ is the Heaviside step function equal to one if $x \geq 0$ and to zero otherwise, and δ its derivative, the Dirac function. With this signal structure the ex-post expectation of the supervisor is simply a mixture between the prior expectation and the signal received, where the weights depend on λ, the precision of the signal.

Empirical counterparts: these assumptions give three possible options for the organization of supervision: a *centralized architecture* if the central supervisor inspects the bank all the time (regardless of the signal received), a *delegated architecture* if inspections are always done by the local supervisor, and a *joint architecture* if both may inspect the bank, depending on the signal received about its soundness. The precision of the monitoring technology is also an endogenous part of the supervisory architecture. These different supervisory arrangements can be found in "federal" or two-layered supervisory systems, the two main examples being the United States, and more recently the European Union.

In the European Union, the supervision of banks under the SSM relies on a partition of the banking system into two groups. The "most significant credit institutions" are supervised directly by the ECB. Although the national supervisors play a role in the inspections, the ultimate decision lies with the ECB, which corresponds to a centralized architecture. While the on-site supervision of the other banks is left to the national competent authorities, the ECB may decide at any time to take responsibility, corresponding to the joint architecture. Presumably, some banks in this group are of such small significance that the ECB would never take this decision, in which case we have a delegated architecture.

In the United States, almost all State-chartered commercial banks are supervised both by a State supervisor and a Federal supervisor, either the Fed or the FDIC. The frequency of inspections by the Federal supervisor may depend on the significance of the bank and on its soundness, as estimated for instance via a call report (a signal, in this model). This arrangement corresponds to a joint architecture, admitting as a special case the centralized architecture when the Federal supervisor always inspects the bank with maximum frequency.

2.3 Centralization and delegation in the short-run

I first look at the choice whether to delegate more or less to the local supervisor, taking the central supervisor's signal s and its precision λ as given. If she does not inspect the bank, she anticipates that the local supervisor intervenes if and only if $p < p^*$. If she pays the cost $c_0 + c$, she will intervene below p^{**}. Comparing the total welfare in both cases gives us that the central supervisor pays the cost $c_0 + c$ upon receiving signal s if and only if:

$$\begin{aligned}\int_0^{p^{**}} W_I\tilde{\phi}_s(p)dp + \int_{p^{**}}^1 [pW_1 + (1-p)W_0]\tilde{\phi}_s(p)dp - c &\geq \int_0^{p^*} W_I\tilde{\phi}_s(p)dp + \int_{p^*}^1 [pW_1 + (1-p)W_0]\tilde{\phi}_s(p)dp \\ \Leftrightarrow (W_1 - W_0)\int_{p^*}^{p^{**}} (p^{**} - p)\tilde{\phi}_s(p)dp &\geq c \qquad (6)\end{aligned}$$

The integral on the left-hand side is equal to the probability that the true p belongs to $[p^*, p^{**}]$, times the expected distance between p^{**} and p, conditional on p being in this interval and on receiving signal s. Notice that when $p < p^*$ both the central and the local supervisor want to intervene, while when $p > p^{**}$ both want not to intervene. In contrast, $[p^*, p^{**}]$ measures the region of conflicting objectives, as the central supervisor would like to overrule the local supervisor's decision. The central supervisor wants to inspect the bank when s

is such that p is likely to be in $[p^*, p^{**}]$ and close to p^*, that is for intermediate values of s. The particular signal structure chosen makes it straightforward to reexpress equation (6) explicitly, using (3) and (4). It is first useful to define:

$$\bar{B}(p^*, p^{**}) = \int_{p^*}^{p^{**}} (p^{**} - p)\phi(p)dp \tag{7}$$

The expected benefit from inspecting upon receiving signal s with precision λ can then be written as:

$$B(\lambda, s) = \begin{cases} (W_1 - W_0)\left[(1-\lambda)\bar{B}(p^*, p^{**}) + \lambda(p^{**} - s)\right] & \text{if } s \in [p^*, p^{**}] \\ (W_1 - W_0)(1-\lambda)\bar{B}(p^*, p^{**}) & \text{if } s \notin [p^*, p^{**}] \end{cases} \tag{8}$$

Lemma 1. *1. A centralized architecture is optimal if and only if $B(\lambda, 0) > c$.*
2. A delegated architecture is optimal if and only if $B(\lambda, p^*) < c$.
3. When $c \in [B(\lambda, 0), B(\lambda, p^*)]$, a joint architecture is optimal and there exists $\bar{s}(\lambda) \in [p^*, p^{**}]$ such that the central supervisor inspects the bank when $s \in [p^*, \bar{s}(\lambda)]$.

Proof: $B(\lambda, s)$ takes the same value for all $s \notin [p^*, p^{**}]$, which is lower than the value it takes inside the interval, showing 1. For $s \in [p^*, p^{**}]$ $B(\lambda, s)$ is decreasing in s and thus takes its maximal value for $s = p^*$, showing 2. For intermediate values of c the supervisor inspects only for some $s \in [p^*, p^{**}]$. $B(\lambda, s)$ is decreasing in s, higher than the right-hand side in $s = p^*$ and lower in $s = p^{**}$ by definition of these intermediate values, showing 3. ■

$\bar{s}(\lambda)$ will be called the *inspection threshold*. A higher threshold implies a higher probability that the central supervisor inspects the bank. Whenever $c \in [B(\lambda, 0), B(\lambda, p^*)]$, we have:

$$\bar{s}(\lambda) = p^{**} - \frac{c}{\lambda(W_1 - W_0)} + \frac{1-\lambda}{\lambda}\bar{B}(p^*, p^{**}) \tag{9}$$

Lemma 1 is quite intuitive. When the supervisor receives a signal s outside $[p^*, p^{**}]$ there is probably no conflict of objectives. If she nonetheless inspects, she would do so *a fortiori* for a signal inside the interval. Conversely, among all the signals she can receive inside $[p^*, p^{**}]$, the most favorable to inspection is s close to but above p^*: for p close to p^* there is a conflict of objectives, and since p is relatively low not much upside is lost by liquidating. If upon receiving this signal the supervisor does not inspect, then she never does.

Lemma 1 defines three regions in the $(\lambda, c, p^*, p^{**})$ space, where either a centralized, a delegated or a joint architecture are optimal. Figure 1 gives a 3D plot of these regions for a given p^{**}[6]. The next proposition shows how one moves from one region to the next when changing the parameters of the model:

Proposition 1. *1. If the optimal architecture changes after an increase in p^{**} or a decrease in p^*, it is from a delegated to a joint or a centralized architecture, or from a joint to a centralized architecture.*

2. If the optimal architecture changes after an increase in c, it is from a centralized to a joint or a delegated architecture, or from a joint to a delegated architecture.

3. If a joint architecture is optimal before and after the change in a parameter, the inspection threshold increases in p^{**} and decreases in p^*. It also increases in λ if $c > (W_1 - W_0)\bar{B}(p^*, p^{**})$, and decreases otherwise.

[Insert Fig. 1 here.]

See the Appendix A.2 for the proof. The effects of p^*, p^{**} and c are intuitive: the central supervisor always inspects more when her information disadvantage c is lower or when the conflict of objectives with the local supervisor, as measured by the wedge between p^{**} and p^*, is higher.

The role of λ is more subtle. When the cost c is low, a supervisor with very imprecise information wants to inspect banks on-site as this is not very costly and delegating would be risky. When precision becomes higher, she will sometimes get signals outside $[p^*, p^{**}]$ giving a very high probability that the local supervisor will take the first-best decision, and it is then optimal to delegate. More information thus allows the central supervisor to take less risks when delegating to the local supervisor.

Conversely, if c is high, a supervisor with imprecise information fully delegates to the local supervisor because there is a risk that costly inspection is unnecessary, even if the signal points towards a conflict of objectives. With a higher precision, the central supervisor

[6]All the figures are in the Appendix A.1. The parameters used for the figure are $W_1 = 1.05, W_I = 0.8, W_0 = 0$, so that $p^{**} = 0.76$, and $\Phi(x) = x$.

is more confident that inspecting will be useful if the signal belongs to $[p^*, p^{**}]$, so that it is sometimes optimal to inspect. More information allows to take less risks when inspecting.

2.4 Investment in monitoring

We can now solve for the optimal level of investment by the central supervisor in the stress-testing technology. The supervisor's problem is to maximize in λ the expected benefits from supervision minus the investment costs. Denoting $\mathcal{B}(\lambda)$ this quantity, we have:

$$\begin{aligned}
\mathcal{B}(\lambda) &= \mathbb{E}(\max(B(\lambda, s) - c, 0)) - C(\lambda) \\
&= \begin{cases} (W_1 - W_0)\bar{B}(p^*, p^{**}) - c - C(\lambda) & \text{if } B(\lambda, 0) > c \\ -C(\lambda) & \text{if } B(\lambda, p^*) < c \\ \int_{p^*}^{\bar{s}(\lambda)} (B(\lambda, s) - c)\phi(s)ds - C(\lambda) & \text{otherwise} \end{cases}
\end{aligned}$$

Graphically, the goal is to maximize the function plotted on Figure 2[7] minus the cost $C(\lambda)$. If the solution chosen is not mixed then surely the supervisor chooses $\lambda = 0$, as acquiring a signal is costly and no signal can affect her choice. If $\lambda = 0$ then either c is high and the solution is to delegate, or it is low and the solution is to centralize. Finally, as getting an infinitely precise signal is by assumption too costly, $\lambda = 1$ cannot be optimal. Hence for a given c we have to compare the benefit obtained with $\lambda = 0$ and the benefit obtained with an interior solution satisfying the following first-order condition:

$$C'(\lambda) = (W_1 - W_0) \int_{p^*}^{\bar{s}(\lambda)} \left(p^{**} - s - \bar{B}(p^*, p^{**})\right) \phi(s)ds \qquad (10)$$

Proposition 2. *There exist $\underline{c}$ and $\overline{c}$ with $\overline{c} > (W_1 - W_0)\bar{B}(p^*, p^{**}) > \underline{c}$ such that:*

1. If $c < \underline{c}$ the centralized architecture is optimal, with $\lambda = 0$.

2. If $c > \overline{c}$ a delegated architecture is optimal, with $\lambda = 0$.

3. If $c \in [\underline{c}, \overline{c}]$ a joint architecture is optimal, with $\lambda > 0$. The optimal λ is increasing in c for $c \in [\underline{c}, (W_1 - W_0)\bar{B}(p^*, p^{**})]$ and decreasing in c for $c \in [(W_1 - W_0)\bar{B}(p^*, p^{**}), \overline{c}]$.

