Optimal Supervisory Architecture and Financial Integration in a Banking Union

Jean-Edouard Colliard

First version: March 2013
This version: March 15, 2017

Abstract

Both in the United States and in the Euro area, bank supervision is the joint responsibility of local and central supervisors. Local supervisors do not internalize as many externalities as the central supervisor and are thus more lenient. However, banks also have weaker incentives to hide information from them. The optimal supervisory architecture is mixed, and puts more weight on centralized supervision when bank defaults generate larger cross-border externalities. Conversely, centralized supervision endogenously encourages banks to integrate more cross-border. Due to this complementarity, the economy can be trapped in an equilibrium with both too little central supervision and too little market integration, when a superior equilibrium would be achievable.

JEL Classification Number: G28, G21, L51.

Keywords: banking union, bank supervision, financial integration.

*I am grateful to Elena Carletti, Dean Corbae, Olivier De Bandt, Hans Degryse, Giovanni Di Iasio, Co-Pierre Georg, Denis Gromb, Peter Hoffmann, Charles Kahn, Julian Kohl, Myron Kwast, Perrin Lefebvre, Gyongyi Loranth, David Marques-Ibanez, Clemens Otto, Marco Pagano, Marcelo Rezende, Roberto Savona, Bernd Schwaab, Alireza Tahbaz-Salehi, Alexandros Vardoulakis, Larry Wall, Marius Zoican, seminar participants at the European Central Bank, the Deutsche Bundesbank, the Paris School of Economics, the University of Mannheim, the University of Zurich and HEC Paris, and participants to the 2015 CSEF conference on Bank Performance, Financial Stability and the Real Economy; the 2014 IBEFA meetings, the 5th Financial Stability Conference in Tilburg, the 2013 Bocconi-Carefin Conference, the 2013 CREDIT Conference, the 2013 Conference on Banks and Governments in Globalised Financial Markets and the 2013 EEA Congress for helpful comments and suggestions. An earlier version of this paper won the 2013 SUERF/Unicredit & Universities Foundation Research Prize.

†HEC Paris, Finance department. Address: HEC Paris, 1 rue de la Liberation, 78351 Jouy-en-Josas, France. E-mail: colliard@hec.fr. Phone: (33) 1 39 67 72 90.
1 Introduction

Following the increasing integration of banking systems in the past decades, the boundaries of a bank’s activities can stretch significantly further than the mandate of its supervisor. As a result, supervisors can lack either the power or the incentives to properly monitor banks. For instance, Agarwal, Lucca, Seru, and Trebbi (2014) show that bank supervision in the United States is systematically more lenient at the State level than at the Federal level. In Europe, the European Commission proposed the creation of a “Single Supervisory Mechanism” (SSM) in September 2012, so as to solve the “supervisory failings” associated with national supervision.¹ Both areas now have a dual supervisory architecture, with supervisors both at the State/Federal or national/supranational levels.

This paper adopts an organization theory perspective to study the architecture of bank supervision. Banks can be monitored either by a local supervisor or a central supervisor. Both have the same monitoring technology, but only the central supervisor takes into account cross-border externalities. While central supervision is always optimal ex post, a more lenient local supervisor gives banks weaker incentives to hide problems, which can be optimal ex ante. This mechanism rationalizes the existence of a dual architecture. In particular, observing conflicts of objectives between different supervisors, as in Agarwal, Lucca, Seru, and Trebbi (2014), can be compatible with a second-best architecture.

Based on this theory of dual bank supervision, the paper asks what is the right amount of centralization. I show a complementarity between centralization and financial integration, measured by cross-border capital flows. Local supervision makes it riskier for foreign agents

¹The term “failings” is used in the Proposal for a Council regulation conferring specific tasks on the European Central Bank concerning policies relating to the prudential supervision of credit institutions, European Commission, 12.09.12, p.2.
to lend to the bank. As a result, the bank has little cross-border liabilities and it appears unnecessary to resort to supranational supervision. However, centralizing supervision would eventually help the bank to borrow from foreign investors, endogenously making centralized supervision preferable. The optimal architecture is thus forward-looking and takes into account how the market adapts to the new architecture. Conversely, the current rules in the Euro area that govern which supervisor is responsible for a given bank are static, so that some banks may remain “stuck” in a suboptimal equilibrium with local supervision and little cross-border integration.

More precisely, a bank in the model can have bad loans that it tries to “evergreen” instead of liquidating them. A central supervisor decides whether to inspect the bank herself, or delegate this task to a local supervisor, maybe only with some probability. The mix between both types of inspections is called a supervisory architecture. The supervisor who conducts the on-site inspection learns the quality of the bank’s loans and can order a liquidation, but inspecting is costly. Moreover, the bank can voluntarily increase the complexity of its operations, at a cost, so as to make inspection costs higher and avoid liquidation.

The bank’s choice of complexity depends on the supervisory architecture. The local supervisor does not take into account the cross-border (or interstate) externalities of a bank’s distress, which makes him soft on the bank. Conversely, the central supervisor internalizes all the losses triggered by the bank’s default, making her tougher. Even though the central supervisor always prefers to be responsible for inspections ex post, a joint architecture acts as a commitment to being more lenient with the bank. This reduces incentives to invest in complexity ex ante, which can lead to a more efficient outcome than fully centralized
supervision.²

This simple theory of dual supervision architectures first allows me to derive normative implications on the optimal level of centralization for a given bank. In particular, there is less scope for centralized supervision when the bank relies more on domestic deposits, since cross-border externalities are weaker. Interestingly, some of the other criteria used in practice to allocate a bank to the central supervisor have an ambiguous effect in the model. Bank size, a key criterion for the European SSM, scales up both the costs and benefits of centralizing supervision. The expected riskiness of the bank, whose increase can allow the Federal supervisor to take over supervision in the United States, also has an ambiguous impact. If a bank has very poor prospects, even the local supervisor will liquidate it. Central supervision is useful for banks that are likely to be weak enough to warrant liquidation from the perspective of the central supervisor, but not from the perspective of the local supervisor.

Second, I show that financial integration and centralized supervision reinforce each other. Imagine a bank in a region with a deficit of deposits that relies on funding from foreign agents in a surplus region. Supervisory forbearance at the local level implies that it is risky for foreign investors to lend to the bank. Centralizing supervision reduces this risk, so that the bank can borrow more from foreign investors. As a result, a higher proportion of the bank’s losses are now borne by foreign investors, which worsens the local supervisor’s incentives. It is then necessary to reinforce central supervision even more.

This complementarity can generate multiple equilibria. When looking at a bank with few foreign creditors, the central supervisor concludes that the bank is best left to local authori-

²At an abstract level, this argument is similar to the choice between integration and delegation in Aghion and Tirole (1997). A related application in the corporate finance literature is the idea that committing to being soft with a company’s manager increases her incentives to collect and communicate information (e.g., Burkart, Gromb, and Panunzi (1997) and Adams and Ferreira (2007)).
ties. Precisely for this reason, few foreign investors lend to the bank. Centralizing supervision would generate more lending by foreigners, making central supervision necessary. If the supervisory architecture does not internalize this impact, which I call being “forward-looking,” the economy can be trapped in an equilibrium with both too little central supervision and too little market integration, when a superior equilibrium is achievable. This effect is typically not taken into account in practice. In the Euro area, SSM-membership is triggered by a number of sufficient criteria that are all backward-looking in nature.

While the paper derives a number of normative implications about the organization of bank supervision, the second part also delivers empirical implications on the impact of changes in the supervisory architecture on banks. The main mechanism is that banks supervised at the central level should increase their cross-border activities and find it easier to borrow from foreign sources than comparable banks supervised at the local level. This effect should be reflected in the rates at which banks can borrow on the interbank market, the composition of their balance sheet, and their profitability. I discuss in more details in section 4.3 how these implications could be tested on European or on U.S. data.

This paper contributes to the literature on frictions in bank supervision, which includes papers such as Mailath and Mester (1994) and Kahn and Santos (2005). Recent studies have shown the empirical relevance of these frictions. In addition to the already mentioned Agarwal, Lucca, Seru, and Trebbi (2014), examples include Beck, Todorov, and Wagner (2013), who provide a theory of supervisory forbearance which they test on European data, Kang, Lowery, and Wardlaw (2015), who estimate a model of forbearance on U.S. data,

A parallel can be made with the endogeneity of optimal currency areas (Frankel and Rose (1998)).
and Rezende (2014), who gives new evidence on the impact of competition between U.S. supervisors.

