Monitoring the supervisors: optimal regulatory architecture in a banking union*

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Abstract

I study the optimal architecture of bank supervision in a federal system. A central supervisor relies on off-site monitoring to learn about a bank's soundness, and then decides whether she should perform an on-site inspection or whether it is better left to local authorities. Local supervisors are more efficient at performing on-site examinations, but do not internalize cross-border externalities. The optimal degree of supervisory centralization depends on the severity of these externalities, the opacity of the supervised bank and the specificity of its assets. Cross-border externalities are endogenous as in equilibrium investors react to the supervisory architecture. Better supervision leads to more financial integration, which worsens the incentives of local supervisors. The economy can be trapped in an equilibrium with low supervision and low integration, while a forward-looking design of the supervisory architecture would coordinate economic agents on a superior equilibrium.

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1 Introduction

The European Commission proposed in September 2012 the creation of a "Single Supervisory Mechanism" (SSM) for European banks, motivated by recent "supervisory failings"[1] in Europe, among which the inability of national supervisors to take into account cross-border externalities and insufficient coordination when dealing with the closure of multinational banks. In both instances the national supervisory agencies' interests are not perfectly aligned with those of the Union. A similar problem is documented in the United States, where banks regulated by State and Federal regulators alternatively appear to face regulatory forbearance by State supervisors (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 local 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.

Supervisory forbearance justifies the need for integrated supervision. The core of this paper is to analyze how best to organize a "single supervisory mechanism", taking into account that such a large change has an impact on the market equilibrium. The trade-off is between the biased incentives of local supervisors and their better knowledge of local banks. If local supervisors are simply replaced by a central one then a lot of local knowledge is lost, while conversely not having a central supervisor leads to supervisory forbearance. An intermediate solution is to allocate the inspection of a given bank sometimes to a local agency and sometimes to the central supervisor, depending on whether forbearance by the local supervisor seems likely in a given situation. I study an optimal regulatory architecture along these lines.

I assume that through on-site examinations a supervisor can learn the exact probability

[1] 12.09.12, *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, p.2.

that loans are repaid. To model the informational advantage of the local supervisor, on-site inspections are assumed to be always more costly 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 arrangement for supervising a given bank 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, it is possible to reach a better solution 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 local 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 local banks. Thus a higher proportion of their losses are borne by foreign investors and the local supervisor's incentives worsen, making it necessary to reinforce central supervision. The optimal architecture should thus be flexible in 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

[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".

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.

The framework is flexible and allows for a number of interesting extensions. One of them discusses the conflict of objectives dimension and shows that looking at the direct impact of a bank's losses may be misleading: due to second-round effects of defaults, even banks indebted towards local agents only may be inadequately supervised. The choice of the banks to include in the single European supervision should thus be based on the analysis of liabilities in the whole banking system, and on which banks have the most negative spill-overs towards non-domestic agents. This could significantly enlarge the set of banks where local supervision is potentially inadequate. 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. Finally, I discuss other potential conflicts between the two levels of supervision, and how they relate in particular to the U.S. case.

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 model of banking supervision based on Mailath and Mester (1994) to study the incentives faced by the local supervisor of such a bank. 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 and complementary here as I look at the optimal "vertical" regulatory architecture instead of the interaction between equal national supervisors.

There is more generally a theoretical 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.

Section 2 is related to the recent theoretical literature on delegation, starting with Holmstrom (1977), the main idea being to study an agency problem 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. I choose a simple model of supervision so as to express the agency problem in simple terms and embed it in a market equilibrium model which interacts with the delegation problem. An interesting specificity in the delegation problem studied in this paper is the complementarity between centralization and foreign investment which is obtained when which can lead to multiple equilibria. The simplicity of the modeling makes it possible for future research to apply insights from recent papers in this literature such as Alonso and Matouschek (2008).

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.

Lastly, supervisors in this model are assumed to maximize a measure of welfare, domestic or global. An alternative explanation of supervisory failings is capture by private interests. If capture is a concern that the new supervisory architecture should address, the literature on regulatory design with lobbying gives interesting insights. Hiriart, Martimort, and Pouyet (2010) in particular 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 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 total welfare. 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 each state $s \in \{0, 1, I\}$ 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 the local 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. 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. This is with no loss of generality as adapting this section to the symmetric case $p^{**} < p^*$ is straightforward. The quantity $p^{**} - p^*$ measures the intensity of the *conflict of objectives* between the local supervisor and the general interest.

Example: the framework of this section is kept general on purpose. Section 3 develops a precise example in order to study how the supervision can interact with a market equilibrium. To make the framework less abstract, the setting of this section can be seen as follows: the bank chooses in $t = 0$ how much to invest in risky projects, the success probability of which is p. Once p is learnt, it is socially efficient to liquidate the projects if p is too low. The bank will typically prefer to exert "evergreening"[3] instead and continue to lend. A benevolent social planner would compare the total welfare W_I obtained when liquidating the projects to W_1 obtained without liquidation when projects are successful, and W_0 obtained without liquidation when projects fail, defining p^{**}. If some of the bank's creditors are foreign investors for instance, a local supervisor will not internalize their losses and thus choose $p^* < p^{**}$, leading to suboptimally low liquidation and supervisory forbearance.

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

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.

There are intermediate solutions. The European Commission's proposal is to build a supervisory mechanism where the most systemic banks are supervised by a Single Supervisory Mechanism coordinated by the ECB (which corresponds to the centralized solution in the model), while other banks are left under the umbrella of national supervisors, unless the SSM decides to intervene (which corresponds to a mixed solution). The United States also use a complex regulatory architecture, with both a State supervisor and the Fed or the FDIC for State-chartered commercial banks. In such a system there are two agency problems: 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.

There are both a central and a local supervisors. The central supervisor has an off-site monitoring technology giving a noisy signal on p[4]. It could be based on simple balance sheet items and ratios, stress-tests, or quarterly call reports in the U.S. case. Based on this signal, the central supervisor decides whether the bank should be 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 loans should be liquidated. If the central supervisor always inspects the bank independently of her signal then we have complete centralization. If she

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

never does so there is complete delegation instead.

Assumptions and information structure: I assume a simple information structure borrowed from Petriconi (2012). The central supervisor receives a signal s, which can be thought of as based on balance sheet ratios. With some probability λ, this signal is exactly equal to the true p. With probability $1-\lambda$, s is drawn from the prior distribution Φ. In words, the signal 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.

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:

$$\int_0^{p^{**}} W_I\tilde{\phi}_s(p)dp + \int_{p^{**}}^1 p(W_1 - W_0)\tilde{\phi}_s(p)dp - c \geq \int_0^{p^*} W_I\tilde{\phi}_s(p)dp + \int_{p^*}^1 p(W_1 - W_0)\tilde{\phi}_s(p)dp$$

$$\Leftrightarrow \quad W_I[\tilde{\Phi}_s(p^{**}) - \tilde{\Phi}_s(p^*)] - (W_1 - W_0)\int_{p^*}^{p^{**}} p\tilde{\phi}_s(p)dp > c \quad (6)$$

Only the probabilities associated to values of p in $[p^*, p^{**}]$ enter this equation. 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. $\tilde{\Phi}_s(p^{**}) - \tilde{\Phi}_s(p^*)$ measures the probability that we are in this region.

It is straightforward to reexpress equation (6) using (3) and (4). This defines the expected benefit from inspecting upon receiving signal s with precision λ:

$$B(\lambda, s) = \begin{cases} (W_1 - W_0)\left[(1-\lambda)\int_{p^*}^{p^{**}}(p^{**} - p)\phi(p)dp + \lambda(p^{**} - s)\right] & \text{if } s \in [p^*, p^{**}] \\ (W_1 - W_0)\left[(1-\lambda)\int_{p^*}^{p^{**}}(p^{**} - p)\phi(p)dp\right] & \text{if } s \notin [p^*, p^{**}] \end{cases} \tag{7}$$

Lemma 1. *1. The central supervisor always inspects the bank (centralization) if and only if* $B(\lambda, 0) > c$.