[Insert Fig. 2 and Fig. 3 here.]

[7] p^* is assumed to be equal to 0.5 on the figure.

See the Appendix A.3 for the complete proof. Figure 3[8] shows the optimal λ as a function of c, as well as the probability that the central supervisor inspects and the probability of a supervisory intervention. For low inspection costs the best option is to fully centralize and not invest in a more precise signal. As costs increase, inspection is more costly and investing in a more precise signal is a way to save on these costs, hence λ is increasing in c. As the threshold $(W_1 - W_0)\bar{B}(p^*, p^{**})$ is reached, inspecting is so costly that the default option without any signal would be to fully delegate. Investing in a better signal is a way to make sure that the central supervisor will still inspect when it's worth it. When $\bar{c}$ is reached the supervisor decides to fully delegate and thus does not invest in a better signal.

Considering equation (10), it is immediate that near an interior solution a cost function with a higher marginal cost gives a lower optimal λ and a lower expected benefit:

Corollary 1. *If the cost function C can be written as $C(\lambda) = \gamma\tilde{C}(\lambda)$ and a joint architecture is optimal, an increase in γ leads either to a joint architecture with a lower λ, or to a switch to either a delegated or a centralized architecture, depending on whether c is higher or lower than $(W_1 - W_0)\bar{B}(p^*, p^{**})$.*

Higher monitoring costs thus lead to an extreme solution, either centralization or delegation. Finally, we can look at the impact of p^* and p^{**} on the choice of supervisory architecture:

Corollary 2. *1. If the optimal architecture changes after an increase in p^{**} or in $W_1 - W_0$, it is from a delegated to a joint or a centralized architecture, or from a joint to a centralized architecture.*

2. If a joint architecture is optimal before and after the change in a parameter, an increase in p^{**} or in $W_1 - W_0$ lead to a higher investment in monitoring λ.

3. Points 1 and 2 also hold for a decrease in p^* if $\Phi(p^{**}) - \Phi(p^*) < \frac{1}{2}$.

See the Appendix A.4 for the proof. In general increasing the conflict of objectives implies a move towards regions with more centralization and more investment in early warning signals. The impact of p^* is not straightforward: decreasing p^* worsens the conflict of objectives and should encourage acquiring more information. At the same time, since the interval

[8] The cost function used to produce the graph is $C(\lambda) = 0.05\lambda^2$.

$[p^*, p^{**}]$ is higher even a less precise signal in this interval would be enough to inspect, which goes in the other direction. The sufficient condition given for the first effect to dominate is actually quite mild, as it means that the probability of p being in the conflict of objectives region is less than one half.

2.5 Discussion: towards a supervisory typology of banks

This section sheds light on possible options for organizing banking supervision at a federal or supranational level. The optimal regulatory arrangement depends on three different dimensions:

-the **conflict of objectives** is measured in the model by $\bar{B}(p^*, p^{**})$ and can be microfounded as in Section 3.1. As will be discussed in later sections, this dimension will typically depend on a bank's **cross-border activities** and on the **governance** of each supervisor.

-the **informational advantage of the local supervisor** is measured in the model by c and determines whether the default option for an uninformed central supervisor is delegation or centralization. This parameter should be related to a bank's **national/regional specificity**. The supervision of a bank investing mostly in local assets and getting funds from domestic agents requires specialized supervisory teams with a good knowledge of local conditions, financial products or structures[9], local language. It is more difficult for a central supervisor to inspect such a bank.

-**off-site monitoring costs** are measured in the model by the function $C(\lambda)$ and determine how costly it is for the central supervisor to acquire information without on-site inspection. It should be thought of as mostly related to a bank's **complexity** or **opaqueness**. A few indicators may be enough to assess the soundness of a commercial bank with a simple business model, while much more information is required to watch over a bank with a complex funding structure and investing in non standard products.

Proposition 2 shows that the key parameter for determining the optimal architecture

[9] In Europe, examples of such products largely specific to particular countries would be "Prêts cautionnés" (France), "Pfandbriefe" (Germany), shares in Finnish residential housing companies. The French model of "bank insurance", driven by tax conditions, is also unique and its future treatment by the federal supervisor is the topic of much calculation

is c divided by $(W_1 - W_0)\bar{B}(p^*, p^{**})$, that is a measure of the informational advantage of local supervisors, relative to a measure of the conflict of objectives times the value of not liquidating the loans. With a high ratio the optimal architecture tends to delegation, but if off-site monitoring costs are low enough the central supervisor inspects the bank after low signals. With a low ratio the optimal architecture tends to centralization, but the central supervisor delegates inspections to the local level after high signals. The following table gives the optimal architecture in four cases:

$c/[(W_1 - W_0)\bar{B}]$ Monitoring costs	Low	High
High	Centralized	Delegated
Low	Joint, Delegate after high signal	Joint, Centralize after low signal

While it is beyond the scope of this paper to flesh out this typology with an empirical analysis, it is worth noting that two of the three relevant dimensions at least can be measured. In its guidelines to identify G-SIBs[10], the Basel Committee on Banking Supervision gives indicators for complexity, as well as for interconnectedness and cross-jurisdictional activities which can proxy for the conflict of objectives. The latter can also be measured by looking at past supervisory interventions, estimating how "delayed" they were and what are the determinants of the delay. Beck, Todorov, and Wagner (2012) provide such estimates for the European case. The only thing still needed to operationalize the above typology is a measure of national specificities for a given bank, based for instance on the composition of its assets, the complexity of the national legal framework and other parameters.

The United States provide a natural application of the model, as commercial state banks are jointly supervised by State and Federal supervisors, with different levels of delegation. The primary supervisor of a U.S. bank is determined by its type of charter and its access to Federal deposit insurance, which is consistent with the impact of a higher conflict of objectives: the FDIC is in a better position to internalize the impact of a bank's losses on

[10]BCBS, "Global systemically important banks: assessment methodology and the additional loss absorbency requirement", November 2011.

the federal deposit insurance fund than a State supervisor (see also Section 4.3). Agarwal *et al.* (2012) provide evidence on supervisory forbearance at the State level, which they relate to proxies for regulatory capture and to staff characteristics. These variables can be seen as measures of the conflict of objectives, and give guidance on where a more centralized architecture would be more profitable.

Still for the U.S. case, Rezende (2011) shows that joint examinations by State and Federal supervisors are more frequent for large and complex institutions, which corresponds well to the predictions of the model. The author gives an alternative explanation, which is that Federal supervisors support State supervisors with not enough staff to properly supervise a particular bank. This is also consistent with the model if one reinterprets the difference $p^{**} - p^{*}$ as coming not from externalities but from different abilities to spot problem banks. The trade-off is then between a more costly but more robust inspection technology (Federal supervisor) and a cheaper but less robust one (State supervisor).

In the European Union, the Spanish *cajas* for instance can be thought of as having a high specificity, low complexity and maybe moderate cross-border externalities as a cluster (see Section 4). This would suggest a joint architecture, involving mainly offsite monitoring by the ECB. The large Cypriot banks that recently triggered an intervention by the IMF, the EU and the ECB are another interesting example. These banks had high externalities (interestingly, mostly on non EU agents), a low degree of specificity as they invested a lot abroad, and a high opaqueness. This is a typical case where a centralized architecture is optimal, as it is difficult to get good warning signals from afar. European SIFIs have both a low specificity and high cross-border externalities, but may have different levels of opaqueness. The ECB should directly supervise at least the most opaque ones, but maybe partly delegate the supervision of the others to national supervisors, depending on how easy it is to have reliable warning signals for these banks.

A last conclusion that applies to both regions is that the central supervisor should not focus his attention on the banks on which she receives the worst signals, as in these cases the local supervisor takes the correct decision because potential losses in case of no intervention far outweigh the benefits. This can also be seen as a dynamic problem: the supervisor who inspects the bank learns innovations in p over time and can choose when to intervene. When bad news arrive the local supervisor waits for too long before intervening, in the hope that the situation will get better, while the central supervisor acts more promptly. Indeed, the perception that regulators delayed taking action during the savings and loans crisis in the United States was one of the rationales for the doctrine of prompt corrective action put forward by the FDIC Improvement Act of 1991 (Komai and Richardson (2011)).

3 Market response to supervision

Changes in the supervisory architecture are important enough to have a substantial impact on the banking sector. To study this interaction, this section embeds the model of supervision just developed in an equilibrium model of financial intermediation. This is done by fleshing out a particular example corresponding to the general framework of Section 2.

3.1 A simple example of supervisory forbearance

Building blocks: consider an economy with three types of agents - borrowers, banks, foreign investors - and three assets - a storage asset, loans and claims on the banks.