Most theory papers on this topic consider a bank operating in only one area, whereas the multiplicity of countries or supervisors plays an important role in the empirical literature. A limited number of theoretical studies have considered the supervision of cross-border activities, such as Dalen and Olsen (2003), Holthausen and Ronde (2004), Calzolari and Loranth (2011), and Hardy and Nieto (2011). My setup differs from this literature as I look at the “vertical” problem of a central supervisor delegating to a local supervisor instead of the “horizontal” interaction between equal national supervisors. This vertical dimension is the one that seems relevant to understand the recent U.S. based empirical evidence, and also reflects the new situation in the Euro area.

More broadly, this paper is related to the literature on competition and coordination among regulators. Note that both in the United States and in the European Union regulation is already integrated. The costs and benefits of this integration have been studied for instance in Dell’Ariccia and Marquez (2006) and Morrison and White (2009). While common regulation seems to be desirable in relatively homogeneous regions, Acharya (2003) shows that it can actually worsen the coordination problems between bank supervisors. My analysis thus complements this literature by studying the mechanisms through which a more uniform supervision can be achieved.

The development of the European Banking Union has spurred a number of theoretical papers deriving new economic mechanisms that are important to understand the challenges of supranational supervision. Górnicka and Zoican (2016) and Foarta (2014) focus on the

---

4See also Vives (2001) for an early discussion of the challenges for financial integration and common
impact of bail-outs and recapitalizations in the Banking Union, thus complementing this paper’s analysis of common supervision with a study of bank resolution. Boyer and Ponce (2012) caution that a central supervisor will be weaker against lobbying efforts than separate supervisors. Beck and Wagner (2016) study the costs of centralizing bank supervision when different regions have diverse preferences regarding financial stability. Calzolari, Colliard, and Loranth (2016) show that centralized supervision can induce multinational banks to expand abroad through branches rather than subsidiaries, thereby increasing potential losses for deposit insurance funds.

Carletti, Dell’Ariccia, and Marquez (2016) consider a situation in which local supervisors are responsible for collecting information about banks, while intervention decisions are taken by a central supervisor. Centralized decision-making then lowers the local supervisor’s incentives to collect information. In some cases, this makes centralized supervision less efficient at controlling the bank’s risk-taking. This is an important caveat for the current design of the SSM.\footnote{In practice, SSM inspections are conducted by “joint supervisory teams” involving both national supervisors and supervisors from the European Central Bank. I consider the polar case in which the team’s objectives are aligned with the central supervisor, while Carletti, Dell’Ariccia, and Marquez (2016) consider the other polar case, the reality being somewhere in between.} My paper focuses on a different friction, as I assume that the central supervisor can conduct inspections herself, as is the case in the U.S.

Finally, this paper can be seen as an application of organization theory to the topic of banking supervision. Consistent with actual supervisory arrangements, I assume that it is legally infeasible to use monetary transfers to control the local supervisor’s incentives, so that a supervisory architecture simply consists in allocating the authority to inspect and close a bank to either a local or a central supervisor. This is formally related to the delegation regulation in Europe.
problems studied in, e.g., Holmstrom (1977), Aghion and Tirole (1997), and more recently Alonso and Matouschek (2008). Two specificities of banking supervision make it a particularly interesting application. First, randomized allocations of authority are often neglected in the theoretical literature. In my model, they come out as a natural solution and have an empirical counterpart, since the supervision of U.S. State banks actually alternates between State and Federal supervisors.\footnote{Inspections are scheduled, not random as in the model, but both are theoretically equivalent as long as banks do not have time to adjust their complexity level between two inspections, and have to optimize over an entire cycle of inspections instead.} Second, I take into account that the supervisory architecture affects market outcomes and the wedge between private and social objectives. This would be similar to assuming in Aghion and Tirole (1997) that the private benefit of the agent is endogenous and reacts to the mechanism chosen by the principal. This key feature of the present paper generates new challenges for designing an optimal supervisory architecture.

The remainder of the paper is organized as follows. Section 2 introduces the assumptions of the model. Section 3 solves for the optimal supervisory architecture, taking the structure of the banking system as given. This structure is then endogeneized in section 4, which is followed by the conclusion.

2 Framework

The economy: I consider a simple intermediation model in which banks stand between borrowers and investors. All agents are price-takers and risk-neutral.

- A continuum of borrowers can invest in risky projects that require one unit of investment.

With probability $p$, all projects are successful and return $1 + \rho$, otherwise they fail and return
The returns are heterogeneous across borrowers: There are \( q(r) \) borrowers with \( \rho > r \), with \( q'(r) < 0 \), \( q(0) = +\infty \) and \( \lim_{r \to +\infty} q(r) = 0 \). \( q(r) \) is thus the demand for loans at a given net interest rate \( r \).

At \( t = 0 \), all agents only know the distribution of the success probability, \( p \mapsto F(.) \) over \([0, 1]\), with a continuous density \( f(.) \). The actual \( p \) is privately revealed to the bank only in \( t = 2 \), at which date the project can be liquidated. A liquidated project yields \((1 - \ell)\).

- **Banks** extend a quantity \( L \) of loans to borrowers at rate \( 1 + r \). On the liability side, I focus on how much funding they can obtain from foreign investors. I thus assume that they have a given quantity \( D \) of domestic deposits and no capital.\(^8\) In order to lend \( L > D \), banks need to borrow \( L - D \) from foreign investors at rate \( 1 + i \). They take \( i \) as given and charge an exogenous intermediation margin \( s \) to borrowers, so that \( r = i + s \).\(^9\)

- **Foreign investors** stand ready to lend to banks at rate \( 1 + i \) as long as their expected return on these loans is higher than the return on the storage asset, normalized to 1.

Foreign investors are uninsured, as well as depositors. Equivalently, depositors can be covered by a domestic deposit insurance fund which charges a fair insurance premium.\(^{10}\) If a bank defaults, its assets are distributed pro-rata to its creditors.

Finally, throughout the paper I will make the assumption that demand is always higher

---

\(^7\) \( p \) thus represents the probability of a negative macroeconomic shock, whereas diversifiable shocks are already included in the average return \( \rho \).

\(^8\) This assumption models in a stylized way a bank with a high leverage in a country short of deposits. The model can be extended to the case of positive capital and to the possibility of increasing domestic deposits, as shown in the Internet Appendix.

\(^9\) A possible microfoundation for this assumption is that banks play a Salop-type game of differentiated competition when lending to borrowers. \( s \) is then a parameter reflecting the local market power of each bank (see for instance Chapter 3 in Freixas and Rochet (2008)).

\(^{10}\) The main results are not affected if local depositors are insured, but if insurance is not fairly priced this adds another friction to the model, which makes the interpretation less clear. The key assumption is that foreign investors are not insured (e.g., wholesale funding), or at least not fully. Otherwise, the bank’s default would have no cross-border externality, making centralized supervision unnecessary.
than $D$, so as to exclude uninteresting cases in which the bank does not need to borrow from foreign investors. To state this assumption formally, notice that the worst case for foreign investors is that loans are never liquidated, so that they recover $1 + i$ with probability $\mathbb{E}(p)$, and 0 otherwise. This defines an interest rate $i_{max}$ such that in this situation the foreign investors break even. I then make the following assumption throughout the paper:

$$q(i_{max} + s) > D, \text{ with } (1 + i_{max})\mathbb{E}(p) = 1. \quad (H1)$$

**Supervision and inspections:** By construction, the liquidation value of loans is not enough for banks to repay their debt, so that due to limited liability they never voluntarily liquidate the loans (a practice called “evergreening”).\textsuperscript{11} Depositors and investors cannot observe $p$, for instance because they are individually too small for such monitoring to be efficient. In line with Dewatripont and Tirole (1994), the bank supervisor monitors the bank in lieu of the other agents, thus achieving economies of scale. She learns the probability $p$ that the project will succeed, and can force liquidation if this probability is too low.

A supervisor can conduct inspections in $t = 2$, at a cost $k$.\textsuperscript{12} The supervisor who inspects the bank learns the exact value of $p$ and decides whether the bank’s loans should be liquidated. It is assumed that for informational and legal reasons it is impossible to liquidate the bank’s projects without inspecting the bank first.

The inspection cost $k$ is a choice variable for the bank: It can pay a non-pecuniary cost $C(k)$ per unit of loan in order to increase the inspection cost from 0 to $k$, with $C$ increasing

---

\textsuperscript{11}See Peek and Rosengren (2005), as well as Albertazzi and Marchetti (2010) for recent European evidence.