2. The central supervisor never inspects the bank (delegation) if and only if $B(\lambda, p^*) < c$.

3. When $c \in [B(\lambda, 0), B(\lambda, p^*)]$*, there exists* $\bar{s}(\lambda) \in [p^*, p^{**}]$ *such that the central supervisor inspects the bank if and only if* $s \in [p^*, \bar{s}(\lambda)]$.

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:

$$\bar{s}(\lambda) = p^{**} - \frac{c}{\lambda(W_1 - W_0)} + \frac{1-\lambda}{\lambda}\bar{B}, \text{ with } \bar{B} = \int_{p^*}^{p^{**}}(p^{**} - p)\phi(p)dp \tag{8}$$

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 (λ, c, p^*) space: centralization, delegation, and mixed, plotted on Figure 1[5]. The next proposition gives comparative statics results on delegation:

Proposition 1. *1. A higher p^{**} or a lower p^* increase the inspection threshold $\bar{s}(\lambda)$ and expand the centralization and mixed regions at the expense of delegation. In all cases the inspection probability increases.*
2. A higher c decreases the inspection threshold, can lead to a switch from centralization to mixed, or from mixed to delegation. In all cases the inspection probability decreases.
3. A higher λ increases inspection if $c > (W_1 - W_0)\bar{B}$, decreases inspection otherwise.

[Insert Fig. 1 here.]

See the Appendix A.1 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 $p^{**} - p^*$, 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 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.

[5] All the figures are in the Appendix A.8. The parameters used correspond to Section 3.1 with $r = 0.05, L = 1, \ell = 0.2$ and $\Phi(x) = x$.

2.4 Investment in monitoring

Assume that in the long-run the central supervisor can invest in off-site monitoring and increase the precision of her signal, for instance by building additional warning indicators or processing more balance sheet data coming from the supervised banks. In order to get a signal with precision λ, she needs to pay *monitoring costs* $C(\lambda)$, with $C(0) = C'(0) = 0$, $C' \geq 0, C'' \geq 0$ and $\lim_{x \to 1} C(x) = +\infty$. 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:

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

Graphically, the goal is to maximize the function plotted on Figure 2[6] 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:

$$C'(\lambda) = (W_1 - W_0) \int_{p^*}^{\bar{s}(\lambda)} \left(p^{**} - s - \bar{B}\right) \phi(s)ds \qquad (9)$$

Proposition 2. *There exist $\underline{c}$ and $\overline{c}$ with $\overline{c} > (W_1 - W_0)\bar{B} > \underline{c}$ such that the central supervisor chooses $\lambda = 0$ and full supervision if $c < \underline{c}$; $\lambda > 0$ and a mixed solution if $c \in [\underline{c}, \overline{c}]$; $\lambda = 0$ and delegation if $c > \overline{c}$. The optimal λ is increasing in c for $c \in [\underline{c}, (W_1 - W_0)\bar{B}]$ and decreasing in c for $c \in [(W_1 - W_0)\bar{B}, \overline{c}]$.*

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

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

See the Appendix A.2 for the complete proof. Figure 3[7] shows the optimal λ as a function of c, as well as the probability that the central supervisor inspects and the probability that assets are liquidated. 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 $(W_1 - W_0)\bar{B}$ 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 (9), 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 $C(\lambda) = \gamma\tilde{C}(\lambda)$, an increase in γ leads to a lower optimal λ and can imply a switch from a mixed solution to either delegation or centralization, depending on whether c is higher or lower than $(W_1 - W_0)\bar{B}$.*

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 λ:

Corollary 2. *1. Both a lower p^* and a higher p^{**} shrink the delegation region.*
2. A higher p^{**} expands the centralization region, and leads to a higher λ in the mixed region.
3. If $\Phi(p^{**}) - \Phi(p^*) < \frac{1}{2}$, a lower p^* expands the centralization region, and leads to a higher λ in the mixed region.

See the Appendix A.3 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 $[p^*, p^{**}]$ 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.

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

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. Taking the precision of the central supervisor's off-site monitoring as given, the key parameter is c divided by $(W_1 - W_0)\bar{B}$. The first term is the informational gap between both supervisors, the second one is a measure of expected conflicts of objectives between the central and the local supervisor, times the welfare difference at stake. Taking into account that in the long-run the precision of the warning signals is a choice variable for the central supervisor, a low monitoring cost $C(\lambda)$ implies a mixed solution, while a high cost implies either centralization or delegation. The results of this section can then be summed up in the following table, giving the optimal solution in four cases:

Monitoring cost | Info. gap/Conflict	Low	High
High	Centralization	Delegation
Low	Mixed solution, monitoring decreases inspection	Mixed solution, monitoring increases inspection

The insight derived from this theoretical analysis is thus that the optimal regulatory arrangement depends on three different dimensions:

The **conflict of objectives** is measured in the model by the length of the interval $[p^*, p^{**}]$, can be microfounded as in Section 3.1 or as in Beck, Todorov, and Wagner (2012). This parameter is difficult to measure (see Section 4.1), even in a case where the supervisor's incentives are quite straightforward. The situation is even more complex when the political economy of bank supervision is taken into account and the supervisor is assigned a more complex objective, along the lines of Kahn and Santos (2005).

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 **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, local language. Conversely, it is 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.

It is beyond the scope of this paper to flesh out this typology with an empirical analysis. However, many of the examples referred to when discussing the functioning of the SSM can be usefully classified using the three dimensions above. The "centralization" solution corresponds well to banks directly supervised by the SSM, the "delegation" solution to banks outside of the mechanism, and the mixed solution to banks supervised at the local level but in which the SSM can choose to intervene.

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 mixed solution, involving mainly offsite monitoring by the central supervisor. 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 high degree of centralization is optimal in the model, 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 central supervisor 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.

In its guidelines to identify G-SIBs[8], 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 only thing still needed to operationalize the above typology is a measure of national specificities for a given bank.

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

It is also interesting to consider the U.S. case along these three dimensions. The primary supervisor of a U.S. bank is determined by its type of charter and its access to Federal deposit insurance, which fits with the conflict of objectives dimension (see also Section 4.3). Interestingly, commercial state banks are jointly supervised by State and Federal supervisors, with different levels of delegation. On-site examinations can be joint or independent for instance. Rezende (2011) shows that joint examinations are more frequent for large and complex institutions, which corresponds well to the third dimension explored in this model.

A last conclusion from this simple framework is that the central supervisor should not focus his attention on the worst outcomes for p, as in these cases the local supervisor takes the correct decision because potential losses in case of no intervention far outweigh the benefits. The central supervisor should focus on middle outcomes instead, where it is likely that the local supervisor is not exerting all the care he should. An interesting extension would be to see the problem as dynamic: both supervisors learn innovations in p over time and can choose to intervene or not. The conflict of objectives would then imply that 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 credit markets. To study this interaction, this section embeds the model of supervision just developed in an equilibrium model of the credit market. 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, local banks, foreign investors - and three assets - a storage asset, local loans and claims on local banks.

-*Borrowers* can get loans from local banks only. These loans are perfectly correlated (think of loans for building projects in a given region). Borrowers promise to repay $1 + r$ on each unit of loan, but their projects fail with probability p, where $p \hookrightarrow \Phi(.)$ over $[0, 1]$. In case of failure the borrowers do not repay anything. Borrowers are price-takers and the derived demand for loans is $D(r)$, with $D'(r) \leq 0$, $D(0) = +\infty$ and $\lim_{r \to +\infty} D(r) = 0$.

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

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

There is a continuum $[0, 1]$ of each type of agents, all 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) already showed 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.

At $t = 0$ local banks simultaneously choose how much to lend to borrowers and to borrow from foreign investors, while the central supervisor chooses λ. The prices r and i_S are determined by competitive equilibrium conditions. At $t = 1$ the probability p that local loans are reimbursed is determined, the central supervisor receives a signal s on p and decides who should inspect the bank. p is then learnt by either the local or the central supervisor depending on who performs the inspection. At this point in time only, projects can be liquidated for a value of $1 - \ell$[9]. The liquidation value is by construction not enough for small banks to repay their debt, so that due to limited liability they always choose to "gamble for resurrection" and keep their loans. The local supervisor can take the decision to liquidate the projects, and does so if it increases *local welfare*, which is the sum of payoffs to depositors, local banks and the deposit insurance fund, but not foreign investors. In $t = 2$ the returns

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

on local loans are realized, debts are reimbursed and deposits are given back to depositors. In case of default by a bank its assets accrue to creditors (depositors and foreign investors) on a pro-rata basis.