-Penniless *borrowers* have risky projects which can either success or fail. The gross return on the nth project is $1+\rho(n)$ if it is successful, where $\rho(.)$ is a strictly decreasing function. The borrowers can borrow only from a bank, promise to repay $1+r$ on each unit of loan. The projects fail with probability p, where $p \hookrightarrow \Phi(.)$ over $[0,1]$, and the projects are perfectly correlated. In case of failure the borrowers do not repay anything. Borrowers are price-takers and the derived demand for loans is $q(r)=\rho^{-1}(r)$, with $q'(r) \leq 0$, $q(0)=+\infty$ and $\lim_{r \to +\infty} q(r)=0$. Under this specification, when loans are successful they generate a surplus that can be measured by $V(r)=\int_0^{q(r)}(1+\rho(t))dt$, of which $V(r)-(1+r)L$ goes to the borrowers.

-*Banks* have D deposits and choose the quantity L of loans they want to extend to borrowers, taking the net interest rate r on those loans as given. They can finance the loans in excess of D by borrowing from foreign investors at rate r_F.

-*Foreign investors* stand ready to lend to banks as long as their expected return on a marginal loan is higher than the return on the storage asset, normalized to 1.

All agents are risk-neutral and price-takers. Banks have access to deposits which they cannot increase in the short run. Depositors are insured and have no incentive to withdraw early. For simplicity banks have no capital. As Beck, Todorov, and Wagner (2012) show that what matters is only the imbalance between the shares of foreign assets, foreign equity and foreign liabilities, I focus on a simple case where only liabilities can be held by foreign agents. The only thing that matters for the model is that there is some imbalance that tilts incentives towards under-supervision (see section 4.1).

Supervision: we can now embed the model of supervisory architecture developed in Section 2 into this market structure and endogenize the values of $\hat{W}_S$ and W_S for $S \in \{0, I, 1\}$. Define V_S, π_S, π_S^F and π_S^D as the welfare of borrowers, the profit of banks, the profit of foreign investors, the payoff to depositors minus the costs to the deposit insurance fund. The central supervisor takes into account these four categories of agents, whereas the local supervisor neglects the foreign investors. We thus have $\hat{W}_S = V_S + \pi_S + \pi_S^D$ and $W_S = \hat{W}_S + \pi_S^F$.

I first introduce a new period $t = 0$ in which the central supervisor chooses λ while borrowers, banks and foreign investors choose how much to lend or borrow, determining r and r_F by competitive equilibrium conditions. The model is solved backwards: taking r, r_F and L as given, I first study each supervisor's choice in $t = 1$ after a given realization of p. Assume for now that $L \geq D$ and $r \geq r_F$ so that banks borrow from foreign investors.

In $t = 1$ only there is a possibility to liquidate the projects and recover a value of $1-\ell$ per unit invested[11]. The liquidation value is by construction not enough for banks to repay their debt, so that due to limited liability they would always choose to exert "evergreening"[12] and keep their loans, making supervision necessary. In this period the central supervisor decides who inspects the bank. If the inspection leads to state I (intervention), the proceeds of the liquidated projects $(1-\ell)L$ are shared between the depositors (or the deposit insurance fund) and the foreign investors. Denoting α the share accruing to depositors, we have $V_I = 0, \pi_I =$

[11] Alternatively, these loans could need a refinancing of ℓ.

[12] See Peek and Rosengren (2005), as well as Albertazzi and Marchetti (2010) for recent European evidence.

$0, \pi_I^D = \alpha L(1-\ell), \pi_I^D = (1-\alpha)L(1-\ell)$ and $\hat{W}_I = \alpha L(1-\ell)$, with:

$$\alpha = \frac{D}{D + (L-D)(1+r_F)} \tag{11}$$

If there was no intervention in $t = 1$, the returns on the projects are realized in $t = 2$: With probability p the projects are successful, debts are reimbursed and deposits are given back to depositors, so that we have $V_1 = V(r) - (1+r)L, \pi_1 = (1+r)L - (L-D)(1+r_F) - D$, $\pi_1^D = D$, $\pi_1^F = (L-D)(1+r_F)$ and thus $\hat{W}_1 = V(r) - (L-D)(1+r_F), W_1 = V(r)$.

With probability $1-p$ the projects fail, the deposit insurer gives D to depositors and foreign investors get nothing, hence $V_0 = 0, \pi_0 = 0, \pi_0^D = 0, \pi_0^F = 0$ and $\hat{W}_0 = W_0 = 0$.

Applying Section 2.1, the intervention thresholds for both supervisors are given by:

$$p^* = \frac{\alpha(1-\ell)L}{V(r) - (L-D)(1+r_F)},\ p^{**} = \frac{(1-\ell)L}{V(r)} \tag{12}$$

Using (11) and rearranging, $p^{**} \geq p^*$ is equivalent to $V(r) \geq (1+r_F)L - r_F D$, which is true as by definition the surplus $V(r)$ is higher than $(1+r)L$ and $r \geq r_F$. The local supervisor thus exerts forbearance. When $D = L$ both $\hat{W}_1 = W_1$ and $\hat{W}_I = W_I$, so that forbearance goes to zero.

The difference between the local supervisor's behavior and the first-best comes from two opposite effects. First, in case of intervention a fraction $1-\alpha$ of the liquidated projects goes to foreign investors instead of local agents, giving less incentives to intervene than in the first-best. Second, when loans are repaid a part of the surplus also goes to foreign investors, giving less incentives to let the banks operate. The combination of these two effects is always towards forbearance. When D is close to L, the banks almost do not need to borrow, hence local welfare is almost equal to global welfare in all states and the local supervisor's incentives are aligned with the first-best.

3.2 Multiplicity of equilibria

We now have a model of how the supervisor behaves for given interest rates and loan volumes. But if the central supervisor reacts to the current market situation, for instance by choosing more centralization, this will in turn affect the foreign investors' incentives to lend to the banks, and thus interest rates. This will lead to a further change in supervisory architecture, and so on. The outcome of such a process is an equilibrium where both supervision and market outcomes are endogenized: the central supervisor's decision is optimal for the anticipated interest rates and loan volumes, private agents' decisions are optimal given the anticipated supervisory architecture, and anticipations are correct. Moreover, while private agents are assumed to correctly anticipate the value p^* chosen by the local supervisor, p^{**} and λ chosen by the central supervisor, as they are infinitesimally small they neglect the effect of their own behavior on these variables. Figure 4 gives the timeline:

[Insert Fig. 4 here.]

Denote $\mathcal{L}$ the set in (s,p) that leads to an intervention either by the local or the central supervisor. The banks make an expected profit of:

$$\pi = \Pr((s,p) \in \mathcal{L})\mathbb{E}(\tilde{p}|(s,p) \notin \mathcal{L})[L(r - r_F) + r_F D_S] \tag{13}$$

Thus it must be the case in equilibrium that $r = r_F$, otherwise the banks would choose to borrow and lend more. A foreign investor lending a marginal amount dx to a bank expects to get $(1 + r_F)dx$ if there is no intervention and the loan is repaid, 0 if the local projects fail. In case of liquidation, the liquidated assets are worth $(1 - \ell)L$ and the total liabilities of the bank are are $D_S + (L - D_S)(1 + r_F)$. A foreign investor thus expects to recover $[(1 + r_F)dx/(D_S + (L - D_S)(1 + r_F))] \times (1 - \ell)L$ at the margin in case of liquidation. In equilibrium, foreign investors lend up to the point where their expected marginal return on loans is equal to the safe interest rate, which is one in this model:

$$\Pr((s,p) \in \mathcal{L})\frac{(1 + r_F)(1 - \ell)L}{D_S + (L - D_S)(1 + r_F)} + \Pr((s,p) \notin \mathcal{L})\mathbb{E}(\tilde{p}|(s,p) \notin \mathcal{L})(1 + r_F) = 1 \tag{14}$$

The probability of liquidation depends on the supervisory architecture. With a centralized architecture we have $\mathcal{L} = \mathcal{L}_C = \{(s,p), p \leq p^{**}\}$, while with a delegated architecture $\mathcal{L} = \mathcal{L}_D = \{(s,p), p \leq p^*\}$. In both cases it is straightforward to derive $\Pr((s,p) \in \mathcal{L})$ and $\mathbb{E}(\tilde{p}|(s,p) \notin \mathcal{L})$. Finally, under a joint architecture liquidation is obtained if either supervisor intervenes, which gives $\mathcal{L} = \mathcal{L}_J = \{(s,p), p \leq p^*\} \bigcup \{(s,p), s \leq \bar{s}(\lambda), p \leq p^{**}\}$. In this case we have:

$$\begin{aligned}
\Pr((s,p)\in\mathcal{L}) &= \lambda\Phi(\bar{s}(\lambda))+(1-\lambda)[\Phi(p^*)+(\Phi(p^{**})-\Phi(p^*))(\Phi(\bar{s}(\lambda))-\Phi(p^*))] \quad (15)\\
\Pr((s,p)\notin\mathcal{L})\mathbb{E}(\tilde{p}|(s,p)\notin\mathcal{L}) &= \lambda\int_{\bar{s}(\lambda)}^{1} s\phi(s)ds+(1-\lambda)\int_{p^*}^{1}p\phi(p)dp \quad (16)\\
&- (1-\lambda)(\Phi(\bar{s}(\lambda))-\Phi(p^*))\int_{p^*}^{p^{**}}p\phi(p)dp
\end{aligned}$$

Although the exact expressions are lengthy, the intuition is simple: conditional on some success probabilities $p\in[p^*,p^{**}]$, the probability of liquidation increases with more supervision (centralization or higher $\bar{s}(\lambda)$). We can now formally define an equilibrium where both market participants and supervisors react optimally to each others' actions:

Definition 1. *In a market equilibrium the interest rate r^* satisfies:*

$$\Pr((s,p)\in\mathcal{L})\frac{(1+r^*)(1-\ell)q(r^*)}{D+(q(r^*)-D)(1+r^*)}+\Pr((s,p)\notin\mathcal{L})\mathbb{E}(\tilde{p}|(s,p)\notin\mathcal{L})(1+r^*)=1 \quad (17)$$

Moreover p^* and p^{**} satisfy (12); equations (15) and (16) are satisfied; λ and the central supervisor's behavior obey Proposition 2 and Lemma 1.