\textsuperscript{12}The cost is on purpose the same for both supervisors. A previous version of this paper considered a central supervisor who faces higher costs, which simply tilts the balance towards more local supervision.
and \( C(0) = 0 \). I interpret this cost as coming from the complexity of the bank, which can be voluntarily increased. I will refer to \( k \) as the bank’s complexity.

**Supervisory architecture:** There are two risk-neutral supervisors. The local supervisor aims at maximizing the welfare of local agents, and the central supervisor at maximizing total welfare in the economy.\(^{13}\) Local welfare is denoted \( \hat{W}_1, \hat{W}_0, \hat{W}_\ell \), depending on whether loans are successful, failed, or liquidated, respectively. Similarly, total welfare is equal to \( W_1, W_0, \) or \( W_\ell \). Local welfare includes the borrowers’ surplus, the banks’ profit, and the payoffs to home depositors. Global welfare additionally includes the foreign investors’ payoff.

With probability \( \lambda \), the central supervisor is tasked with conducting the inspection in \( t = 2 \), whereas the local supervisor is in charge with probability \( 1 - \lambda \). \( \lambda \) is freely chosen by the central supervisor and represents the supervisory architecture. A special case is \( \lambda = 1 \), which corresponds to centralized supervision.

**Timeline:** I consider two possible timings of the model. In the *no commitment case*, the central supervisor can overrule the local supervisor at any time.\(^{14}\) In particular, the central supervisor can change \( \lambda \) after investors have set market prices. The timing is then:

- \( t = -1 \): Investors choose the interest rate \( 1 + i \) at which they lend to banks, banks choose the quantity \( L \) they lend to borrowers, and borrow \( L - D \) from foreign investors.

- \( t = 0 \): The central supervisor chooses the probability \( \lambda \) that she will be responsible for inspecting the bank.

- \( t = 1 \): Banks choose their complexity \( k \), at cost \( L \times C(k) \).

\(^{13}\)I will refer to the central supervisor with the female pronoun “she” and to the local supervisor with the male pronoun “he.”

\(^{14}\)This assumption fits the institutional setup in place both in the U.S. and in the Euro area.
- $t = 2$: $p$ is realized. With probability $\lambda$, the central supervisor chooses whether to pay $k$ in order to inspect the bank, and with probability $1 - \lambda$ the local supervisor takes this decision. A supervisor who inspects the bank learns $p$ and can force the liquidation of the project.

- $t = 3$: If the projects were not liquidated in $t = 1$, they succeed with probability $p$ and banks are repaid $(1 + r)L$. The banks repay $(1 + i)D$ to their depositors and $(1 + i)(L - D)$ to foreign investors. With probability $1 - p$ the loans fail, the banks and their depositors obtain a zero payoff.

As market participants are competitive, they do not take into account that their actions can influence the supervisor in $t = 0$, so that the situation is as if the decision in the two periods $t = -1$ and $t = 0$ were taken simultaneously. In the alternative commitment case, periods $t = -1$ and $t = 0$ are inverted, and the central supervisor influences market participants through her choice of $\lambda$.

The timeline without commitment is summed up in the following two figures. Fig. 1 describes the timing of the overall game, whereas Fig. 2 focuses on the inspection stage, in which the decision-maker can be either the local or the central supervisor. **Discussion:** The model allows to study “federal” or two-layered supervisory systems, the two main examples being the United States, and more recently the Euro area:

- In the United States, almost all State-chartered commercial banks are supervised both by a State supervisor and a Federal supervisor, either the Fed or the FDIC. The frequency of inspections by the Federal supervisor depends on the significance of the bank, and is represented by $\lambda$ in the model (see footnote 6).

- In the Euro area, the supervision of banks under the SSM relies on a partition of the
Figure 1: Timeline - Market equilibrium and choice of a supervisory architecture.

Figure 2: Timeline - Inspection stage.
banking system into two groups. The “most significant credit institutions” are supervised directly by the European Central Bank (ECB). Although the national supervisors play a role in the inspections, the ultimate decision lies with the ECB, which corresponds to the case $\lambda = 1$. While the on-site supervision of the other banks is left to the national competent authorities, the ECB can decide at any time to take responsibility. This corresponds to the case $\lambda = 0$ in the model, with no commitment to not switching back to $\lambda = 1$.

The model relies on two separate sets of assumptions. First, the assumptions on the economy model a situation in which a region with financing needs relies heavily on foreign capital flows. This structure creates an imbalance in the geographic composition of the bank’s assets and liabilities, which creates a wedge between the two supervisors. This wedge implies that the bank’s projects are not always liquidated when they should, which limits the capital flows from the foreign country to the home country.\(^\text{15}\)

Second, the assumptions on supervision rationalize the need for a central supervisor, and the possible optimality of a mixed system. Fundamentally, two ingredients are required in the model: (i) There must be some wedge between local and global welfare, so that there is a scope for having a central supervisor inspecting the bank and taking the liquidation decision; (ii) While central inspections are optimal ex post, they have a negative effect on the bank’s incentives ex ante, so that centralizing supervision is not necessarily optimal.

While I consider two possible timings, in both cases it is important that the bank can modify its complexity $k$ after the central supervisor chooses $\lambda$. However, if $\lambda \in (0, 1)$, the bank cannot adjust $k$ after learning which supervisor was drawn to inspect the bank.

\(^{15}\)While I assume that funding in the bank’s country of origin is capped at $D$, the model can be extended to the more general case of two countries with different endowments, savings being higher in the foreign country (see the Internet Appendix). See also Beck, Todorov, and Wagner (2013) for a more general treatment of how the bank balance sheet composition affects the wedge between local and central supervisors.
3 Optimal delegation of supervisory powers

This section solves for the optimal supervisory architecture, taking the interest rates \( i \) and \( r = i + s \) and thus the banks’ assets \( L = q(r) \) as given.

3.1 Inspections and complexity

Proceeding by backwards induction, we can first solve the optimal decision taken by a supervisor at the inspection stage (Fig. 2). In case the bank is liquidated, the borrowers receive zero surplus as their projects are liquidated. The bank’s shareholders receive zero, too. The total surplus is equal to \((1 - \ell)L\), and is shared between domestic and foreign creditors proportionally to their claims on the bank, \( D \) and \( L - D \). As \( L = q(r) = q(i + s) \), the social surplus from the perspective of the central supervisor is \( W_\ell(i) = (1 - \ell)q(i + s) \). As the local supervisor neglects the foreign investors, from his perspective the social surplus is only \( \hat{W}_\ell(i) = (1 - \ell)D \).\(^{16}\)

If the bank is not liquidated, its loans are repaid with probability \( p \). In that case, the borrowers receive the Marshallian consumer surplus associated to the demand function \( q \), which is equal to \( \int_r^{+\infty} q(x)dx \). The bank receives \( L(1 + r) - L(1 + i) \), which equals \( sL \), \( s \) being the intermediation margin charged by the bank. Domestic depositors receive \((1 + i)D \) and foreign creditors \((1 + i)(L - D) \). Thus, the central supervisor considers the social surplus to be \( W_1(i) = S(i + s) \), denoting \( S(r) = \int_r^{+\infty} q(x)dx + (1 + r)q(r) \) the total Marshallian surplus from the loans. From the perspective of the local supervisor, the social surplus is the same amount, minus the payoff accruing to foreign investors, that is \( \hat{W}_1(i) = S(i + s) - (q(i + s) - D)(1 + i) \).

\(^{16}\)As for all variables in this section, I make the dependence on \( i \) explicit when defining \( W_\ell(i) \) and \( \hat{W}_\ell(i) \), but I later use the lighter notations \( W_\ell \) and \( \hat{W}_\ell \), as long as it does not introduce confusion.
Finally, when loans are not repaid, all agents receive a zero payoff and we have $W_0 = \hat{W}_0 = 0$.