Solution: The model is solved backwards. Taking r, i_S and L as given, I first study each supervisor's choice in $t = 1$ after a given realization of p. Assume for now that $L \geq D_S$ and $r \geq i_S$ so that local banks borrow from foreign investors.

For a given state $s \in \{0, 1, I\}$, define π_s^S, π_s^F and π_s^D as the profit of local banks, the profit of foreign investors, the payoff to depositors minus the costs to the deposit insurance fund. We have $\hat{W}_S = \pi_s^S + \pi_s^D$ and $W_S = \hat{W}_S + \pi_s^F$. The different states are the following:

-*State* 1*: no intervention, successful loans.* This state occurs with probability p when the supervisor does not intervene. Local banks reimburse foreign investors and depositors in full, so that we have $\pi_1^S = (1+r)L - (L - D_S)(1 + i_S) - D_S$, $\pi_1^D = D_S$, $\pi_1^F = (L - D_S)(1 + i_S)$ and thus $\hat{W}_1 = (1 + r)L - (L - D_S)(1 + i_S)$.

-*State* 0*: no intervention, defaulting loans.* This state occurs with probability $1 - p$ when the supervisor does not intervene. Local banks having optimally invested their deposits and credits in loans, they have no asset left and default. The deposit insurer gives D_S to depositors and foreign investors get nothing, hence $\pi_0^S = 0, \pi_0^D = 0, \pi_0^F = 0$ and $\hat{W}_0 = 0$.

-*State* I*: supervisory intervention, loans are liquidated.* When the supervisor intervenes, the proceeds of liquidated projects are $(1 - \ell)L$. This quantity being by definition lower than the local banks' liabilities, these banks default and the proceeds are shared between depositors and foreign investors. Denoting α_S the share accruing to depositors, we have $\pi_I^S = 0, \pi_I^D = \alpha_S L(1 - \ell), \pi_I^D = (1 - \alpha_S)L(1 - \ell)$ and $\hat{W}_I = \alpha_S L(1 - \ell)$, with:

$$\alpha_S = \frac{D_S}{D_S + (L - D_S)(1 + i_S)} \tag{10}$$

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

$$p^* = \frac{\alpha_S(1 - \ell)L}{(1 + r)L - (L - D_S)(1 + i_S)},\ p^{**} = \frac{1 - \ell}{1 + r} \tag{11}$$

We can express the difference $p^{**} - p^*$ as:

$$p^{**} - p^* = \frac{1-\ell}{1+r} \times \frac{1-\alpha_S}{\hat{W}_1}(L(r-i_S) + i_S D_S) \tag{12}$$

since $i_S \leq r$ the numerator is positive and thus $p^* < p^{**}$: the supervisor exerts forbearance. When $D_S = L$ both $\hat{W}_1 = W_1$ and $\hat{W}_I = W_I$, 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 $1 - \alpha_S$ of the liquidated loans 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 local banks operate. The combination of these two effects is always towards forbearance. When D_S is close to L, local 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. Of course there are many other externalities of local supervision that are absent from this model. Ongena, Popov, and Udell (2013) for instance show that stricter regulation of a bank in its home country lowers the lending standards of its subsidiaries abroad.

3.2 Centralization of supervision and market integration

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 local 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.]

Local banks make an expected profit of:

$$\pi^S = \Pr(\text{No liquidation})\mathbb{E}(\tilde{p}|\text{No liquidation})[L(r - i_S) + i_S D_S] \tag{13}$$

Thus it must be the case in equilibrium that $r = i_S$, otherwise local banks would choose to borrow and lend more. To compute the probability of liquidation, define $\mathcal{L}_L$ the set in (s, p) such that the local supervisor would liquidate the assets, and $\mathcal{L}_C$ the set such that only the central supervisor would liquidate the assets. We have $\mathcal{L}_L = [0, 1] \times [0, p^*]$ and $\mathcal{L}_C = [p^*, \bar{s}(\lambda)] \times [p^*, p^{**}]$ in case of a mixed solution, $\mathcal{L}_C = \emptyset$ under delegation and $\mathcal{L}_C = [0, 1] \times [p^*, p^{**}]$ in case of centralization. Finally, denote $\mathcal{L} = \mathcal{L}_L \cup \mathcal{L}_C$ the whole *liquidation set*. The probability of liquidation is obtained by computing $\Pr((s, p) \in \mathcal{L})$, weighing by $\tilde{\phi}_s(p)$ over all possible signals s.

A foreign investor lending a marginal amount dx to local banks expects to get $(1 + i_S)dx$ 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 $D_S + (L - D_S)(1 + i_S)$. A foreign investor thus expects to recover $[(1 + i_S)dx/(D_S + (L - D_S)(1 + i_S))] \times (1 - \ell)L$ 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:

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

The central supervisor's choice determines the probability of liquidation. It is equal to $\Phi(p^*)$ under delegation, and to $\Phi(p^{**})$ under centralization. With a mixed solution and a signal precision of λ, simple computations give us the following:

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

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:*

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

Moreover p^* and p^{**} satisfy (11); 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 i_S and imposing the equilibrium condition $L = D(r^*)$. It gives a long-run equilibrium where demand equals supply both for loans to borrowers and to local banks, the local supervisor optimally reacts to the balance sheet of local 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. An exogenous change in supervision increasing the liquidation set $\mathcal{L}$ leads to a lower r^* (more foreign lending).*
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.4. 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.

This corollary partly vindicates the idea that a more efficient supervisory system will foster credit market integration. This is actually one of the objectives expressed in the European Commission's proposal on the Banking union: better and more harmonized supervision is seen as a tool towards a more integrated market for credit and financial services in Europe. 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.

Point 2 however shows that integration also has a less optimistic consequence: as r decreases and foreign lending increases, so does the conflict of objectives between local and central supervisors if demand elasticity is high enough. As a result, the central supervisor has to invest more in monitoring, or may choose to centralize supervision.

Taken together, these results show that the extent of local supervisory forbearance is endogenously limited by market forces. When forbearance is high, foreign lending is low, reducing incentives for forbearance. The effects of an increase in central supervision are thus partially offset by a decrease in a form of market discipline exerted on the local supervisor.

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. In a simple dynamic process where investors would react to the behavior of supervisors in the previous period and supervisors would react to past levels of foreign lending, centralization and integration would both increase over time until an equilibrium is reached. A conclusion for the design of the European SSM is that some 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 central supervisor should retain responsibility for all European banks, as the implementation of the SSM itself may worsen conflicts of objectives. It is easier to gradually adjust the degree of central supervision for specific banks over time than to periodically update a list of centrally supervised banks.

Finally, 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.5 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 for the same parameters. One with centralized supervision, in which foreign investors are ready to lend a high quantity at a low interest rate because risk is small, and another one with delegated supervision, where foreign investors lend much less, hence the conflict of objectives is small and the supervision is entirely delegated to the local level. This proposition shows that, when deciding on an optimal supervisory architecture, *the starting point matters*: a small bank entirely supervised at the local level may attract few foreign lenders precisely because supervision is local, and the low proportion of foreign lenders justifies local supervision. But switching to a more centralized supervision may increase foreign lending and endogenously justify centralized supervision. Moreover, such a switch can lead the economy out of an equilibrium with a lower global welfare, at least when supervision costs are low enough.

Notice that the timing assumption matters in this proposition. 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.