This definition directly follows from the previous developments, equating r^* with r_F and imposing the equilibrium condition $L=q(r^*)$. It gives a long-run equilibrium where demand equals supply both for loans to borrowers and to banks, the local supervisor optimally reacts to the balance sheet of banks, the central supervisor optimally invests in monitoring and inspects based on the local supervisor's behavior, and the supervisory architecture is taken into account by foreign investors when they ask for a certain interest rate. The following proposition studies the direction of these best response functions:

Proposition 3. *1. r is lower (more foreign lending) under the optimal architecture chosen by the central supervisor than if there is only a local supervisor.*
2. If the elasticity of demand for loans is high enough and $\Phi(1-\ell)<\frac{1}{2}$, an exogenous decrease in r (more foreign lending) leads to a higher conflict of objectives, more off-site monitoring by the central supervisor or a switch to centralization.

The proof is in the Appendix A.5. The assumption on ℓ simply ensures that the condition given in point 3 of Corollary 2 is necessarily met. A decrease in r pushes p^* upwards because the loans are less costly to liquidate; the assumption on demand elasticity ensures that this effect is more than compensated by the increase in foreign lending. These assumptions give sufficient conditions only and are by no means necessary.

Foreign lending and centralized supervision reinforce each other: more centralized supervision increases foreign lending, more foreign lending increases the conflict of objectives, and a higher conflict of objectives increases the incentives for central supervision. If increased central supervision more than compensates the higher degree of forbearance of the local supervisor (which is not necessarily the case), foreign lending increases again. This complementarity between foreign lending and centralized supervision can lead to a multiplicity of equilibria. The next proposition gives sufficient conditions for the extreme cases of centralization and delegation to be both possible equilibrium outcomes:

Proposition 4. *If the elasticity of demand for loans is high enough and $\Phi(1-\ell) < \frac{1}{2}$, then for high enough monitoring costs $C(\lambda)$ there exist c_1, c_2 with $c_1 < c_2$ so that for $c \in [c_1, c_2]$ both an equilibrium with centralization and an equilibrium with delegation exist.*

At least for c close enough to c_1, the equilibrium with centralization is associated to a higher global welfare than the equilibrium with delegation.

See the Appendix A.6 for the proof. The additional assumption that $C(.)$ is high simplifies the problem by excluding the possibility of a mixed solution in equilibrium, but is not necessary.

According to the proposition, two very different equilibria may obtain. With a centralized architecture, foreign investors are ready to lend a high quantity at a low interest rate because the central supervisor takes into account their potential losses. Banks then have high cross-border externalities, making a centralized architecture necessary. With the same parameters but a delegated architecture, foreign investors lend less because they expect the local supervisor to be too lenient. Cross-border externalities are then low and supervision is optimally delegated to the local level.

Fig. 5 gives an example where multiplicity is obtained[13]. On the left panel we have for different values of r the marginal gross return of one unit lent to a bank according to (17),

[13] The parameters used are $\ell = 0.6$, $D = 1$, $q(r) = r^{-1.5}$, and p follows a Beta distribution with parameters $(9, 1)$, so that $\mathbb{E}(p) = 0.9$.

both if liquidation is triggered by the local ($p \leq p^*$) and by the central supervisor ($p \leq p^{**}$). The points at which these returns are equal to 1 give us r_c and r_d, the equilibrium interest rate under a delegated and a centralized architecture. The right panel displays the surplus from centralizing the supervision, equal to $(W_1 - W_0)\bar{B}(p^*, p^{**})$, as a function of r. For multiplicity to obtain we need a cost c such that the level of r making the central supervisor between delegating and centralizing falls between r_d and r_d. This is obtained in the figure for example with $c = 0.83$, such that centralization is obtained whenever $r \leq 0.1$, and delegation is obtained otherwise. As $r_c = 0.08$ and $r_d = 0.12$, both equilibria can be obtained.

The figure underlines well the condition for multiplicity: the marginal return on a loan to a bank must be higher under the centralized architecture than under the delegated architecture so that $r_c \leq r_d$ (Point 1 of Proposition 3), and the surplus from centralizing must be decreasing in r (Point 2 of the proposition).

[Insert Fig. 5 here.]

3.3 Discussion: supervisory architecture and market integration

Policy implications: the assumption that local deposits are fixed and that banks can only get extra funding from foreign investors models a situation where the optimal allocation of capital makes cross-border capital flows necessary. The supervised banks can be seen as operating in a country with a savings deficit, while foreign investors live in a surplus country. This fits the European situation particularly well, also because European banks play a major role in the cross-border allocation of capital.

Adequate banking supervision then has an impact on cross-border capital flows, that is on market integration. To see this, consider the extreme case where there is no bank supervisor and loans are never liquidated. Applying (17), the equilibrium interest rate satisfies:

$$(1 + r) \int_0^1 p\phi(p)dp = 1 \tag{18}$$

In comparison, a welfare-maximizing interest rate would satisfy:

$$\Phi(p^{**})(1 - \ell) + \int_{p^{**}}^1 (1 + r)p\phi(p)dp = 1, \; p^{**} = \frac{(1 - \ell)q(r)}{V(r)} \tag{19}$$

Notice that for $p \leq p^{**}$ we have by definition $1 - \ell \geq p(1 + r)$. This shows that for a given r the left-hand side of (19) is larger than $(1 + r) \int_0^1 p\phi(p)dp$. The optimal r is thus lower than the one prevailing in the absence of supervision.

In other words, a low level of supervision acts as a friction preventing capital to flow through banks from surplus to deposit countries. The first part of Proposition 3 shows that the European SSM may indeed contribute to restoring market integration in the Euro area, which is one of the objectives stated by the European Commission[14]. This reassuring result comes with two caveats however:

-another face of the same coin is that market integration increases cross-border externalities, and thus the conflict of objectives between local and central supervisors (if demand elasticity is high enough). A conclusion for the design of the European SSM is that flexibility in the degree of centralization is valuable, because changes in supervisory architecture affect supervised agents, which changes the trade-off for the central supervisor.

-the timing assumption matters in Proposition 4. If the central supervisor could credibly commit to a specific architecture, she could always choose the best equilibrium in case of multiplicity. This may for instance involve setting up a more centralized architecture even though *current* market conditions would not justify it. In other words, the optimal architecture should be forward-looking and take into account how it can affect market integration in the long-run.

-a risk is that the forward-looking players may be the banks themselves. A bank with market power anticipating the central supervisor's choice may strategically decide to keep the amount it borrows from foreign creditors just below the threshold above which the bank would be allocated to the central supervisor, or may even strategically invest in specific assets so as to increase the cost c. This phenomenon would be the European equivalent of U.S. banks strategically choosing their supervisor, as studied in Rezende (2012).

Empirical implications: the main implication of this section is that banks switching to a more centralized supervisory architecture should get funding at lower rates and attract more

[14] Morrison and White (2009) also show that harmonized supervision increases market integration, through a different mechanism: absent a "level playing field", good banks choose to be chartered in countries with a strong supervisory reputation, while banks of lower quality choose lenient countries, giving rise to distortions in the banking market.

funding from foreign agents. This prediction could be tested in several ways:

As the SSM separates banks into two groups, the model predicts that banks directly supervised by the ECB should be able to borrow at lower rates, typically on interbank markets, compared to similar banks under national supervision. CDS spreads should also fall. Cross-border activities and market integration more generally should increase. Although banks are of course not allocated randomly into the two groups, the selection criteria disclosed by the ECB are easily observable[15], allowing for a matching approach.

Such drastic and partly exogenous changes in the supervision of a bank may be more difficult to find in the United States, especially because banks that switch their primary supervisor choose to do so, thus introducing a selection bias. The rotating supervision by State and Federal supervisors used in Agarwal *et al.* (2012) could also be used to solve this problem: the model implies that during the Federal supervisor's shift a bank should find it easier to borrow at short maturities on the interbank market, especially from banks in a different State.

In both cases the difficulty is of course to get access to detailed data on bank funding. An alternative for listed banks is to look at their stock price. In the absence of the effect on bank funding one would expect more supervision to decrease the value of the bank to shareholders, as less losses will be borne by the deposit insurance fund and the bank's loans will be liquidated more often. This negative impact may be more than compensated for banks that find it difficult to borrow from interbank markets. The stock price of banks falling under the central supervisor's umbrella could thus be expected to increase if the bank is in a country with a savings deficit, or relies more heavily on the central bank for funding.

4 Extensions

4.1 Other cross-border externalities

While section 2 can embed any type of cross-border externalities driving a wedge between local and global interests, section 3 focuses the analysis on liabilities held by foreigners, so as to derive a tractable model of a market equilibrium with different supervisory architectures.

[15]See `http://www.ecb.europa.eu/ssm/html/index.en.html`.

Foreign assets and equity holders: Beck, Todorov, and Wagner (2012) study other sources of externalities such as banks with foreign assets and foreign equity holders. While building a model endogenizing all these sources of cross-border externalities on top of the optimal regulatory architecture is challenging, the complementarity which drives the results of section 3 can still obtain.