Knowing the loans’ success probability $p$, the central supervisor receives $W_\ell$ if she liquidates the loans, against an expected welfare of $pW_1 + (1 - p)W_0 = pW_1$ if she does not. Liquidation thus occurs when $p$ is lower than the intervention threshold $p_c$ defined by:

$$p_c(i) = \frac{W_\ell(i)}{W_1(i)} = \frac{(1 - \ell)q(i + s)}{S(i + s)}. \quad (1)$$

Similarly, the local supervisor intervenes when $p$ is lower than $p_l$ defined by:

$$p_l(i) = \frac{\hat{W}_\ell(i)}{\hat{W}_1(i)} = \frac{(1 - \ell)D}{S(i + s) - (q(i + s) - D)(1 + i)}. \quad (2)$$

Since $S(r) > (1 + r)q(r)$, we have $p_l(i) \leq p_c(i)$ in equilibrium: the local supervisor intervenes less than the central supervisor. This is due to the local supervisor neglecting the losses borne by foreign investors when the bank’s projects fail.

Suppose that the power to inspect the bank is allocated to the central supervisor. If she inspects, with probability $F(p_c)$ she finds out that $p < p_c$ and liquidates the bank, which generates a social surplus $W_\ell$. For all other values of $p$, she keeps the bank open, which generates $pW_1$. As it costs $k$ to inspect the bank, the central supervisor’s payoff is she inspects is:

$$F(p_c)W_\ell + \int_{p_c}^1 pW_1dF(p) - k. \quad (3)$$

If instead the central supervisor does not inspect, the bank is always left open and the expected social surplus is $E(p)W_1$. Comparing this quantity to the previous equation, after
rearranging, we obtain that the central supervisor inspects if and only if $k < k_c$, with:

$$k_c(i) = F(p_c)W_\ell + \int_{p_c}^1 pW_1 dF(p) - \int_0^1 pW_1 dF(p) = W_1(i) \int_0^{p_c(i)} (p_c(i) - p) dF(p). \tag{4}$$

This last expression shows that the gains of inspecting the bank depend on how far below $p_c$ the supervisor expects $p$ to be. The reasoning is similar for the local supervisor, who inspects if and only if $k < k_l$, with:

$$k_l(i) = \hat{W}_1(i) \int_0^{p_l(i)} (p_l(i) - p) dF(p). \tag{5}$$

As $\hat{W}_1 \leq W_1$ and $p_l \leq p_c$, we have $k_l \leq k_c$. Intuitively, since the central supervisor internalizes the losses borne by foreign investors, her value of inspecting is larger and she is thus ready to pay larger inspection costs.

We can now solve for the bank’s optimal choice of complexity in $t = 1$. Denote $\pi_n$ the bank’s expected profit per loan in the absence of any inspection, $\pi_l$ and $\pi_c$ its expected profit per loan under a local or a central inspection, respectively.\footnote{That is, total profits are simply equal to $L\pi_n, L\pi_l, L\pi_c$.} As already explained, the bank makes a profit of $s$ per loan with probability $p$ if it is not liquidated. We thus have:

$$\pi_n(i) = s \times \int_0^1 pdF(p), \quad \pi_l(i) = s \times \int_{p_l(i)}^1 pdF(p), \quad \pi_c(i) = s \times \int_{p_c(i)}^1 pdF(p). \tag{6}$$

As $0 \leq p_l \leq p_c$, we have $\pi_n \geq \pi_l \geq \pi_c$: All else equal, more supervision implies that the bank survives in fewer states of the world and thus receives a lower expected profit. Remember that with probability $\lambda$ the bank faces a central supervisor who inspects if $k < k_c$, and with
probability $1 - \lambda$ it faces a local supervisor who inspects if $k < k_l$. Thus, there are only three candidates for the bank’s optimal level of complexity $k^*$. If $k^* = 0$, the bank is always inspected by the chosen supervisor; if $k^* = k_l$, the bank is sufficiently complex to prevent the local supervisor from inspecting, but not the central supervisor; if $k^* = k_c$, the bank is so complex that it avoids inspections conducted by either supervisor. Simple pairwise comparisons yield the following Lemma.\footnote{All proofs are in the Appendix.}

**Lemma 1.** The bank’s optimal level of complexity $k^*$ is given by:

$$
    k^*(i) = \begin{cases} 
    k_l(i) & \text{if } \lambda < \min(\lambda_1(i), \lambda_3(i)), \\
    0 & \text{if } \lambda \in [\lambda_1(i), \lambda_2(i)], \\
    k_c(i) & \text{if } \lambda > \max(\lambda_2(i), \lambda_3(i)).
    \end{cases}
$$

(7)

The thresholds are defined as:

$$
    \lambda_1(i) = 1 - \frac{C(k_l(i))}{\pi_n(i) - \pi_l(i)}, \quad \lambda_2(i) = \frac{C(k_c(i)) - (\pi_n(i) - \pi_l(i))}{\pi_l(i) - \pi_c(i)}, \quad \lambda_3(i) = \frac{C(k_c(i)) - C(k_l(i))}{\pi_n(i) - \pi_c(i)}. 
$$

(8)

Notice that some of the intervals on which $k^*$ is defined might be empty, depending on the parameters (see the Appendix A.1). Interestingly, $k^*$ is not monotonic in $\lambda$. This is intuitive: When $\lambda$ is close to zero, the central supervisor is almost never responsible for conducting inspections. The bank is very likely to face the local supervisor and the return on “investing” in order to avoid a local inspection is maximal. Conversely, when $\lambda$ is close to 1, the bank is very likely to face a central supervisor, which makes investing $k = k_c$ more attractive. An intermediate value of $\lambda$ makes both strategies less profitable. In particular, both can be
dominated by $k = 0$.

### 3.2 Optimal supervisory architecture

We can now solve for the central supervisor’s optimal choice of $\lambda$, for given values of $p_c$ and $p_l$. The solution is as follows:

**Proposition 1.** For a given $i$, the optimal architecture $\lambda^*(i)$ is given by:

$$
\lambda^*(i) = \begin{cases} 
\lambda_3(i) & \text{if } C(k_c(i)) < \pi_n(i) - \pi_c(i) - C(k_l(i)) \times \frac{\pi_l(i) - \pi_c(i)}{\pi_n(i) - \pi_l(i)}, \\
\lambda_2(i) & \text{if } C(k_c(i)) \in \left[ \pi_n(i) - \pi_c(i) - C(k_l(i)) \times \frac{\pi_l(i) - \pi_c(i)}{\pi_n(i) - \pi_l(i)}, \pi_n(i) - \pi_c(i) \right], \\
1 & \text{if } C(k_c(i)) > \pi_n(i) - \pi_c(i).
\end{cases}
$$

Equivalently, $\lambda^*(i) = \min(1, \max(\lambda_2(i), \lambda_3(i)))$.

The optimal architecture thus depends on how costly it is for the bank to avoid each type of inspection relative to the gains. In the first case, the costs $C(k_c)$ and $C(k_l)$ of preventing the central supervisor and the local supervisor from inspecting are both low. For a low probability $\lambda$ that the central supervisor is responsible for inspections, the bank optimally chooses to be complex enough to discourage local inspections only. If $\lambda$ is too high, then the bank increases its complexity to $k_c$, and the central supervisor is prevented from inspecting as well. The best the central supervisor can do is then to choose the highest $\lambda$ such that the bank chooses $k_l$ and not $k_c$, which leads to $\lambda^* = \lambda_3$. In the second case, discouraging a central inspection is more costly, and the bank now chooses a complexity level of 0 for intermediate values of $\lambda$, but maximal complexity if $\lambda$ is too high. The best is then to choose $\lambda^* = \lambda_2$. 
which is the highest level of centralization compatible with the bank choosing \( k = 0 \). Finally, if \( C(k_c) \) is large enough, then the bank never chooses \( k = k_c \), even for \( \lambda = 1 \), so that fully centralizing supervision is optimal.

### 3.3 Implications: How much central supervision is optimal?

Proposition 1 gives a potential rationale for the two-layered banking supervision systems found both in the United States and in the Euro area. Even when central inspections are strictly more efficient than local inspections ex post, they give banks more incentives to hide information ex ante. A mixed system, corresponding to the case \( \lambda^* \in (0, 1) \), surprisingly gives weaker incentives to hide information than either fully local or fully central supervision. Indeed, paying the complexity cost \( C(k_l) \) is only useful when the local supervisor is in charge, and thus becomes less profitable as \( \lambda \) increases. Conversely, paying \( C(k_c) \) is more profitable when \( \lambda \) is high. In between, there can be intermediate values of \( \lambda \) such that the best option is not to hide information at all.\(^{19} \) Formally, the model gives us:

**Implication 1.** For a small enough complexity cost \( C(\cdot) \), choosing \( \lambda = 1 \) (full centralization) is never optimal.