The proposition shows analytically how multiplicity obtains in a particular case, but the conditions given are not necessary. Figure 5 is based on an example featuring both an equilibrium with centralization and an equilibrium with a mixed solution[10]. For every possible

[10]The parameterization used is $\ell = 0.2$, $D_S = 0$, $D(r) = r^{-2}$, Φ is a Beta CDF with $a = 9, b = 1$. To neutralize trivial economies of scale effects, costs are assumed to be proportional to $(1+r)L$: $c = 0.0001 \times (1+r)L$ and $C(\lambda) = (1+r)L \times (\exp(\gamma/(1-\lambda)) - \exp(\gamma))$, with $\gamma = 10^{-7}$.

r on the x-axis, I compute p^*, p^{**} and the central supervisor's optimal choice. This defines in particular an interval of r for which supervision is centralized, and another one in which the solution is mixed. When it is mixed the blue line RM represents the regulator's optimal choice λ. The red line MM represents for each λ the interest rate r that makes investors indifferent. The intersection defines a first equilibrium with a mixed solution (r_m, λ_m). In the centralized supervision region, I simply plot the line MC that gives the interest rate r making investors indifferent when supervision is centralized. This gives another equilibrium with centralization and $r = r_c$. Figure 6 additionally plots the values of p^* and p^{**} obtained for each r and in the two equilibria. The example on purpose considers a case quite different from that of Proposition 4, as in particular elasticity is not high enough for p^* to be increasing in r.

[Insert Fig. 5 and Fig. 6 here.]

4 Extensions

4.1 Financial system architecture and forbearance

The model developed in Section 3.1 features a simple distribution of credit losses between local and foreign agents. This section develops an extension incorporating the possibility of a bank's default indirectly affecting other banks via domino effects.

The new market structure: I introduce a new asset, and a new type of agents:

-*Diversified risky assets* are accessible to core banks and represent a portfolio of assets not tied to a particular region. These assets have a return of $1+\rho$, where $\rho \hookrightarrow F(.)$ over $[0, +\infty]$. Diversified assets are thus essentially safe, a convenient assumption that allows to focus on the risk coming from local loans. $\bar{\rho}$ denotes the expected value of ρ.

-*Core banks* have deposits D_C and borrow at rate i_C from foreign investors. They can lend to small banks or invest in diversified risky assets, assumed to be independent. All core banks are ex ante identical and exactly $F(x)$ banks will have a return ρ lower than x on their assets. α_C denotes the proportion of their liabilities owed to local depositors.

Local banks (or small banks) can no longer borrow directly from foreign investors. Instead, they can only borrow at rate i_S from core banks, which have access to the foreign investors. Notice that as core banks are also domestic banks, their profit enters the definition of local welfare. This structure mimics in a simplified manner the "core-periphery" structure of many (in particular European) interbank markets. I make the same assumptions on core banks as on local banks: risk-neutrality, limited liability, price-taking behavior.

The analysis focuses on parameter values where in equilibrium small banks want to invest more than D_S in local loans and core banks want to invest up to D_C in diversified assets, so that additional local loans are ultimately financed by foreign banks, core banks acting as intermediaries. I assume an equilibrium where $r \geq i_S \geq i_C$ and $L > 0$ and look at the supervisor's incentives as in Section 3.1.

Remark 1. *There exists $\underline{\ell} \in [0, 1)$ such that the local supervisor chooses $p^* < p^{**}$ when $\ell \geq \underline{\ell}$ and engages in supervisory forbearance. Under these parameters:*

1. *Local supervision and forbearance decrease in ℓ.*
2. *Local supervision increases and forbearance decreases in α_C and α_S.*
3. *D_S and D_C have a positive impact on α_C and α_S but their total impact is ambiguous.*
4. *Multiplying D_S, D_C, L by the same scalar does not affect local supervision and forbearance.*
5. *Forbearance disappears in the following cases: $\ell \to 1$, $\alpha_C \to 1$, $D_S \to L$, $D_C \to +\infty$.*

The proof is in the Appendix A.6. The comparative statics illustrate the source of supervisory forbearance in this extended model, namely that the surplus generated through supervision of the small banks' assets "leaks" towards foreign creditors. When α_S increases more of the liquidated local assets will remain in the hands of local depositors. The rest goes to the core banks, part of them will default and hand over the proceeds of the liquidated assets to their depositors and to foreign banks. When α_C increases they give less to foreign banks, so that the supervisor has better incentives.

The results on the impact of D_S, D_C and L nicely relate to the debates on whether the SSM should apply to all European banks or only the largest ones. Local banks in this model can be very small but yet "systemic as a herd" (Brunnermeier *et al.* (2009)), as they are all exposed to the same risk. What needs to be appreciated is not the size of each individual bank, but how they determine the distribution of losses among local and foreign agents.

When core banks are so big relative to local banks that they can almost certainly absorb losses, the supervisor has correct incentives because liquidation proceeds do not accrue to foreigners. Conversely, if L is large then the domestic banking sector as a whole borrows heavily from foreign banks, which gives few incentives to liquidate the projects.

Finally, imagine that the local supervisor is made responsible for the small banks only. This is the case in the United States for instance where State supervisors are not responsible for national banks, and this was also one of the solutions discussed, and abandoned, for the European SSM. A supervisor with a limited mandate may simply neglect the impact of his choices on banks he does not supervise. This effect will lead the supervisor to be too forbearant, as part of the losses are now some other supervisor's problem. This is easy to see in the framework of this section:

Remark 2. *Assume $D_C \to +\infty$. A supervisor taking into account both core and small banks chooses the efficient threshold p^{**}, while a supervisor responsible for small banks only chooses $p^* < p^{**}$ and is too forbearant.*

Proof: point 5 in Remark 1 shows that a supervisor responsible for both types of banks takes the efficient decision in this limit case. A supervisor responsible for small banks only will expect a welfare $\tilde{W}_s$ in state s, with $\tilde{W}_0 = 0, \tilde{W}_1 = (1+r)L - (L - D_S)(1 + i_S)$ and $\tilde{W}_I = \alpha_S(1-\ell)L$. We just have to show that these quantities define $p^* = \frac{W_1}{W_I} < p^{**}$ which has already been done as it is equivalent to showing that the expression in (12) is positive.■

This section concludes on two warnings. First, although evaluating the proportion of foreign creditors of a bank is a necessary step, it is not sufficient and can lead to significant type 2 errors when testing whether a bank is correctly supervised at the local level. This section studied a case where small banks are only indebted towards other domestic banks, and yet they are incorrectly supervised due to domino effects when they default. Allocation of supervisory powers should be based on simulations of who would be indirectly impacted by a default and the focus should not be on multinational banks only. Second, there is a risk that a supervisor who gets allocated only a part of the banking system will neglect the negative spill-overs of "his" banks towards others. An optimal architecture should thus rely on joint supervision (with more or less involvement of the different levels) rather than on strict separation.

4.2 Risk-averse supervisors and systemic risk

The framework of Section 2.1 can be used to model many types of externalities and preferences. It is particularly interesting 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 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 3. *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. Imagine that a systemic failure would imply losses of 2% of a country's GDP, reduced to 0.5% in case of intervention. Additionally, there are external losses of 1% and 0.1%, respectively. The trade-off for the local supervisor is between -0.5% for sure against either no change in GDP or -2%. Imagine a central supervisor responsible for ten countries as large. She compares sure losses of 0.06% with a lottery giving no change or -0.3%. Risk-neutral supervisors would choose $p^{**} = 0.8 > p^* = 0.75$. This section additionally takes into account that facing a -2% decrease in GDP should make the local supervisor much more cautious, potentially reversing this order.

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, suggesting that the local supervisor should be quite cautious. A counter-example would be Cyprus, where it is difficult to understand ex post how the supervisor did not intervene earlier. This suggests looking further into the supervisors' incentives using a political economy approach. It is possible in particular that rewards for triggering moderate losses in the banking sector for fear of seeing more losses in the future are quite low, which gives the supervisor risk-seeking preferences.

4.3 Common deposit insurance and resolution authority

Although fully studying the additional components foreseen in the building of a European Banking union is beyond the scope of this paper, it is possible to illustrate some effects of deposit insurance and resolution rules on the supervisors' incentives.

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. A less obvious implication is that once common deposit insurance is introduced, an already in place common supervision system has to be further strengthened as local supervisors' incentives are weakened. Again this is an argument for a flexible mechanism in Europe that could be strengthened over time.

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. To some extent, 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 may lend less.

We can modify the framework of Section 3.2. We had no discrimination between domestic and foreign agents in that section, which would typically be the case with a common resolution authority, so that a proportion α_S of the proceeds accrued to domestic agents. Assume that this proportion is now an exogenous parameter $\alpha \in [\alpha_S, 1]$, measuring the protection of foreign depositors in case of default, from equal rights to full expropriation.