Consider a bank that has only domestic creditors and domestic equity holders but has the opportunity to invest in projects abroad. Part of the surplus from the loans to foreign borrowers goes to foreign agents and is not taken into account by the local supervisor. He may then be too strict with the bank, as he neglects the fact that a supervisory intervention may destroy valuable loans abroad. A more centralized supervisory architecture alleviates this problem, which allows the bank to lend more abroad. As a result, cross-border externalities increase, the incentives of the local supervisor become more biased towards too much intervention, which makes centralized supervision more desirable.

Consider now the case of a bank with domestic creditors and domestic assets but foreign equity holders. Again the local supervisor will tend to intervene too often as part of the bank's profits accrue to foreign equity holders. This discourages foreign investors to invest in the bank. A more centralized architecture softens this problem, allowing for banks with a higher proportion of foreign equity holders to be profitable. Cross-border externalities increase again, making a more centralized architecture optimal.

The complementarity between market integration and centralized supervision thus seems more general than the example derived in section 3. The property driving this complementarity is that a cross-border externality leads to biased incentives for the local supervisor, in a way that discourages the market from generating these cross-border externalities. Whenever this is the case, the externalities and centralized supervision are complementary, leading to the possibility of multiple equilibria.

The case of a bank holding foreign claims has an interesting implication. If we think of foreign investors in the model as foreign banks belonging to the same banking union or federal system, then common supervision promotes market integration on both sides of the interbank market: lending to banks with a deposits deficit is safer as they are better supervised, while such lending is less discouraged by the supervisor of a bank with a deposits surplus. While this benefit is particularly strong when there are important imbalances between different countries or regions, imbalances can also be a source of political frictions as different countries then have different interests in common supervision.

Core-periphery banking sector: while a bank with many cross-border activities can logically be expected to be a significant source of externalities, this is not a necessary condition. The model can be extended to feature a core-periphery banking system[16]: small domestic banks are only indebted towards domestic depositors and domestic "core" banks, which borrow from international markets. If the small banks are "systemic as a herd" (Brunnermeier *et al.* (2009)), they can default simultaneously, thus endangering the core banks, whose losses can affect foreign investors. The empirical identification of cross-border externalities should thus ideally be based on a network analysis allowing to take into account second-round effects of a bank's default.

4.2 Other supervisory incentives

Many other microfoundations can be given to the supervisors' intervention thresholds p^* and p^{**}. An interesting extension is to look at a risk averse supervisor, which may be a more reasonable assumption if the "failure" state corresponds to a systemic event. Assume that in the good state the welfare taken into account by the supervisor is ω. With intervention this quantity reduces to $\omega - e_I$, without intervention if there is failure then it reduces to $\omega - e_0$, with $e_0 > e_I$. The supervisor is risk averse and has a utility function $u(.)$, with $u' \geq 0, u'' \leq 0$.

The intervention threshold p^* is computed as before and is such that $p^* u(\omega) + (1 - p^{**})u(\omega - e_0) = u(\omega - e_I)$: welfare in case of intervention is the *certainty equivalent* of the lottery that brings success with probability p^* and failure otherwise. Using second-order linear approximations of the different utilities, when e_0 and e_I are small compared to ω we have:

$$p^* \simeq \frac{e_0 - e_I}{e_0} \times \frac{1 + \frac{e_0 + e_I}{2} r_A(\omega)}{1 + \frac{e_0}{2} r_A(\omega)}$$

where $r_A(\omega) = -u''(\omega)/u'(\omega)$ is the Arrow-Pratt measure of risk aversion. The first term

[16] This extension is developed in a supplementary on-line Appendix, available at `http://sites.google.com/site/jecolliardengl/Supervision-Appendix.pdf`.

corresponds to the p^* that would be obtained under risk-neutrality, or for e_I and e_0 so small that second-order terms can be neglected. If e_0 and e_I are larger, this term is multiplied by a quantity greater than 1 and increasing in the risk-aversion coefficient r_A.

Compare again the decision of a local supervisor with the decision of a central supervisor, assuming they have the same utility function (corresponding to some social preferences over risk) $u(.)$. On the one hand, the central supervisor by definition takes into account more losses and negative spill-overs than the local supervisor (higher e_0), implying a higher intervention threshold. On the other hand, these losses are smaller in relative terms for her: since she takes into account the welfare of more agents, she also has a higher ω.

Remark 1. *If supervisors have a utility function with decreasing absolute risk aversion, all else equal the conflict of objectives will be reduced if the local supervisor has a smaller scope.*

Indeed, under decreasing absolute risk aversion r_A is decreasing in ω and p^* is increasing in r_A. If *for given losses* e_0, e_I a local supervisor is responsible for less banks or for a more restricted geographical region then these losses seem relatively larger, which increases his risk aversion and incentives to be cautious. Systemic banks could thus be less inadequately supervised if they are important enough at the local level. France for instance has 3 of the 28 G-SIFIs identified by the FSB. The failure of any of these could have devastating effects abroad, but much more so locally in relative terms, reducing the local supervisor's incentives to be too lenient.

More generally, understanding the incentives of local compared to central supervisors is difficult when both are assumed to be benevolent, and becomes a real challenge if the political economy of bank supervision is taken into account, for instance along the lines of Kahn and Santos (2005). This suggests that when deciding on the optimal supervisory architecture for a given bank, the conflict of objectives dimension is quite difficult to estimate. An implication for policymakers is to make more use of the two other dimensions discussed in 2.5, as their impact is valid for any p^* and p^{**}.

4.3 The next steps of the European banking union

Although fully studying the additional components foreseen in the building of a European Banking union is beyond the scope of this paper, it can be used to think about the impact of the next steps of this process on supervisory incentives.

Resolution: the recent examples of the banking crises in Iceland and Cyprus have shown that, in the absence of a clear legal framework for resolution, foreign depositors and creditors may have to bear a higher proportion of losses than local agents. Somewhat surprisingly, this may have a positive impact: if in case of intervention a larger proportion of the proceeds of liquidation accrue to local investors, this gives the supervisor more incentives to intervene. Anticipating this however, foreign investors should lend less. One of the effects of the introduction of a common resolution mechanism in Europe would be to make the allocation of losses to creditors unbiased and more predictable, which should again favour market integration. The value of α in (12) becomes smaller as less losses can be shifted to foreign creditors, which decreases p^*, and an increase in the share of foreign creditors further increases the conflict of objectives (Proposition 3). The introduction of a Single Resolution Mechanism in Europe will thus endogenously reinforce the need for an integration supervisory architecture.

Deposit insurance: a common deposit insurance scheme at the European level is necessary to make sure that deposit insurance is credible even in cases where a national deposit insurance fund would be overwhelmed. A corollary is that common deposit insurance is useful precisely because part of the losses in this case will be borne by non nationals. But this can in turn weaken the incentives of the local supervisor.

Imagine an extreme case where the local supervisor does not take into account losses to the deposit insurance fund. In the framework of Section 3.1, this implies that $\hat{W}_I = \hat{W}_0 = 0$. As a result, the local supervisor chooses $p^* = 0$: intervening is only beneficial for the deposit insurer which is separate from the supervisor, hence it is optimal never to intervene.

This risk of worsening the incentives of local supervisors is an argument for putting a robust "central" supervisory system before common deposit insurance is introduced. The same reasoning applies in the United States, where access to Federal deposit insurance is conditional on being supervised at the Federal level as well.

5 Conclusion

This paper develops a framework to analyze optimal supervisory architectures in a federal/international context where local supervisors have incentives to be forbearant, but also have more information about domestic banks than does a central supervisor. Whether the optimal architecture is centralized, delegated, or uses both local and central supervisors is shown to depend on three dimensions. Supervision should be more centralized when the conflict of objectives between the two supervisors is more severe, for banks with less specific assets, and banks with an opaque structure difficult to monitor from afar.

The conflict of objectives is the dimension that has attracted the most attention, but is also the most difficult to evaluate: it does not depend only on the different banks' sizes *per se* or on whether their creditors are foreign or domestic, but on who ultimately bears losses in case of default, as well as on a correct evaluation of the local supervisor's incentives. The other important dimensions in the trade-off between centralized and delegated supervision may be easier to estimate empirically, and could thus give more guidance on who should be the supervisor of a particular bank.

The optimal architecture may endogenously change due to the reaction of the banking sector to a new supervisory framework. A more centralized supervision can be expected to reduce market segmentation, which increases cross-border externalities and makes centralized supervision even more necessary. A good supervisory architecture should have some flexibility in order to accommodate changes in market conditions triggered by supervisory changes. Moreover, due to the complementarity between centralized supervision and market integration, it is possible to be stuck in an equilibrium where market integration and centralization are both low, when another equilibrium where both are high would be possible and preferable. The choice of a supervisory architecture should thus be forward-looking and anticipate how the market will react to the new supervision framework.

A Appendix

A.1 Figures

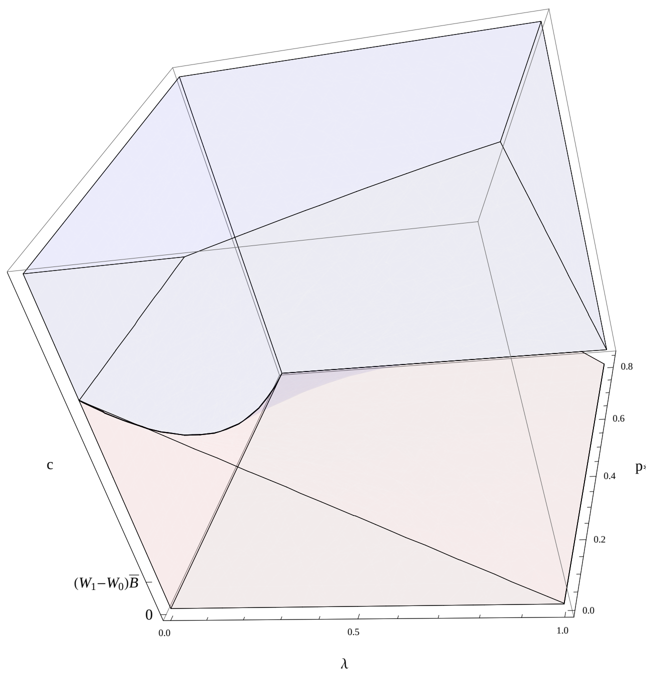

Figure 1: Regions with centralization (red), delegation (blue) and mixed solution (transparent) depending on p^*, λ and c.