Focusing on the case in which \( \lambda^* < 1 \), we can derive comparative static results from Proposition 1, in order to shed light on which types of banks should be supervised more centrally. This “ceteris paribus” analysis does not take into account the effects of the different variables on the equilibrium value of \( i \). It corresponds to the “no commitment” case of a supervisor who decides on \( \lambda \) after observing the market outcome and thus takes \( i \) as given.

\(^{19} \)While the exact form this trade-off takes is specific to this model, the idea that \( \lambda = 1 \) will not be optimal when the bank can pay a cost to avoid inspections is more general.
Empirically, these implications can be seen as predictions on the type of bank supervision in a cross-section of banks, as in Beck, Todorov, and Wagner (2013).

**Implication 2.** *All else equal, $\lambda^*$ decreases in the amount of domestic deposits $D$.*

Remember that the bank borrows $D$ from domestic depositors and $q(r) - D$ from foreign investors. When $D = q(r)$, all loans are financed by domestic deposits. We have $p_l = p_c$, so that there is no benefit from having central inspections. As $D$ decreases, the bank has fewer local deposits and needs to rely more and more on foreign funding. The central supervisor’s intervention threshold $p_c$ is constant, but the local supervisor’s threshold $p_l$ decreases, and reaches 0 for $D = 0$. Indeed, liquidating the bank increasingly benefits foreign creditors over domestic agents, so that the local supervisor becomes more forbearant. $q(r) - D$ is thus a measure of the conflict of objectives between the local and the central supervisors in this model. When this conflict is larger, incentives to conduct central inspections are higher and the optimal $\lambda$ thus increases.

In line with this idea, access to Federal deposit insurance in the United States automatically implies that a bank must have a Federal supervisor (either the Federal Reserve or the FDIC), as the bank’s default triggers losses beyond the State. Indeed, Agarwal, Lucca, Seru, and Trebbi (2014) provide evidence on supervisory forbearance at the State level, which they relate to proxies for regulatory capture that can be seen as related to the conflict of objectives. Similarly to access to Federal deposit insurance in the United States, a Euro area bank that has requested assistance from the European Stability Mechanism or the European Financial Stability Facility automatically falls under SSM supervision. Also in line with this idea, one of the sufficient criteria for a bank to be directly supervised by the ECB is to have
a ratio of cross-border liabilities (or assets) over total liabilities (or assets) above 20%.

**Implication 3.** *All else equal, \( \lambda^* \) decreases in the bank’s intermediation margin \( s \).*

The gain of hiding information is to reduce the probability of liquidation and earn \( L \) times the intermediation margin \( s \) in more states of the world. A higher \( s \) thus increases the willingness of the bank to pay a high cost \( LC(k) \). This deters the central supervisor from imposing a high value of \( \lambda \), which would encourage the bank to choose \( k = k_c \). This suggests that centralized supervision is less beneficial in regions with a *less competitive* banking system, or with banks specializing in sectors with higher margins. Conversely, when \( s \to 0 \), the banking system is perfectly competitive and banks make zero profit in all states of the world, so that they have no incentive to hide information and fully centralized supervision is optimal.

**Implication 4.** *All else equal, scaling up the cost function from \( C(.) \) to \( \hat{C}(.) = \alpha C(.) \), with \( \alpha > 1 \), increases the value of \( \lambda^* \).*

The intuition for this result is as follows: If the *cost of hiding information* increases for any given \( k \), the central supervisor can inspect more often without giving banks incentives to move from \( k = 0 \) or \( k = k_l \) to \( k = k_c \). In practice, this cost function is likely to reflect both the ease with which the bank can hide or misreport information, and the skill of the supervisor at discovering such attempts. \( C(.) \) should thus be higher in countries with a better quality of supervision (as measured in Cihak and Tieman (2008) or Barth, Caprio, and Levine (2013)), and lower for banks with more complex assets and business models.\(^{20}\)

\(^{20}\)The BCBS uses three proxies for complexity, namely the amounts of over-the-counter derivatives, level 3 assets, and trading and available-for-sale securities. Additional proxies for opacity have been used in the literature, such as the proportion of “transparent assets” or whether the bank is publicly traded or not (see, e.g., Morgan (2002)).
However, it is not clear that complexity simply amounts to scaling up the function $C(\cdot)$. For instance, Rezende (2011) shows that joint examinations by State and Federal supervisors are more frequent for large and complex institutions, and explains this result by the fact that Federal supervisors support State supervisors with not enough staff to properly supervise a particular bank. In the framework of this model, it would be a case in which for simple banks $C(k_l)$ is large, while for complex banks $C(k_l)$ is small but $C(k_c)$ is large.

Finally, there are other variables that are used in practice by regulators but whose impact in the model is not clear-cut. The first one is size. It is the most important criterion for Euro area banks. For given values of $p_c$ and $p_l$ in the model, it is true that a larger bank (as measured by total assets $L$) magnifies the differences between the two supervisors and increases the difference between $k_l$ and $k_c$ and thus the incentives to centralize supervision. However, size also increases potential gains from avoiding tougher inspections. The model considers the particular case in which the cost of increasing complexity is proportional to asset size, which implies that $\lambda^*$ indeed increases with size. However, this result would not necessarily obtain if costs increased less than proportionally with size.\footnote{Note that inspection costs do not increase with size per se in the model, which is consistent with the evidence in Eisenbach, Lucca, and Townsend (2016) of economies of scale in bank supervision.}

The second variable that has an ambiguous impact is risk. In the United States, a bank that receives a bad enough CAMELS rating automatically becomes supervised by a Federal supervisor. Similarly, the ECB has discretion to take over supervision of a “less significant institution,” an option that will presumably be used if bad signals are received about a bank. However, it is clear in the model that the relevant question is not whether a bank has a low success probability $p$, but whether $p$ is likely to be between $p_l$ and $p_c$, that is, in the region in
which the central supervisor wants to liquidate the bank but the local supervisor does not. Indeed, if the bank is so bad that $p$ is almost surely below $p_l$, then the local supervisor’s incentives are aligned with the central supervisor’s, and there is no benefit in centralizing.

This is illustrated in Figure 3 below, which plots the value of $\lambda^*$ when $p$ follows a Beta distribution with parameters $a$ and $b$, for different values of the parameters.\textsuperscript{22} We have $\mathbb{E}(p) = \frac{a}{a+b}$, so that a lower $a$ or a higher $b$ represent a riskier bank. As the figure illustrates, there is no monotonic relationship between $\lambda^*$ and either $a$ or $b$.

4 Optimal supervision and market equilibrium

I now close the model by solving for the optimal reaction of market participants to the supervisory architecture. As explained in Section 2, there are two possibilities: Without\textsuperscript{22} The other parameters are the following: $\ell = 0.1$, $D = 0.2$, $s = 0.02$, $r = 0.05$, $C(x) = 0.001 \exp(2x)$, $q(r) = (1 + r)^{-2}$.
commitment, market participants take their decisions based on their anticipation of what
the central supervisor’s decision will be. In the case with commitment, the central supervisor
commits to a particular architecture before market participants take their decisions.

4.1 Equilibrium without commitment

We need to solve for the equilibrium interest rate $i$ in $t = 1$. This rate makes foreign
investors indifferent between lending to the bank and investing in a safe asset with a net
return normalized to 0. Conditional on $p$, an investor receives $(1 - \ell)$ on each unit he lent
to the bank in case of liquidation, and $(1 + i)$ with probability $p$ otherwise. Denoting $u(i, x)$
the expected return on one unit lent to the bank at interest rate $i$ if the bank is liquidated
when $p < x$, we have:

$$u(i, x) = (1 - \ell)F(x) + (1 + i)\int_x^1 pdF(p).$$

(10)

An investor expects $u(i, p_c)$ if the central supervisor always inspects, $u(i, p_l)$ if the local
supervisor always inspects, and $u(i, 0)$ if there is no inspection. For a given interest rate $i$
and a given probability $\lambda$ that the central supervisor is in charge of inspections, and using
Lemma 1, the expected payoff $U(i, \lambda)$ of a foreign investor for one unit of loan is:

$$U(i, \lambda) = \begin{cases} 
\lambda u(i, p_c(i)) + (1 - \lambda)u(i, 0) & \text{if } \lambda < \min(\lambda_1(i), \lambda_3(i)), \\
\lambda u(i, p_c(i)) + (1 - \lambda)u(i, p_l(i)) & \text{if } \lambda \in [\lambda_1(i), \lambda_2(i)], \\
u(i, 0) & \text{if } \lambda > \max(\lambda_2(i), \lambda_3(i)).
\end{cases}$$

(11)
For a given \( \lambda \), the equilibrium interest rate is the lowest one such that \( U(i, \lambda) \geq 1 \).