A common resolution mechanism is modeled as a decrease in α. Assuming for simplicity the other parameters to be such that supervision is entirely delegated to the local level, r^* and p^* are simultaneously determined in equilibrium. The following Remark, proved in the Appendix A.7, shows how both are affected by the introduction of common resolution:

Remark 4. *The introduction of a common resolution mechanism leads to less forbearance and more market integration if α is close enough to 1.*

A common resolution scheme thus improves both market integration and supervision if in the initial situation foreign depositors get almost nothing in case of intervention. This also decreases the conflict of objectives between the two supervisors. In a less extreme situation however, a positive impact is not warranted: supervisors may be less inclined to intervene if triggering the resolution of banks implies more losses to domestic agents. Foreign agents are less eager to invest if this effect more than compensates their fairer treatment under intervention. Finally, notice that foreign investors are risk-neutral here, so that it is possible to compensate them for possible future expropriation by increasing interest rates. With risk averse investors the risk of expropriation would matter more, and a common resolution mechanism would have a more positive impact on market integration.

4.4 Other strategic problems

This paper focuses on a particular friction between the central supervisor and the local supervisor, namely hidden information, which reflects the informational advantage of the local supervisor. Moreover there are no gains from cooperation for the local supervisor. The model could be extended by relaxing these two assumptions.

Moral hazard: in some instances the problem is not that the local supervisor takes the wrong decision, but rather that he does not exert enough effort at monitoring the bank. The local supervisor could for instance have only a signal about a bank's soundness, with a technology similar to the central supervisor's. He may under-invest in information acquisition, as the losses arising from failing to identify a risky bank are partly borne by outsiders.

These efforts at acquiring information are not necessarily hidden. A local supervisor with a low budget may signal to the central supervisor that local supervision is inadequate. Indeed, Rezende (2011) shows that in the United States the Fed and the FDIC are more likely to engage in joint supervision with a local supervisor when the latter has a lower budget. The author hypothesizes that State supervisors with low budgets are more eager to get the help from a Federal supervisor, but concerns by the latter that the State supervisor does not have the resources to adequately inspect the banks may also play a role.

Strategic communication: the central supervisor in the model produces her own signal, which is thus reliable. Alternatively, the local supervisor could send information to the central supervisor. In the United States, a bad CAMELS rating given by a State supervisor can trigger an examination by a Federal supervisor. There is no scope for such communication in the model: double inspections are assumed to be too costly, and a supervisor who inspects the bank has all the information and thus does not need to communicate with other supervisory authorities. A possible extension would be to assume that both supervisors get imperfect and independent signals. A local supervisor then has an incentive to reveal his information at least when it's sufficiently negative: without any central supervisor he would liquidate the bank himself, and involving the central supervisor only makes a difference if the latter has a positive signal and decides not to liquidate the projects. This would fit the finding of Agarwal *et al.* (2012) that State supervisors are less likely than Federal supervisors to downgrade CAMELS ratings. See Holthausen and Ronde (2004) for a model of a cheap talk game between two supervisors of a multinational bank.

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 local banks than does a central supervisor. Supervision can be centralized, delegated, or in the middle a central supervisor can rely on off-site monitoring to inspect banks when she suspects that the local supervisor is too forbearant. The optimum 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 dimension has attracted the most attention, but it 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. Even small banks not directly connected to foreign institutions can be inadequately supervised if their distress has second-round effects. More generally, measuring this dimension requires the difficult task of identifying the incentives of the local supervisor.

Finally, which arrangement is optimal for a specific bank is likely to evolve due to the supervision's impact on the market. Centralized supervision makes it more attractive for foreign agents to lend to domestic banks, which makes centralized supervision more necessary. This implies that a central supervisor should have enough flexibility to centralize or delegate more as market conditions change. Moreover, due to this complementarity between centralized supervision and foreign lending, it is possible to be stuck in an equilibrium with low credit market integration and local supervision when another equilibrium with high integration and centralized supervision would be possible and preferable.

A Appendix

A.1 Proof of Proposition 1

Full delegation is obtained whenever $B(\lambda, p^*) < c$, and delegation when $B(\lambda, 0) > c$. For a given λ, an interior solution is obtained for when $c \in [B(\lambda, 0), B(\lambda, p^*)]$. We have:

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

Differentiating $\bar{B}$ gives:

$$\frac{\partial \bar{B}}{\partial p^*} = -(p^{**} - p^*)\phi(p^*) < 0, \ \frac{\partial \bar{B}}{\partial p^{**}} = \Phi(p^{**}) - \Phi(p^*) > 0 \tag{18}$$

It is then straightforward to show that $B(\lambda, 0)$ is decreasing in p^* and increasing in p^{**}, while the opposite holds for $B(\lambda, p^*)$. The size of the interval $[B(\lambda, 0), B(\lambda, p^*)]$ is simply given by $(W_1 - W_0)\lambda(p^{**} - p^*)$, which is decreasing in p^{**} and increasing in p^*. Finally, the probability of inspection is 1 in case of centralization, 0 with delegation, and $\Phi(\bar{s}(\lambda)) - \Phi(p^*)$ for a mixed solution. Using equations (8) and (18) shows that this difference is increasing in p^{**} and decreasing in p^*, which proves point 1.

For point 2, looking at Figure 1 based on Lemma 1, it is easy to see that increasing c implies the mentioned switches. As moreover $\bar{s}(\lambda)$ is decreasing in c this shows that the probability of inspection decreases with a higher c.

For the third point the cases where the proposed change in λ leads to a switch from centralization or delegation to a mixed solution is quite clear on Figure 1. For a small increase of λ inside the mixed solution region, it is enough to show that $\bar{s}(\lambda)$ increases in λ for $c > (W_1 - W_0)\bar{B}$ and decreases otherwise. Using equation (8), the derivative of $\bar{s}$ with respect to λ is given by:

$$\bar{s}'(\lambda) = \frac{1}{\lambda^2(W_1 - W_0)}(c - \bar{B}(W_1 - W_0)) \tag{19}$$

which shows point 3.

A.2 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 $B^c = (W_1 - W_0)\bar{B} - c$.

Consider first the case where $c < (W_1 - W_0)\bar{B}$ and assume c is very close to $(W_1 - W_0)\bar{B}$. 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 (19) and $C'(0) = 0$, the derivative with respect to λ close to zero is given by:

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

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 $(W_1 - W_0)\bar{B}$. 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:

$$\frac{\partial \bar{s}(\lambda)}{\partial \lambda}(B(\lambda, \bar{s}(\lambda)) - c)\phi(\bar{s}(\lambda)) + \int_{p^*}^{\bar{s}(\lambda)} (p^{**} - s - \bar{B})\phi(s)ds - C'(\lambda) \tag{20}$$

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

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

the first term is negative, and we have:

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

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

The study of the case $(W_1 - W_0)\bar{B} > c$ is entirely symmetric. An interior λ is necessarily optimal for c close enough to $(W_1 - W_0)\bar{B}$, 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 $c - (W_1 - W_0)\bar{B} > 0$ we reach the opposite conclusion that the optimal λ is decreasing in c.

A.3 Proof of Corollary 2

Define B^* the maximum benefit from central inspection with an interior λ. We have:

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

Using the envelope theorem, we have:

$$\begin{aligned}
\frac{\partial B^*}{\partial p^*} &= (W_1 - W_0)(1-\lambda)\frac{\partial \bar{B}}{\partial p^*}(\Phi(\bar{s}(\lambda)) - \Phi(p^*)) - (B(\lambda, p^*) - c)\phi(p^*) \\
\frac{\partial B^*}{\partial p^{**}} &= (W_1 - W_0)\left(\lambda + (1-\lambda)\frac{\partial \bar{B}}{\partial p^{**}}\right)(\Phi(\bar{s}(\lambda)) - \Phi(p^*))
\end{aligned}$$

Using (18), B^* increases in p^{**} and decreases in p^*, while B^d is not affected, proving the first point.