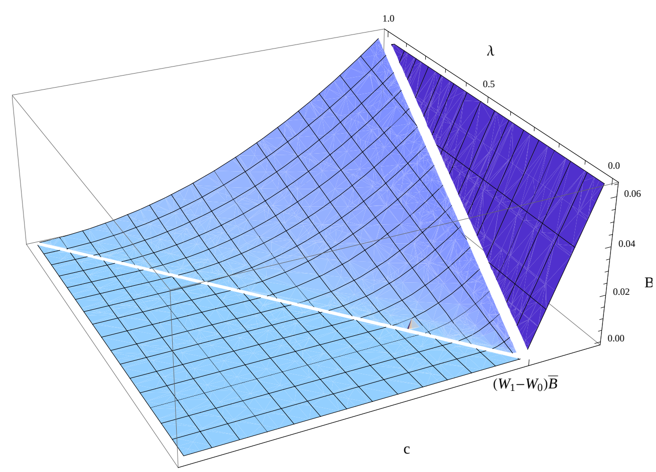

Figure 2: Expected benefit $\mathcal{B}(\lambda)$ as a function of λ and c, $C(\lambda) = 0$.

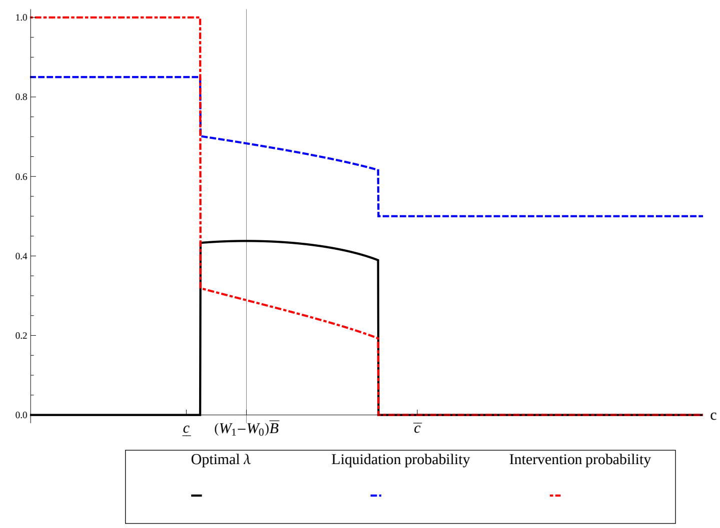

Figure 3: Optimal λ as a function of c, and implied probabilities of inspection and liquidation.

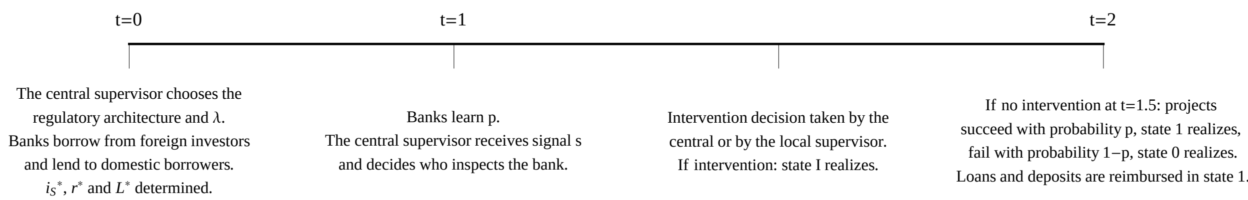

Figure 4: Timeline of the game with endogenous supervision and market equilibrium.

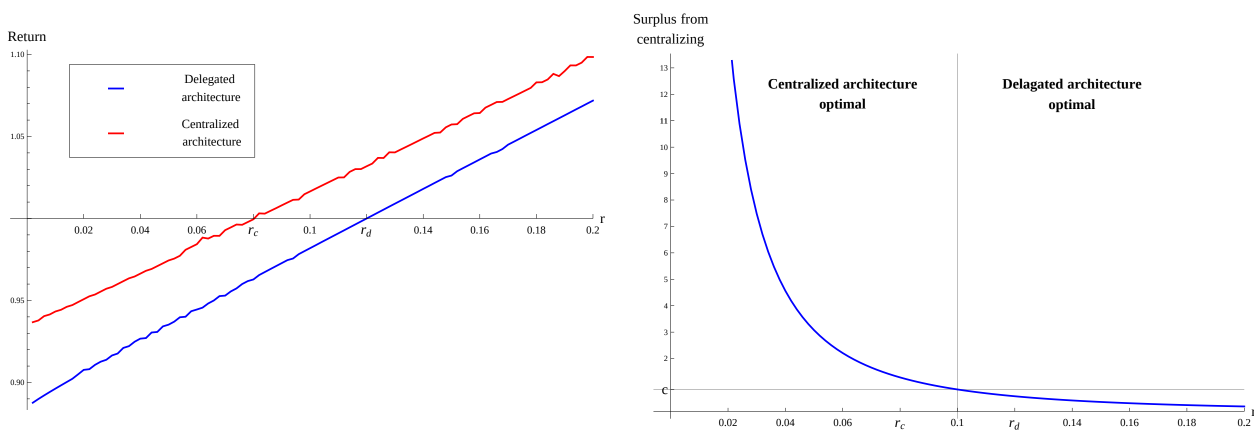

Figure 5: Marginal gross return for foreign investors (left) and surplus from centralizing supervision (right).

A.2 Proof of Proposition 1

The conditions for each type of architecture to be optimal are given by Lemma 1. Point 2 directly follows from the role of c in the Lemma. To prove point 1 we have to show that $B(\lambda, 0)$ increases in p^* and decreases in p^{**}, while the opposite holds for $B(\lambda, p^*)$. We have:

$$\begin{aligned} B(\lambda, 0) &= (W_1 - W_0)(1-\lambda)\bar{B}(p^*, p^{**}) \\ B(\lambda, p^*) &= (W_1 - W_0)((1-\lambda)\bar{B}(p^*, p^{**}) + \lambda(p^{**} - p^*)) \end{aligned}$$

Differentiating $\bar{B}$ gives:

$$\frac{\partial \bar{B}}{\partial p^*} = -(p^{**} - p^*)\phi(p^*) < 0, \ \frac{\partial \bar{B}}{\partial p^{**}} = \Phi(p^{**}) - \Phi(p^*) > 0 \tag{20}$$

It is then easy to show that $B(\lambda, 0)$ and $B(\lambda, p^*)$ vary with p^* and p^{**} as mentioned above.

In order to prove point 3, we must first show that $\bar{s}(\lambda)$ increases in p^{**} and decreases in p^* and c. This is obvious from the definition of $\bar{s}(\lambda)$ given by (9). To conclude the proof, consider the derivative of $\bar{s}$ with respect to λ:

$$\bar{s}'(\lambda) = \frac{1}{\lambda^2(W_1 - W_0)}(c - \bar{B}(p^*, p^{**})(W_1 - W_0)) \tag{21}$$

which shows the desired result on the impact of a higher λ.

A.3 Proof of Proposition 2

Define first the expected benefit B^d for the central supervisor if he fully delegates and chooses $\lambda = 0$ and B^c the benefit if he fully centralizes and $\lambda = 0$. We have $B^d = 0$ and $B^c = (W_1 - W_0)\bar{B}(p^*, p^{**}) - c$.

Consider first the case where $c < (W_1 - W_0)\bar{B}(p^*, p^{**})$ and assume c is very close to $(W_1 - W_0)\bar{B}(p^*, p^{**})$. Then B^c can be made arbitrarily close to 0 and except on an arbitrarily small interval $\mathcal{B}(\lambda)$ is equal to:

$$\int_{p^*}^{\bar{s}(\lambda)} (B(\lambda, s) - c)\phi(s)ds - C(\lambda)$$

Using equation (21) and $C'(0) = 0$, the derivative with respect to λ close to zero is given by:

$$\int_{p^*}^{\bar{s}(\lambda)} (W_1 - W_0)(p^{**} - s - \bar{B}(p^*, p^{**})) - C'(\lambda) = (W_1 - W_0)\bar{B}(p^*, p^{**})(1 - (\Phi(\bar{s}(\lambda)) - \Phi(p^*))) > 0$$

As B^c is close to zero this shows that it is optimal to choose $\lambda > 0$. As moreover cost goes to infinity for $\lambda \to 1$ an interior solution $\lambda \in (0, 1)$ is optimal for c close to but below $(W_1 - W_0)\bar{B}(p^*, p^{**})$. When c decreases by a small amount dc the benefit with centralization increases by dc. Using the envelope theorem, the impact on the optimal benefit with an interior λ is given by:

$$-dc\left(\frac{\partial \bar{s}(\lambda)}{\partial c}(B(\lambda, \bar{s}(\lambda)) - c)\phi(\bar{s}(\lambda)) - \int_{p^*}^{\bar{s}(\lambda)} \phi(s)ds\right)$$

As the first term is by definition negative this gives us an impact of $(\Phi(\bar{s}(\lambda)) - \Phi(p^*))dc < dc$. Thus for a low enough c centralization will be preferred to any interior λ (this will certainly happen for $c = 0$). Moreover, the marginal increase in expected benefit when increasing λ is given by:

$$\frac{\partial \bar{s}(\lambda)}{\partial \lambda}(B(\lambda, \bar{s}(\lambda)) - c)\phi(\bar{s}(\lambda)) + \int_{p^*}^{\bar{s}(\lambda)} (p^{**} - s - \bar{B}(p^*, p^{**}))\phi(s)ds - C'(\lambda) \tag{22}$$

where the first term is null by definition of $\bar{s}(\lambda)$. Differentiating with respect to c gives us:

$$\frac{\partial \bar{s}(\lambda)}{\partial c}(p^{**} - \bar{s}(\lambda) - \bar{B}(p^*, p^{**}))$$

the first term is negative, and we have:

$$p^{**} - \bar{s}(\lambda) - \bar{B}(p^*, p^{**}) = \frac{1}{\lambda(W_1 - W_0)}(c - (W_1 - W_0)\bar{B}(p^*, p^{**})) < 0$$

which shows that increasing c leads the supervisor to choose a higher λ.