**Lemma 2.** Denote:

\[
i^*(\lambda) = \min\{i \geq 0, \text{ s.t. } U(i, \lambda) \geq 1\}. \tag{12}
\]

\( i^*(\lambda) \) is uniquely defined for any \( \lambda \in [0, 1] \), and \( i^* \in [i_{\text{min}}, i_{\text{max}}] \), with \( i_{\text{min}} \) such that:

\[
(1 - \ell)F\left(\frac{1 - \ell}{1 + i_{\text{min}}}\right) + (1 + i_{\text{min}})\int_{\frac{1 - \ell}{1 + i_{\text{min}}}}^{1} pdF(p) = 1. \tag{13}
\]

The Lemma shows that an equilibrium interest rate exists, and gives useful bounds corresponding to the case in which there is no inspection (\( i_{\text{max}} \)) and the case in which inspections maximize the creditors’ payoff (\( i_{\text{min}} \)). We can now define an equilibrium:

**Definition 1.** An equilibrium without commitment is a pair \( (i^*, \lambda^*) \) such that \( i^* = i^*(\lambda) \) and \( \lambda^* = \lambda^*(i) \).

An equilibrium without commitment can be seen as the intersection of the two curves \( i^*(\lambda) \), the equilibrium interest rate for a given level of supervision, and \( \lambda^*(i) \), the optimal level of supervision for a given interest rate. The possibility of multiple equilibria comes from the fact that both curves are typically decreasing:

**Proposition 2.** \( i^*(\lambda) \) is constant or decreasing in \( \lambda \), except at a finite number of discontinuity points.

When \( \lambda \) increases, there are more inspections by the central supervisor and fewer by the local supervisor. The difference between them is that the central supervisor takes into account the foreign investors’ payoff. Thus, all else equal, increasing \( \lambda \) has a positive impact.
on the foreign investors’ payoff $U(i, \lambda)$ for a given $i$, and thus reduces the equilibrium $i$. An exception to this mechanism is that at some points a higher $\lambda$ will change the complexity $k$ chosen by the bank. For instance, when $\lambda$ increases above $\max(\lambda_2, \lambda_3)$, the bank chooses $k_c$. Both supervisors become powerless, and the interest rate jumps upwards to $i_{\text{max}}$. This is of course the worst possible outcome for the central supervisor, so that there cannot be an equilibrium in such a region.

Conversely, a higher interest rate typically decreases the central supervisor’s incentives to inspect. The main mechanism behind this result comes from the following observation:

**Lemma 3.** $p_l$ and $k_l$ are increasing in $i$, whereas $p_c$ and $k_c$ are decreasing in $i$.

Intuitively, when $i$ increases $r$ is higher, so that surplus per loan is higher (the borrowers have projects with higher returns) and the central supervisor is less likely to liquidate them. Inspecting the bank is then less useful, so that the complexity threshold $k_c$ above which the central supervisor stops inspecting the bank is lower. Simultaneously, $L - D = q(i + s) - D$ is lower, so that a higher proportion of the liquidation proceeds go to domestic agents. This makes the local supervisor more likely to intervene. Inspecting the bank is then more useful to him, and the complexity threshold $k_l$ above which he stops inspecting is higher. In the limit, if both $i$ and $s$ are very small then the local supervisor does not liquidate even the worst banks ($p_l \rightarrow 0$), since liquidation only benefits foreign agents. Conversely, if $i$ is so high that $q(i + s) = D$, then $p_l = p_c$. The conflict of objectives between the two levels of supervision disappears, as the bank only relies on domestic depositors.

Lemma 3 has two opposite consequences. On the one hand, when $i$ decreases the central supervisor has more incentives to intervene, which increases $\lambda^*$. On the other hand, since the
central supervisor becomes tougher, the bank also has more incentives to increase complexity so as to avoid inspections. A higher $\lambda$ can thus more easily be counterproductive. Consider for instance the case in which $\lambda^* = \lambda_2$. A lower $i$ increases the numerator $C(k_c) - C(k_l)$, but it also increases the denominator $\pi_n - \pi_c$. Which effect dominates depends on the curvature of $C$. To see this, consider the following particular functional form for $C$:

$$C(k) = \alpha \exp(\beta k) - 1, \quad (14)$$

where $\beta$ measures the convexity of the cost function. We have:

**Proposition 3.** There exists $\bar{\beta} \geq 0$ such that if $\beta \geq \bar{\beta}$ then $\lambda^*(i)$ is decreasing in $i$ for any $i \in [i_{\text{min}}, i_{\text{max}}]$.

When $\beta$ is high, the cost of increasing the bank’s complexity is very convex. As a result, a higher difference between $p_c$ and $p_l$ translates into an even higher difference between $C(k_c)$ and $C(k_l)$, so that the effect of $i$ on the central supervisor’s incentives to inspect dominates the effect on the bank’s incentives to increase complexity. As a result, the total effect of an increase in $i$ is to reduce the likelihood of central inspections.

Propositions 2 and 3 show that 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. This complementarity between foreign lending and centralized supervision can lead to a multiplicity of equilibria. Figure 4 gives such an example.\(^{23}\) In this example, two very different equilibria may obtain. The central supervisor can impose full centralization,

---

\(^{23}\)The other parameters are the following: $\ell = 0.2, D = 0.32, s = 0.02, r = 0.05, C(x) = 0.01 \exp(x), q(r) = (1 + r)^{-2.1}, p \sim \text{Beta}(0.6, 0.4)$. 

27
\(\lambda = 1\). In that case, foreign investors are ready to lend a high quantity at a low interest rate because the central supervisor takes into account their potential losses. Banks then have high cross-border externalities, which makes it profitable to have only central inspections. Moreover, so much is at stake for the central supervisor that the bank would have to pay very high costs to deter an inspection, and chooses not to do so. With the same parameters, the central supervisor can also choose \(\lambda = 0.066\), in which case inspections are almost always conducted by the local supervisor. Foreign investors then lend much less, because they expect the local supervisor to be too lenient. Cross-border externalities are then low, so that central inspections bring a small benefit and it is easy to deter the central supervisor from inspecting. In such a case, it is optimal to delegate supervision to the local level most of the time, as the extra cost for the bank to also deter central inspections is small.

An even more striking example can be obtained by selecting a very convex cost function.
$C(k)$, giving a cost of zero for low values of $k$ and a high cost otherwise. Defining $i_{\text{full}}$ the equilibrium interest rate when $\lambda = 1$ and $k = 0$, we have:

**Proposition 4.** For any parameterization of $q(.)$, $F(.)$, $\ell$, $s$, and $D$, one can find a cost function such that $\lambda^* = 0, i^* = i_{\text{max}}$ and $\lambda^* = 1, i^* = i_{\text{full}}$ are both equilibria.

In particular, one can select $C(.)$ of the form $C(k) = 0$ for $k < \bar{k}$ and $C(k) = \bar{C}$ for $k \geq \bar{k}$, with well-chosen values of $\bar{k}$ and $\bar{C}$.

The Proposition is illustrated in Fig. 5. In the absence of any central inspection, foreign investors expect that projects will never be liquidated and ask for $i = i_{\text{max}}$. At this rate, both $k_l$ and $k_c$ are lower than $\bar{k}$, so that the bank can entirely avoid inspections at no cost, thus validating the foreign investors’ expectations. It is then useless to conduct central inspections. Conversely, if the interest rate is sufficiently low, we have $k_c > \bar{k}$, so that it is now extremely costly for the bank to avoid a central inspection. The central supervisor can then inspect with probability 1 without the bank trying to increase its complexity. Foreign investors thus expect a high level of supervision and ask for a low interest rate.

### 4.2 Equilibrium with commitment

I now consider the case in which the central supervisor can commit to a particular $\lambda$ before the market determines the interest rate $i$. For a given $\lambda$, the equilibrium interest rate will still satisfy $i^* = i^*(\lambda)$, but the supervisor now maximizes welfare taking into account that $\lambda$ affects $i^*$ instead of taking $i^*$ as given. Due to this effect, the central supervisor may not play the static best response to the equilibrium value of $i$. To see the different forces at play, take

\[24\] The parameters are the same as for Fig. 4, except for the cost function, which is $C(k) = 0$ for $k \leq 0.05$, and $C(k) = 0.1$ otherwise.
a given $\lambda$ and assume that $i^*(\lambda)$ is such that $\lambda \in [\lambda_1(i^*(\lambda)), \lambda_2(i^*(\lambda))]$. Define the central supervisor’s objective function as:

$$\Omega(\lambda) = \lambda \omega(p_c(i^*(\lambda)), i^*(\lambda)) + (1 - \lambda) \omega(p_l(i^*(\lambda)), i^*(\lambda)),$$

(15)

with $\omega(x, i) = F(x)(1 - \ell)q(i + s) + S(i + s) \int_x^1 p dF(p)$.