For the second point we need to compute the derivative of B^c with respect to p^{**}:

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

It is enough to show that $\frac{\partial B^c}{\partial p^{**}} > \frac{\partial B^*}{\partial p^{**}}$, which 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. This shows that a higher p^{**} increases the region with centralization.

Taking the derivative with respect to p^{**} of the marginal benefit given in (20):

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

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

The third point is proven similarly. The derivative of B^c with respect to p^* is given by:

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

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

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

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

$$(p^{**} - p^*)(1 - (\Phi(\bar{s}(\lambda)) - \Phi(p^*))) > \bar{B} \tag{21}$$

As moreover $\bar{B} < (p^{**} - p^*)(\Phi(p^{**}) - \Phi(p^*))$ 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 (20) with respect to p^* gives:

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

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

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

which is negative under the same conditions that ensure (21) is satisfied.

A.4 Proof of Proposition 3

Point 1. I first show that, all else equal, an increase in the probability of liquidation conditional on p being in $[p^*, p^{**}]$ 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 $L - D_S$ 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 (22) increases when $\mathcal{L}$ expands. Differentiation shows that the left-hand side is always increasing in r^*. Thus to restore equilibrium r^* has to decrease when supervision increases, since $D(r^*) = L$ and D is decreasing foreign lending $L - D_S$ has to increase.

Point 2. As $\Phi(1-\ell) < \frac{1}{2}$ and $p^{**} < 1-\ell$, point 3 of Corollary 2 applies. The only thing we need to prove is that under the assumptions of the proposition p^{**} decreases in r and p^* increases. This is obvious for p^{**} given equation (11). Then p^* can be written for a given equilibrium r (taking into account $L = D(r)$) as:

$$p^* = \frac{(1-\ell)D(r)}{(1+r)D_S + (1+r)^2(D(r) - D_S)}$$

Differentiating with respect to r and rearranging gives:

$$\frac{\partial p^*}{\partial r} \geq 0 \Leftrightarrow \epsilon \geq 2\frac{D(r) - D_S}{D_S} + \frac{1}{1+r}, \ \epsilon = \frac{-rD'(r)}{D(r)}$$

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

A.5 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 (22) gives us:

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

As shown in A.4, 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 $(1+r)L\bar{B} - c$, and delegation, which brings zero. To have both equilibria as possible outcomes we need:

$$(1+r_c)D(r_c)\int_{p^*(r_c)}^{p^{**}(r_c)} (p^{**}(r_c) - p)\phi(p)dp \geq c \geq (1+r_d)D(r_d)\int_{p^*(r_d)}^{p^{**}(r_d)} (p^{**}(r_d) - p)\phi(p)dp \quad (22)$$

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 $r_c \leq r_d$ and $D(.)$ is very elastic, we also have $(1+r_c)D(r_c) \geq (1+r_d)D(r_d)$. Thus the left-hand side in equation (22) 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, its is sufficient to consider the case where c is equal to the lower bound:

$$c = c_1 = (1 + r_d)D(r_d)(1 + r_d)D(r_d) \int_{p^*(r_d)}^{p^{**}(r_d)} (p^{**}(r_d) - p)\phi(p)dp$$

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:

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

By definition of c_1, the central supervisor is indifferent between centralizing and delegating for the given interest rate r_d. Thus W_d is also equal to the global welfare that would obtain with centralized supervision (this equality can also easily be derived analytically):

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

Given that under our assumptions we have $D(r_c) \geq D(r_d)$ and $(1+r_c)D(r_c) \geq (1+r_d)D(r_d)$, welfare is equal or higher in the centralized equilibrium for any value of p. This shows that $W_c \geq W_d$.

A.6 Proof of Remark 1

Condition for forbearance: Notice that in case of default by small banks, a core bank will default only if its rate of return on diversified assets is too low. Due to limited liability, a core bank will thus evaluate its profits based only on states of the world with a high enough realization of ρ. It will be useful to introduce the following function:

$$s(x) = \int_0^x (x - \rho)f(\rho)d\rho \tag{23}$$

$s(x)$ is the probability that the diversified asset's return is below x, times the expected difference between x and the return conditional on the return being below x. Notice that $s'(x) = F(x)$. Moreover, similarly to α_S introduced in (10), the proportion of a core bank's assets accruing to depositors in case of default is:

$$\alpha_C = \frac{D_C}{D_C + (L - D_S)(1 + i_C)} \tag{24}$$

π_s^C now denotes the profit of core banks in state s. There are again three states to consider:
-*State 1: no intervention, successful loans.* All small banks survive and get a profit of $\pi_1^S = L(r - i_S) + i_S D_S$. As $\rho \geq 0$ and $i_S > i_C$ no core bank defaults and the aggregate profit of core

banks can be rewritten as:

$$\pi_1^C = \int_0^{+\infty} [\rho D_C + (L - D_S)(i_S - i_C)] f(\rho) d\rho = (L - D_S)(i_S - i_C) + D_C \bar{\rho}$$

As there are no defaults we have $\pi_1^D = D_S + D_C$ and $\pi_F^1 = (L - D_S)(1 + i_C)$. Finally local welfare is $W_1 = (1 + r)L + (1 + \bar{\rho})D_C - (L - D_S)(1 + i_C)$.

-*State* 0*: no intervention, defaulting loans.* Small banks's assets are worth zero, hence $\pi_0^S = 0$ and the depositors get nothing. A core bank gets zero return on its loans to small banks and defaults for ρ smaller than some threshold $\rho_0 > 0$. Its profit and ρ_0 are

$$\pi_0^C = \int_{\rho_0}^{+\infty} [\rho D_C - (L - D_S)(1 + i_C)] f(\rho) d\rho = D_C(\bar{\rho} - \rho_0 + s(\rho_0)), \rho_0 = \frac{(L - D_S)(1 + i_C)}{D_C}$$

Computing again the sum of deposits minus costs to the deposit insurer, after some manipulations we have:

$$\pi_0^D = (1 - F(\rho_0))D_C + \alpha_C \int_0^{\rho_0} (1 + \rho) D_C f(\rho) d\rho = D_C(1 - \alpha_C s(\rho_0))$$

So that in the end we get $W_0 = (1 + \bar{\rho})D_C - (L - D_S)(1 + i_C) + (1 - \alpha_C)D_C s(\rho_0)$. Finally, the payoff to foreign banks is $\pi_0^F = (L - D_S)(1 + i_C) - (1 - \alpha_C)D_C s(\rho_0)$.

-*State I: supervisory intervention, loans are liquidated.* As in Section 3.1 we have $\pi_I^S = 0$. Core banks recover $(1 - \alpha_S) \times (1 - \ell)L$. Using the same reasoning as in the case of no intervention:

$$\pi_I^C = D_C(\bar{\rho} - \rho_I + s(\rho_I)), \rho_I = \rho_0 - \frac{(1 - \alpha_S)(1 - \ell)L}{D_C}$$

and then $\pi_I^D = D_C(1 - \alpha_C s(\rho_I))$, $W_I = (1 + \bar{\rho})D_C + (1 - \ell)L - (L - D_S)(1 + i_C) + (1 - \alpha_C)D_C s(\rho_I)$ and $\pi_I^F = (L - D_S)(1 + i_C) - (1 - \alpha_C)D_C s(\rho_I)$.