The study of the case $(W_1 - W_0)\bar{B}(p^*, p^{**}) > c$ is entirely symmetric. An interior λ is necessarily optimal for c close enough to $(W_1 - W_0)\bar{B}(p^*, p^{**})$, increasing c lowers the expected benefit associated with an interior solution while B^d is unchanged, so that at some point it will be optimal to switch. The derivative with respect to c of the marginal expected benefit has the same expression but now since $c - (W_1 - W_0)\bar{B}(p^*, p^{**}) > 0$ we reach the conclusion that the optimal λ is decreasing in c.

A.4 Proof of Corollary 2

We will again use the quantities B^d and B^c. Define also B^j the maximum benefit from central inspection with an interior λ:

$$B^j = \int_{p^*}^{\bar{s}(\lambda)} ((W_1 - W_0)((1 - \lambda)\bar{B}(p^*, p^{**}) + \lambda(p^{**} - s)) - c)\phi(s)ds - C(\lambda)$$

Point 1. We need to show:

$$0 = \frac{\partial B^d}{\partial p^{**}} \leq \frac{\partial B^j}{\partial p^{**}} \leq \frac{\partial B^c}{\partial p^{**}} \tag{23}$$

the same inequalities must be true when differentiating with respect to $W_1 - W_0$. Let us start with p^{**}. Using the envelope theorem, we have:

$$\frac{\partial B^j}{\partial p^{**}} = (W_1 - W_0)\left(\lambda + (1-\lambda)\frac{\partial \bar{B}(p^*, p^{**})}{\partial p^{**}}\right)(\Phi(\bar{s}(\lambda)) - \Phi(p^*))$$

which is positive as $\bar{B}$ increases in p^{**}, proving the first inequality in (23). The derivative of B^c with respect to p^{**} is:

$$\frac{\partial B^c}{\partial p^{**}} = (W_1 - W_0)(\Phi(p^{**}) - \Phi(p^*))$$

The second inequality in (23) is equivalent to:

$$\Phi(p^{**}) - \Phi(p^*) > (\Phi(\bar{s}(\lambda)) - \Phi(p^*))(\lambda + (1-\lambda)(\Phi(p^{**}) - \Phi(p^*)))$$

which is true as $\Phi(p^{**}) > \Phi(\bar{s}(\lambda))$ and the second term on the right-hand side is lower than one.

We follow the same reasoning for the impact of $W_1 - W_0$. We have:

$$\frac{\partial B^j}{\partial (W_1 - W_0)} = \int_{p^*}^{\bar{s}(\lambda)} ((1-\lambda)\bar{B}(p^*, p^{**}) + \lambda(p^{**} - s))\phi(s)ds + \frac{\partial \bar{s}(\lambda)}{\partial (W_1 - W_0)} \times \underbrace{\partial B^j / \partial \bar{s}(\lambda)}_{=0} \geq 0$$

which shows the first inequality. We then need to compare the impact of $W_1 - W_0$ on B^c and B^j:

$$\frac{\partial B^c}{\partial (W_1 - W_0)} \geq \frac{\partial B^j}{\partial (W_1 - W_0)} \Leftrightarrow \bar{B}(p^*, p^{**}) \geq \int_{p^*}^{\bar{s}(\lambda)} ((1-\lambda)\bar{B}(p^*, p^{**}) + \lambda(p^{**} - s))\phi(s)ds$$

This last inequality is true, as it simply means that the benefits from intervention are higher under central than under local supervision. For $\lambda = 1$ there is equality, and the right-hand side is increasing in λ. This shows that an increase in $W_1 - W_0$ favors a centralized solution more than a joint solution.

Point 2. We need to show that the marginal benefit of λ given in (22) increases in p^{**} and in $W_1 - W_0$. This is easily done for $W_1 - W_0$ as this term enters positively into $\bar{s}(\lambda)$. I then take the first-order derivative of (22) with respect to p^{**}:

$$\frac{\partial \bar{s}(\lambda)}{\partial p^{**}}(p^{**} - \bar{s}(\lambda) - \bar{B}(p^*, p^{**}))\phi(\bar{s}(\lambda)) + \left(1 - \frac{\partial \bar{B}(p^*, p^{**})}{\partial p^{**}}\right)(\Phi(\bar{s}(\lambda)) - \Phi(p^*))$$

$\frac{\partial \bar{s}(\lambda)}{\partial p^{**}}$ always has the same sign as $(p^{**} - \bar{s}(\lambda) - \bar{B}(p^*, p^{**}))$ and $\frac{\partial \bar{B}}{\partial p^{**}}$ is lower than 1, hence this expression is positive and increasing.

Point 3. We follow the same reasoning. The impact of p^* on B^j is given by:

$$\frac{\partial B^j}{\partial p^*} = (W_1 - W_0)(1-\lambda)\frac{\partial \bar{B}(p^*, p^{**})}{\partial p^*}(\Phi(\bar{s}(\lambda)) - \Phi(p^*)) - (B(\lambda, p^*) - c)\phi(p^*)$$

Using (20), B^j decreases in p^* while B^d is unaffected. We then have to compare this impact to the impact on B^c:

$$\frac{\partial B^c}{\partial p^*} = -(W_1 - W_0)(p^{**} - p^*)\phi(p^*)$$

$\frac{\partial B^c}{\partial p^*} < \frac{\partial B^j}{\partial p^*}$ is equivalent to:

$$(W_1 - W_0)(p^{**} - p^*)(1 - (1-\lambda)(\Phi(\bar{s}(\lambda)) - \Phi(p^*))) > (W_1 - W_0)((1-\lambda)\bar{B}(p^*, p^{**}) + \lambda(p^{**} - p^*)) - c$$

It is sufficient to show that this inequality holds for $c = 0$, in which case it simplifies to:

$$(p^{**} - p^*)(1 - (\Phi(\bar{s}(\lambda)) - \Phi(p^*))) > \bar{B}(p^*, p^{**}) \tag{24}$$

As moreover $\bar{B}(p^*, p^{**}) < (p^{**} - p^*)(\Phi(p^{**}) - \Phi(p^*))$ it is enough to have $1 > (\Phi(p^{**}) - \Phi(p^*)) + (\Phi(\bar{s}(\lambda)) - \Phi(p^*))$. This is certainly true if $\Phi(p^{**}) - \Phi(p^*) < \frac{1}{2}$ as $\bar{s}(\lambda) \leq p^{**}$.

For the impact on λ, differentiating the marginal benefit (22) with respect to p^* gives:

$$\frac{1-\lambda}{\lambda}\frac{\partial \bar{B}}{\partial p^*}(p^{**} - \bar{s}(\lambda) - \bar{B}(p^*, p^{**}))\phi(\bar{s}(\lambda)) - (p^{**} - p^* - \bar{B}(p^*, p^{**}))\phi(p^*) - (\Phi(\bar{s}(\lambda)) - \Phi(p^*))\frac{\partial \bar{B}}{\partial p^*}$$

We have to show that this expression is negative. The first term in the sum is negative, the remaining terms can be rearranged as:

$$\phi(p^*)[(p^{**} - p^*)(\Phi(\bar{s}(\lambda)) - \Phi(p^*)) - (p^{**} - p^* - \bar{B}(p^*, p^{**}))]$$

which is negative under the same conditions that ensure (24) is satisfied.

A.5 Proof of Proposition 3

Point 1. The choice of the supervisory architecture by a central supervisor increases the probability of liquidation conditional on p being in $[p^*, p^{**}]$. I first show that, all else equal, this increases the left-hand side of equation (14).

By definition, for $p \in [p^*, p^{**}]$ total welfare would be higher with liquidation but local welfare is higher with no liquidation. As the difference between the two quantities is the foreign investors' profit, for such a p this profit is higher in case of liquidation. Total foreign profit is equal to the marginal return on loans times $L - D$, which is given, hence for such a p the marginal return is also higher in case of liquidation. Finally, an increase in the probability of liquidation for a given p gives more weight in the left-hand side of (14) to the marginal return conditional on liquidation and less weight on the marginal return conditional on no liquidation, hence the expression increases.

This show that the left-hand side of (17) increases when a central supervisor is introduced. Differentiation shows that the left-hand side is always increasing in r^*. Thus to restore equilibrium r^* has to decrease when supervision increases, since $q(r^*) = L$ and D is decreasing foreign lending $L - D$ has to increase.