(16)

$\Omega(\lambda)$ is simply an average of the payoffs to the central supervisor in case of liquidation, success, and failure, weighted by the probabilities that these events occur in equilibrium.

We can look at the derivative of the supervisor’s objective function. Denoting $\omega_1(x, i)$ and $\omega_2(x, i)$ the derivatives of $\omega$ with respect to both its arguments, we have:

$$\Omega'(\lambda) = \begin{bmatrix} \omega_1(p_c, i^*(\lambda)) - \omega(p_l, i^*(\lambda)) \geq 0 \\ i^*(\lambda) \leq 0 \end{bmatrix} + \begin{bmatrix} \lambda \omega_2(p_c, i^*(\lambda)) + (1 - \lambda) \omega_2(p_l, i^*(\lambda)) \\ \leq 0 \end{bmatrix} \begin{bmatrix} \lambda \omega_2(p_c, i^*(\lambda)) + (1 - \lambda) \omega_2(p_l, i^*(\lambda)) \\ \leq 0 \end{bmatrix}$$

+ $i^*(\lambda) \times p_l(i^*(\lambda)) \times \omega_1(p_l, i^*(\lambda))$.

(17)
Note that by definition of $p_c$ and $p_l$ we have $\omega_1(p_l, i) \geq \omega_1(p_c, i) = 0$. There are three different effects to consider. First, a higher $\lambda$ implies that the higher intervention threshold $p_c$ is used more often, which increases welfare. Second, a higher $\lambda$ decreases the interest rate, which increases total surplus and thus welfare as well ($\omega_2(x, i) \leq 0$). Third, this decrease in the interest rate increases the quantity $q(r) - D$ and thus the conflict of objectives between the two supervisors. $p_l$ decreases and the local supervisor intervenes less often, which has a negative impact on welfare ($\omega_1(p_l, i) \geq 0$). Because of this last effect, which is not present in the case without commitment, it may not be optimal to choose $\lambda = \lambda_2$, and an interior solution in $(\lambda_1, \lambda_2)$ may be preferred.

There are thus two costs of choosing a higher $\lambda$: It can induce the bank to increase complexity, and it worsens the conflict of objectives between the two supervisors. The second component is present only in the commitment case, in which the optimal architecture is thus more likely to rely on the local supervisor. However, when $\lambda = 1$ the second cost disappears, since the local supervisor is never responsible for inspecting the bank. This has the following consequence:

**Proposition 5.** If for $i = i_{full}$ we have $C(k_c(i_{full})) > \pi_n(i_{full}) - \pi_c(i_{full})$, then $\lambda^* = 1, i^* = i_{full}$ is the only equilibrium in the commitment case, and it is also an equilibrium of the no-commitment case.

The condition comes straightforwardly from Proposition 1. This equilibrium is the best possible outcome for the central supervisor, as inspections are always optimal and the interest rate is the smallest possible. Moreover, it is clear that any equilibrium of the no-commitment case can be implemented by a central supervisor who can commit. This result implies that
there are instances in which a supervisor without commitment may be stuck in an equilibrium with a low probability \( \lambda \) that the central supervisor is in charge, even though with commitment she could attain the best possible equilibrium. This is the case in the examples shown in Fig. 4 and 5.

### 4.3 Discussion: Supervisory architecture and market integration

**Policy implications:** The recent implementation of the SSM in Europe can be interpreted as a change from fully local supervision \((\lambda = 0)\) to fully central supervision \((\lambda = 1)\) for a subset of the banking system. The previous section clearly shows that this can result in better supervision and lower interest rates, but only when the bank cannot react by increasing its level of complexity:

**Implication 5.** *Fully centralizing supervision \((\lambda^* = 1)\) decreases the equilibrium interest rate \(i^*\) and increases cross-border flows \(L - D\) if and only if \(C(k_c(i_{full})) > \pi_n(i_{full}) - \pi_c(i_{full})\).*

The assumption that local deposits are fixed and that banks can only get extra funding from foreign investors models a situation in which the optimal allocation of capital makes large cross-border flows necessary. The supervised banks can be seen as operating in a region with a savings deficit, while foreign investors live in a surplus region.\(^{25}\) This implication shows that increasing central supervision, as done in the Euro area with the SSM, can indeed contribute to restoring market integration, which is one of the objectives stated by the European Commission. However, the possible strategic reaction of banks to more supervision

\(^{25}\)Allen, Beck, Carletti, Lane, Schoenmaker, and Wagner (2011) give an excellent overview of cross-border banking in Europe. Gilje, Loutskina, and Strahan (2016) provide recent evidence that bank branches play an important role in financial integration in the United States.
needs to be taken into account. In particular, the new central supervisor has to be so efficient that a bank cannot hide information without incurring large costs.

Comparing Propositions 4 and 5 makes it clear that a supervisory architecture that may appear optimal taking the liability structure of the bank as given may actually be suboptimal once the impact of supervision on interest rates is taken into account:

**Implication 6.** A central supervisor who cannot commit to a supervisory architecture may be stuck in an equilibrium with \( \lambda^* < 1 \), even though an equilibrium with fully centralized supervision, more market integration, and higher welfare would also be possible.

This implication underlines the necessity to decide on the supervisory architecture in a forward-looking manner, taking into account how this choice affects market integration in the long-run. In the Euro area, criteria for a bank to be centrally supervised are not forward-looking. In particular, a bank is subject to centralized supervision if it currently has significant cross-border activities. This neglects that a bank may not be very active cross-border precisely because supervision is fragmented. Equivalently, a more centralized architecture can be optimal even when current market conditions would not justify it.

**Testable predictions:** The implementation of the SSM in the Euro area gives a unique opportunity to empirically study the impact of bank supervision, as it is a large change affecting differently the banks directly supervised by the ECB and the other ones. While the two groups are not similar before the implementation of the SSM, the heterogeneity of banking systems in the Euro area implies that it is possible to match at least the smaller “treated” banks with comparable non-treated banks. The treatment is not random, but the
selection criteria are public and based on observable variables, so that selection biases can be controlled for. A particularly interesting selection criterion is that at least the three most significant credit institutions in each participating country shall be supervised directly by the ECB, implying that some banks may be in the treated group although they are actually relatively small and comparable to some non-treated banks in other countries.

Implication 5 suggests that treated and untreated banks should diverge over time in a predictable way. Banks directly supervised by the ECB should be able to borrow at lower rates on wholesale markets, compared to similar banks under national supervision. CDS spreads should also fall. This logic should also apply to the bank’s assets and shareholders (see Beck, Todorov, and Wagner (2013)): Centrally supervised banks face less incentives to manipulate the domestic/foreign composition of their different balance sheet items to ensure a more favorable supervisory treatment. Treated banks should thus attract more foreign creditors but also have more foreign assets and more foreign shareholders.

Such drastic and partly exogenous changes in the supervision of a bank are more difficult to find in the United States, but the rotating supervision by State and Federal supervisors used in Agarwal, Lucca, Seru, and Trebbi (2014) offers a nice identification strategy for the impact of State vs. Federal supervision. A prediction of the model that can be tested using the same approach is that during the Federal supervisor’s shift a bank should find it easier to borrow on the interbank market, especially from banks in a different State.

Finally, a variable that is easily observable for listed banks is the stock price, which is related to the bank’s profit in the model. Theoretically, the impact of increased bank supervision on this variable is ambiguous. A more centralized architecture implies that the bank is liquidated more often, which reduces profits. However, this paper underlines a second
effect: The better quality of supervision implies that investors lend to the bank at a lower interest rate, so that the bank can lend more. If the decrease in interest rates is large enough, this second effect can more than compensate the first one. Observing that some banks actually benefited from the increase in supervision would thus validate an original component of this model.