The first-best level of intervention for given prices and quantities is the same as in the previous section. For local supervision we need to compare W_1, W_0 and W_I. As $s(.)$ is increasing and $\rho_0 > \rho_I > 0$ we have $s(\rho_0) > s(\rho_I) > 0$, thus ranking the welfare in the different cases is not obvious. W_I is decreasing in ℓ as its derivative with respect to this variable is equal to $-L + (1 - \alpha_C)(1 - \alpha_S)LF(\rho_I) < 0$. When $\ell \to 1$, W_0 and W_I become equivalent, hence $W_I \geq W_0$. Conversely, W_I is always lower than its value when $\ell = 0$. This value is equal to the value of W_1 when $r = 0$, and W_1 is increasing in r. Hence $W_1 \geq W_I \geq W_0$. Thus the local supervisor liquidate the projects if and only if $p < p^*$, where:

$$p^* = \frac{W_I - W_0}{W_1 - W_0} = \frac{(1 - \ell)L - (1 - \alpha_C)D_C(s(\rho_0) - s(\rho_I))}{(1 + r)L - (1 - \alpha_C)D_C s(\rho_0)}$$

Direct computations using the explicit values of p^* and p^{**} then give the following equivalence:

$$p^* \leq p^{**} \Leftrightarrow p^* \leq \frac{s(\rho_0) - s(\rho_I)}{s(\rho_0)} \Leftrightarrow p^{**} \leq \frac{s(\rho_0) - s(\rho_I)}{s(\rho_0)} \tag{25}$$

Define $\nu(\ell) = (1+r)(s(\rho_0) - s(\rho_I)) - (1-\ell)s(\rho_0)$. We have to show that $\nu(\ell)$ is positive for ℓ high enough. Notice first that for $\ell = 1$ we have $\rho_0 = \rho_I$ and thus $\nu(1) = 0$. We then have:

$$\nu'(\ell) = s(\rho_0) - (1+r)\frac{(1-\alpha_S)L}{D_C}F(\rho_I),\ \nu''(\ell) = -(1+r)\left(\frac{(1-\alpha_S)L}{D_C}\right)^2 f(\rho_I)$$

ν is thus concave. We finally have:

$$\nu'(1) = s(\rho_0) - (1+r)\frac{(1-\alpha_S)L}{D_C}F(\rho_0)$$

As $s'(x) = F(x)$ we have $s(\rho_0) \leq \rho_0 F(\rho_0)$ and thus:

$$\begin{aligned}
\nu'(1) &\leq F(\rho_0)\left(\rho_0 - (1+r)\frac{(1-\alpha_S)L}{D_C}\right) \\
&\leq \frac{F(\rho_0)(L-D_S)}{D_C(D_S + (L-D_S)(1+i_S))}\left(L(1+i_S)(i_C - r) - i_S(1+i_C)\right) \leq 0
\end{aligned}$$

Where the last inequality comes from the fact that in equilibrium r must be larger than i_C. This proves the proposition. $\underline{\ell}$ is the largest $\ell < 1$ such that $\nu(\ell) = 0$. Notice that it is possible to have $\nu(0) \geq 0$, in which case $\underline{\ell} = 0$ and we have under-supervision for any ℓ.

Comparative statics: point 1 directly follows from the previous proof. Notice we have:

$$\frac{\partial p^*}{\partial \ell} = \frac{L}{W_1 - W_0}((1-\alpha_S)(1-\alpha_C)F(\rho_I) - 1)$$

For point 2 we have:

$$\begin{aligned}
\frac{\partial p^*}{\partial \alpha_C} &= D_C L\frac{(s(\rho_0) - s(\rho_I))(1+r) - s(\rho_0)(1-\ell)}{W_1 - W_0} \\
\frac{\partial p^*}{\partial \alpha_S} &= \frac{(1-\alpha_C)D_C F(\rho_I)}{W_1 - W_0} \times \frac{\partial \rho_I}{\partial \alpha_S} = \frac{(1-\alpha_C)(1-\ell)LF(\rho_I)}{W_1 - W_0}
\end{aligned}$$

The first derivative is positive given the inequalities in (25) and the second one is obviously positive. For point 3 we first have:

$$\begin{aligned}
\frac{\partial \alpha_C}{\partial D_S} &= (1+i_C)\frac{\alpha_C^2}{D_C}, \ \frac{\partial \alpha_C}{\partial D_C} = \frac{(1-\alpha_C)\alpha_C}{D_C} \\
\frac{\partial \alpha_S}{\partial D_S} &= \frac{L(1+i_S)\alpha_S^2}{D_S^2} \\
\frac{\partial p^*}{\partial \rho_0} &= -\frac{(1-\alpha_C)D_C F(\rho_0)}{W_1-W_0}(1-p^*), \ \frac{\partial p^*}{\partial \rho_I} = \frac{(1-\alpha_C)D_C F(\rho_I)}{W_1-W_0}
\end{aligned}$$

Then for the effect of D_C:

$$\begin{aligned}
\frac{\partial p^*}{\partial D_C} &= \underbrace{\frac{\partial p^*}{\partial \alpha_C} \times \frac{\partial \alpha_C}{\partial D_C}}_{\geq 0} \underbrace{-\frac{\rho_0}{D_C} \times \frac{\partial p^*}{\partial \rho_0}}_{\geq 0} \underbrace{-\frac{\rho_I}{D_C} \times \frac{\partial p^*}{\partial \rho_I}}_{\leq 0} \\
&+ \frac{(1-\alpha_C)D_C L(1+r)s(\rho_0)}{(W_1-W_0)^2} \times \underbrace{(p^{**} - (s(\rho_0)-s(\rho_I))/s(\rho(0)))}_{\leq 0} \\
&= \frac{1-\alpha_C}{W_1-W_0}\left(\rho_0(1-p^*)F(\rho_0) - \rho_I F(\rho_I) + \left(\frac{s(\rho_0)-s(\rho_I)}{s(\rho_0)} - p^{**}\right) L(1+r)\left(\alpha_C s(\rho_0) - \frac{D_C}{W_1-W_0}\right)\right)
\end{aligned}$$

And for the effect of D_S:

$$\frac{\partial p^*}{\partial D_S} = \underbrace{\frac{\partial p^*}{\partial \alpha_C} \times \frac{\partial \alpha_C}{\partial D_S}}_{\geq 0} + \underbrace{\frac{\partial p^*}{\partial \alpha_S} \times \frac{\partial \alpha_S}{\partial D_S}}_{\geq 0} + \frac{(1+i_C)(1-\alpha_C)}{W_1-W_0}(F(\rho_0)(1-p^*) - F(\rho_I))$$

For point 4 it is easy to check that doubling L, D_S, D_C leaves $\alpha_C, \alpha_S, \rho_0, \rho_I$ and then p^* unchanged. For the last point, it is straightforward to compute that $p^* = p^{**}$ when $\ell = 1$ or $\alpha_C = 1$. When $D_S \to L$ or $D_C \to +\infty$ then $\alpha_C \to 1$ and ρ_0 and ρ_I tend to zero, so that p^* tends to p^{**}.

A.7 Proof of Remark 4

The local supervisor gets $\hat{W}_I = \alpha(1-\ell)L$ in case of intervention instead of $\alpha_S(1-\ell)L$, while $\hat{W}_1$ and $\hat{W}_0$ are the same as in Section 3.1. With $L = D(r)$ in equilibrium this gives us the value of p^*. An amount of $(1-\alpha)(1-\ell)L$ accrues to foreign investors in case of intervention, on a marginal unit lent an investor expects to get this amount over the total quantity of loans $(L - D_S)$ in case of intervention. p^* and r are thus determined in equilibrium by the two following equations, corresponding to optimal intervention, optimal investment by foreigners, and the market equilibrium condition $L = D(r)$:

$$\begin{aligned}
0 &= p^*(1+r)D_S - \alpha(1-\ell)D(r) \\
0 &= \Phi(p^*)(1-\alpha)(1-\ell)D(r) + (1+r)(1-\Phi(p^*))\mathbb{E}(\tilde{p}|\tilde{p} \geq p^*)(D(r) - D_S)
\end{aligned}$$

Differentiating these two equations and replacing gives us the following two relations between $dr/d\alpha$ and $dp^*/d\alpha$:

$$\begin{aligned} \frac{1+r}{1-\ell}\frac{D_S}{D(r)} \times \frac{dp^*}{d\alpha} + \frac{\alpha(1+\eta(r))}{1+r} \times \frac{dr}{d\alpha} &= 1 \quad (26) \\ \frac{\phi(p^*)}{\Phi(p^*)}\frac{D(r)}{D_S}\left(\frac{D_S}{D(r)} - \alpha\right) \times \frac{dp^*}{d\alpha} - \frac{1-\alpha}{1+r}\left(1 - \eta(r)\frac{D_S}{D(r)-D_S}\right)\frac{dr}{d\alpha} &= 1 \quad (27) \end{aligned}$$

where $\eta(r) = -D'(r)(1+r)/D(r) > 0$ measures the elasticity of demand for loans. In (27) the signs of the coefficients on $dp^*/d\alpha$ and $dr/d\alpha$ depend on how large are α (from α_S, no discrimination between local and foreign creditors, to $\alpha = 1$, expropriation of foreign creditors) and $\eta(r)$.