Point 2. As $\Phi(1-\ell) < \frac{1}{2}$ and $p^{**} < 1 - \ell$, all the points of Corollary 2 apply. An increase in r has an impact on p^*, p^{**} and $W_1 - W_0$. If we show that an increase in r leads to a higher p^*, a lower p^{**} and a lower $W_1 - W_0$, point 2 will be directly implied by Corollary 2. $W_1 - W_0 = V(r)$ and $V'(r) = q'(r)(1+r) \leq 0$. For p^{**} we have:

$$\frac{\partial p^{**}}{\partial r} = (1-\ell)q'(r)\frac{V(r) - q(r)(1+r)}{V(r)^2} \leq 0.$$

The last thing to show is that p^* increases in r. Using (11), we have:

$$p^* = \frac{D(1-\ell)q(r)}{V(r)[q(r)(1+r) - rD] - [q(r)(1+r) - rD]^2}$$

and, using a log-derivative:

$$\frac{\partial \ln p^*}{\partial r} = \frac{q'(r)}{q(r)} - \frac{q'(r)(1+r) + q(r) - D}{q(r)(1+r) - rD} + \frac{q(r) - D}{V(r) - q(r)(1+r) + rD}$$

Denoting $\epsilon = \frac{-(1+r)q'(r)}{q(r)}$ the elasticity of the demand for loans to r, we get:

$$\frac{\partial \ln p^*}{\partial r} \geq 0 \Leftrightarrow \epsilon \frac{rD}{(1+r)[q(r)(1+r)-rD]} \geq \frac{V(r)-2[q(r)(1+r)-rD]}{[q(r)(1+r)-rD](V(r)-q(r)(1+r)+rD)}$$

This condition is satisfied if the elasticity ϵ of the demand for loans to r is high enough.

A.6 Proof of Proposition 4

Let us first assume that there exist two equilibrium interest rates r_c and r_d corresponding to an equilibrium with centralization and an equilibrium with delegation, respectively, and denote $p^*(r_c), p^*(r_d), p^{**}(r_c), p^{**}(r_d)$ the intervention thresholds (notice in particular that r_c and r_d do not depend on the cost c, as the central supervisor is supposed to intervene always or never) . We check that both equilibria can be obtained for the same parameters. The market equilibrium condition (17) gives us:

$$\begin{aligned}
\Phi(p^*(r_d))\frac{(1+r_d)(1-\ell)q(r_d)}{D+(q(r_d)-D)(1+r_d)} + (1+r_d)\int_{p^*(r_d)}^{1} p\phi(p)dp &= 1 \\
\Phi(p^{**}(r_c))\frac{(1+r_c)(1-\ell)q(r_c)}{D+(q(r_c)-D)(1+r_c)} + (1+r_c)\int_{p^*(r_c)}^{1} p\phi(p)dp &= 1
\end{aligned}$$

As shown in A.5, under the assumption of high elasticity p^* is increasing in r. As moreover p^{**} is decreasing in r and for any given r we have $p^* \leq p^{**}$, necessarily $p^{**}(r_c) \geq p^*(r_d)$. Then Proposition 3 implies that $r_c \leq r_d$. From this we deduce that $p^*(r_c) \leq p^*(r_d)$ and $p^{**}(r_c) \geq p^{**}(r_d)$.

When for any λ the cost $C(\lambda)$ is made arbitrarily high, the central supervisor only chooses between centralization, which brings $V(r)\bar{B}(p^*, p^{**}) - c$, and delegation, which brings zero. To have both equilibria as possible outcomes we need:

$$V(r_c)\int_{p^*(r_c)}^{p^{**}(r_c)} (p^{**}(r_c)-p)\phi(p)dp \geq c \geq V(r_d)\int_{p^*(r_d)}^{p^{**}(r_d)} (p^{**}(r_d)-p)\phi(p)dp \tag{25}$$

The integral on the left is higher than the integral on the right due the comparison between $p^*(r_c)$ and $p^*(r_d)$ on the one hand, and $p^{**}(r_c)$ and $p^{**}(r_d)$ on the other hand. As $r_c \leq r_d$ we also have $V(r_c) \geq V(r_d)$. Thus the left-hand side in equation (25) is higher than the right-hand side, hence there are intermediate values of c such that both equilibria can be obtained.

Let us now show that the equilibrium with centralization is associated with a higher global welfare than the equilibrium with delegation when c is close enough to the lower bound for multiplicity to obtain. Welfare under delegation or centralization being continuous in c, it is sufficient to consider the case where c is equal to the lower bound:

$$c = c_1 = V(r_d) \int_{p^*(r_d)}^{p^{**}(r_d)} (p^{**}(r_d) - p)\phi(p)dp$$

Let us denote W_c the global welfare under the centralized equilibrium for this particular value of c, and W_d the global welfare in the delegation equilibrium. We can write W_c as:

$$W_c = \int_0^1 \max((1-\ell)q(r_c), pV(r_c))\phi(p)dp - c_1$$

By definition of c_1, welfare W_d obtained in the delegation equilibrium is also equal to welfare if supervision were centralized, but at interest rate r_d instead of r_c:

$$W_d = \int_0^1 \max((1-\ell)q(r_d), pV(r_d))\phi(p)dp - c_1$$

Given that $r_c \leq r_d$, $q(r_c) \geq q(r_d)$ and $V(r_c) \geq V(r_d)$. Hence welfare is equal or higher in the centralized equilibrium for any value of p. This shows that $W_c \geq W_d$.

References

Acharya, V. (2003): "Is the International Convergence of Capital Adequacy Regulation Desirable?," *Journal of Finance*, 58(6). 4

Agarwal, S., D. Lucca, A. Seru, and F. Trebbi (2012): "Inconsistent regulators, evidence from banking," NBER Working paper 17736. 1, 16, 25

Albertazzi, U., and D. J. Marchetti (2010): "Credit supply, flight to quality and evergreening: an analysis of bank-firm relationships after Lehman," Banca d'Italia working paper 756. 18

Alonso, R., and N. Matouschek (2008): "Optimal Delegation," *Review of Economic Studies*, 75(1). 4

Beck, T., R. Todorov, and W. Wagner (2012): "Supervising Cross-border Banks: Theory, Evidence an Policy," European banking center discussion paper. 3, 15, 18, 26

Boyer, P., and J. Ponce (2011): "Regulatory capture and banking supervision reform," Working paper. 5

Brunnermeier, M., A. Crocket, C. Goodhart, A. Persaud, and H. Shin (2009): "The Fundamental Principles of Financial Regulation," Geneva Reports on the World Economy 11. 27

Calzolari, G., and G. Loranth (2011): "Regulation of multinational banks: A theoretical inquiry," *Journal of Financial Intermediation*, 20(2). 4

Costa Lima, R., H. Moreira, and T. Verdier (2012): "Centralized decision making against informed lobbying," CEPR Discussion Paper 9199. 5

Decamps, J.-P., J.-C. Rochet, and B. Roger (2004): "The three pillars of Basel II: optimizing the mix," *Journal of Financial Intermediation*, 13(2), 132–155. 4

Hardy, D., and M. Nieto (2011): "Cross-border coordination of prudential supervision and deposit guarantees," *Journal of Financial Stability*, 7. 4

Hiriart, Y., D. Martimort, and J. Pouyet (2010): "The public management of risk: Separating ex ante and ex post monitors," *Journal of Public Economics*, 94. 5

Holmstrom, B. (1977): *On Incentives and Control in Organizations*. PhD. Thesis, Stanford University. 4, 7

Holthausen, C., and T. Ronde (2004): "Cooperation in International Banking Supervision," ECB Working paper 316. 4

Kahn, C., and J. Santos (2005): "Allocating bank regulatory powers: Lender of last resort, deposit insurance and supervision," *European Economic Review*, 49. 4, 28

Kick, T., and A. Pfingsten (2011): "The importance of qualitative risk assessment in banking supervision before and during the crisis," Bundesbank Discussion paper 2011,09. 7

King, K. K., and J. M. O'Brien (1991): "Market-based, risk-adjusted examination schedules for depository institutions," *Jounal of Banking and Finance*, 15(4-5), 955–974. 4

Komai, A., and G. Richardson (2011): "A brief history of regulations regarding financial markets in the United States: 1789 to 2009," NBER Working paper. 17

Mailath, G., and L. Mester (1994): "A Positive Analysis of Bank Closure," *Journal of Financial Intermediation*, 3. 4, 5

Martimort, D. (1999): "The Life Cycle of Regulatory Agencies: Dynamic Capture and Transaction Costs," *Review of Economic Studies*, 66(4). 5

Merton, R. C. (1978): "On the Cost of Deposit Insurance When There Are Surveillance Costs," *The Journal of Business*, 51(3), 439–52. 4

Morrison, A., and L. White (2009): "Level Playing Fields in International Financial Regulation," *Journal of Finance*, 64(3). 24

Morrison, A. D., and L. White (2010): "Reputational contagion and optimal regulatory forbearance," European Central Bank Working paper 1196. 6

Ongena, S., A. Popov, and G. F. Udell (2013): "When the cat's away the mice will play: Does regulation at home affect bank risk-taking abroad?," *Journal of Financial Economics*, Forthcoming. 6

Peek, J., and E. S. Rosengren (2005): "Unnatural Selection: Perverse Incentives and the Misallocation of Credit in Japan," *American Economic Review*, 95(4), 1144–1166. 18

Petriconi, S. (2012): "Bank Competition, Information Choice and Inefficient Lending Booms," Working paper. 8

Rezende, M. (2011): "How Do Joint Supervisors Examine Financial Institutions? The Case of State Banks," Federal Reserve Board Discussion paper. 16

——— (2012): "The Effects of Bank Regulator Switching on Supervisory Ratings," Working paper. 24