With α close to 1 in equation (27) and since $D(r) > D_S$ in equilibrium we must have $dp^*/d\alpha < 0$, so that decreasing α reduces forbearance. From equation (26) we deduce that either r or p^* is increasing in α near the equilibrium. This implies that r is increasing in α, so that reducing α increases the volume of loans and thus market integration.

A.8 Figures

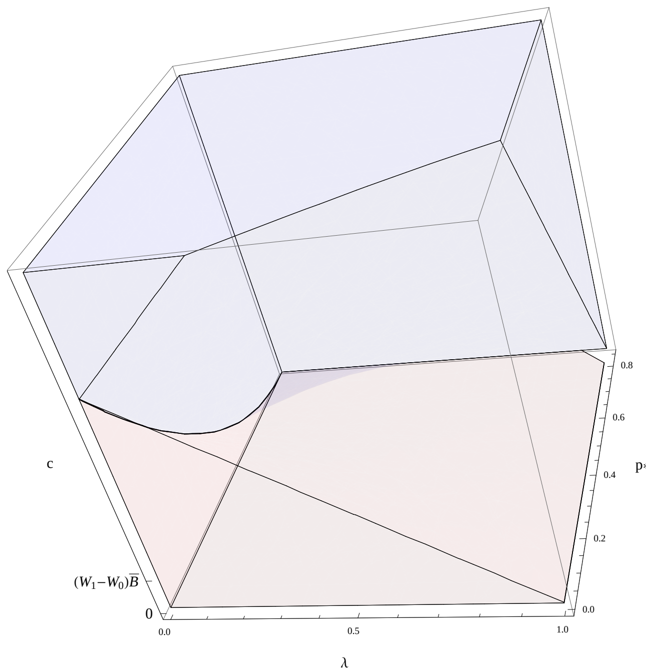

Figure 1: Regions with centralization (red), delegation (blue) and mixed solution (transparent) depending on p^*, λ and c.

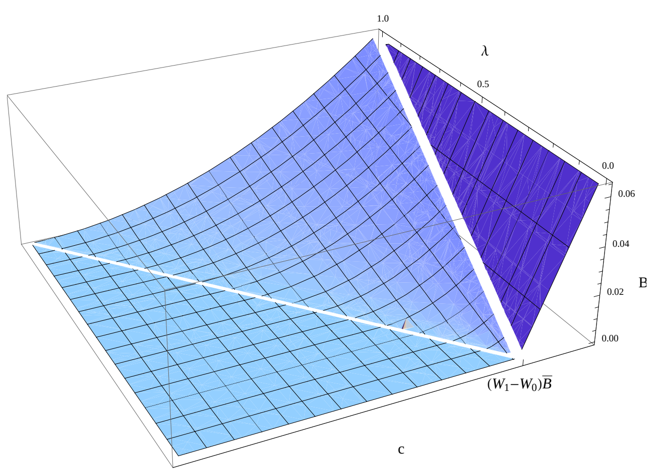

Figure 2: Expected benefit $\mathcal{B}(\lambda)$ as a function of λ and c, $C(\lambda) = 0$.

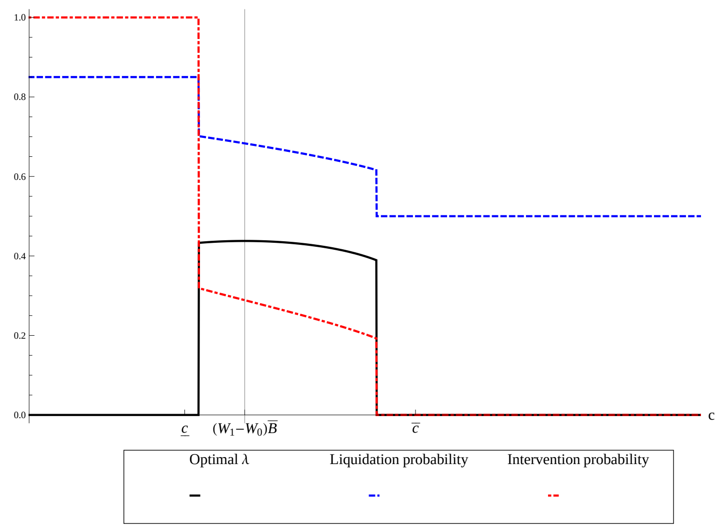

Figure 3: Optimal λ as a function of c, and implied probabilities of inspection and liquidation.

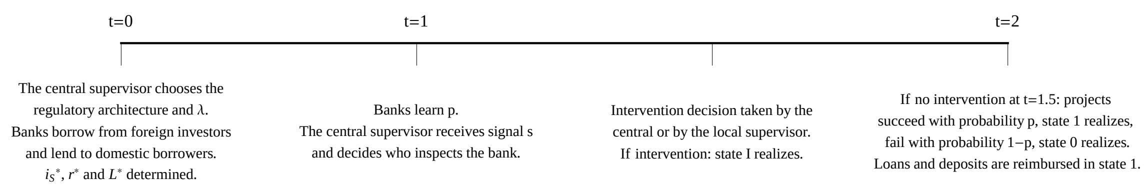

Figure 4: Timeline of the game with endogenous supervision and market equilibrium.

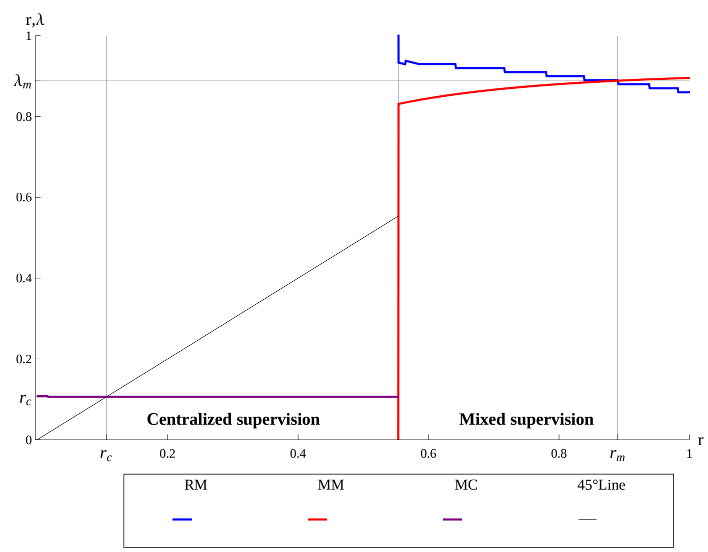

Figure 5: Example with two equilibria: centralization (left) and mixed solution (right).

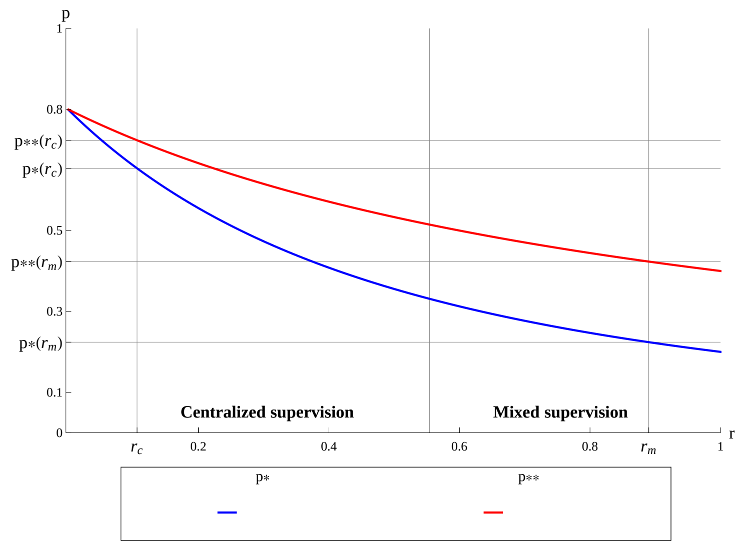

Figure 6: Values of p^* and p^{**} for each r in the example.

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