5 Conclusion

This paper develops a framework to analyze optimal supervisory architectures in a federal/international context in which local supervisors neglect cross-state/cross-border externalities and are too forbearant. Having a tougher central supervisor inspecting the bank is optimal ex post, but also gives a bank a strong incentive to hide information ex ante so as to avoid liquidation. This framework rationalizes the range of solutions observed in the United States and the Euro area: Local supervision, central supervision, or joint supervision.

The model shows that a more centralized supervisory architecture allows the bank to use more foreign funding, while conversely more foreign funding makes the local supervisor more lenient, which increases the benefits from central supervision. This complementarity can generate multiple equilibria. In particular, it is possible to be stuck in an equilibrium in which market integration and centralization are both low, when another equilibrium in which both are high would be possible and welfare-improving. The choice of a supervisory architecture should thus anticipate how the market will react to the new supervision framework.

The recent financial crisis both underlined the importance of bank supervision and triggered many changes in the global supervisory architecture. Simultaneously, more supervisory
data is available, allowing to test finer theories of supervisory behavior. The combination of these two phenomena makes bank supervision an exciting field for applying organization theory to recent reforms, and enrich the current debates on how to organize the supervision of an increasingly connected banking system.
A Appendix

A.1 Proof of Lemma 1

The bank’s payoffs $\pi(k)$ from following each strategy are:

\begin{align*}
\pi(0) &= L(\lambda \pi_c + (1 - \lambda)\pi_l) \\
\pi(k_l) &= L(\lambda \pi_c + (1 - \lambda)\pi_n - C(k_l)) \\
\pi(k_c) &= L(\pi_n - C(k_c)).
\end{align*}

(A.1) (A.2) (A.3)

Simple computations directly give $\pi(0) > \pi(k_l) \iff \lambda > \lambda_1$, $\pi(0) > \pi(k_c) \iff \lambda < \lambda_2$, $\pi(k_l) > \pi(k_c) \iff \lambda < \lambda_3$.

In addition, comparing the different $\lambda$s with each other as well as with 0 and 1 give us the following: $\lambda_1 < 1$, and $\lambda_1 > 0$ if and only if $C(k_l) < \pi_n - \pi_l$; $\lambda_3 > 0$, and $\lambda_3 < 1$ if and only if $C(k_c) - C(k_l) < \pi_n - \pi_c$; $\lambda_2 > 0$ if and only if $C(k_c) > \pi_n - \pi_l$, and $\lambda_2 < 1$ if and only if $C(k_c) < \pi_n - \pi_c$. Finally, we have $\lambda_2 < \lambda_3 < \lambda_1$ if $C(k_c) < \pi_n - \pi_c - C(k_l) \times \frac{\pi_l - \pi_c}{\pi_n - \pi_l}$, and $\lambda_1 \leq \lambda_3 \leq \lambda_2$ otherwise.

A.2 Proof of Proposition 1

Using the end of A.1, we can divide the parameter space in three regions:

(i) $C(k_c) < \pi_n - \pi_c - C(k_l) \times \frac{\pi_l - \pi_c}{\pi_n - \pi_l}$: We have $\lambda_2 < \lambda_3 < \lambda_1$. Moreover, this conditions implies $C(k_c) - C(k_l) < \pi_n - \pi_c$ and thus $\lambda_3 < 1$. As $\lambda_2 < \lambda_1$, the bank never chooses $k = 0$: It selects $k = k_l$ if $\lambda \leq \lambda_3$, and $k = k_c$ if $\lambda > \lambda_3$. This makes $\lambda_3$ optimal for the central supervisor: Above this level the bank chooses $k = k_c$ and avoids all inspections, below this level the central supervisor’s payoff increases in $\lambda$ as more inspections are conducted at the central level.

(ii) $C(k_c) \in \left[\pi_n - \pi_c - C(k_l) \times \frac{\pi_l - \pi_c}{\pi_n - \pi_l}, \pi_n - \pi_c\right]$: We have $\lambda_1 \leq \lambda_3 \leq \lambda_2$. This condition implies $C(k_c) > \pi_n - \pi_l$, so that $\lambda_2 \in (0, 1)$. The bank selects $k = k_l$ for $\lambda < \lambda_1$, $k = 0$ for $\lambda \in [\lambda_1, \lambda_2]$, and $k = k_c$ for $\lambda > \lambda_2$. If the supervisor chooses $\lambda = \lambda_2$, then the bank selects $k = 0$ and both supervisors inspect the bank when selected. Choosing a lower value of $\lambda$ cannot be optimal, as it would only need to take more decisions being taken by the local
supervisor instead of the central supervisor. Any \( \lambda \) above \( \lambda_2 \) would lead the bank to select \( k = k_c \), leading against to the worst outcome for the central supervisor. Hence, \( \lambda_2 \) is optimal.

(iii) \( C(k_c) > \pi_n - \pi_c \): In that case \( \pi(0) > \max(\pi(k_l), \pi(k_c)) \) for any \( \lambda \). If the central supervisor chooses \( \lambda = 1 \), the bank still selects \( k = 0 \), leading to the best possible outcome for the central supervisor, as she is able to inspect the bank all the time at no cost.

A.3 Proof of Implications 2 to 4

Implication 2. As \( \lambda^* = \min(1, \max(\lambda_2, \lambda_3)) \), it suffices to show that both \( \lambda_2 \) and \( \lambda_3 \) decrease in \( D \). Note that \( D \) has no impact on \( p_c \) and \( k_c \). Using the definition of \( \lambda_3 \) in (8), we need to show that \( k_l \) increases in \( D \). Using (5), since \( \hat{W}_1 \) increases in \( D \), the only thing to show is that \( p_l \) also increases in \( D \). We have:

\[
\frac{\partial p_l}{\partial D} = \frac{(1 - \ell)[S(i + s) - q(i + s)(1 + i)]}{(S(i + s) - (q(i + s) - D)(1 + i))^2}.
\]

(A.4)

As \( S(i + s) > q(i + s)(1 + i + s) > q(i + s)(1 + i) \), this derivative is indeed positive.

Using (8), we can write \( \lambda_2 \) as:

\[
\lambda_2 = \frac{C(k_c) - s \int_{0}^{p_l} p dF(p)}{s \int_{p_l}^{p_c} p dF(p)}.
\]

(A.5)

\( D \) enters this expression only via \( p_l \), hence we need to show that \( \lambda_2 \) decreases in \( p_l \):

\[
\frac{\partial \lambda_2}{\partial p_l} = \frac{p_l f(p_l)}{s} \times \frac{C(k_c) - s \left[ \int_{0}^{p_l} p dF(p) + \int_{p_l}^{p_c} p dF(p) \right]}{\left( \int_{p_l}^{p_c} p dF(p) \right)^2}.
\]

(A.6)

We have \( s \left[ \int_{0}^{p_l} p dF(p) + \int_{p_l}^{p_c} p dF(p) \right] = \pi_n - \pi_c \), which is greater than \( C(k_c) \) when \( \lambda_2 < 1 \), showing the result.

Implication 3. This is immediate for \( \lambda_3 \), as \( s \) has a positive impact on \( \pi_n - \pi_c \). For \( \lambda_2 \), using (A.5), we see that \( s \) decreases the numerator and increases the denominator, showing the result.
Implication 4. This result follows directly from the expressions of $\lambda_2$ and $\lambda_3$ in (8).

A.4 Proof of Lemma 2 and Proposition 2

Proof of Lemma 2. Denote $\bar{p}(i) = \arg \max_x u(i,x)$ the optimal intervention threshold from the perspective of an investor. It is straightforward to show that $\bar{p}(i) = \frac{1-t}{1+i} > p_c$: Even the central supervisor does not liquidate often enough from the perspective of an investor (because she takes the total surplus from the loans into account). Moreover, $u(i,x)$ increases in $x$ for $x < \bar{p}(i)$. Defining $i_{\min}$ as in the Lemma, we thus know that even if the bank were always liquidated so as to maximize the creditors’ payoff, for $i < i_{\min}$ we necessarily have $U(i,\lambda) < 1$. Conversely, $u(i,p_c) \geq u(i,p_l) \geq u(i,0)$, and $u(i_{\max},0) = 1$, so that for $i > i_{\max}$ we necessarily have $U(i,\lambda) > 1$. Between these two bounds, there is a smallest value of $i$ at which $U(i,\lambda)$ becomes larger than 1.

Proof of Proposition 2. As $i^*(\lambda)$ is the smallest $i$ satisfying $U(i,\lambda) = 1$, we want to show that, near the equilibrium, $U(i,\lambda)$ is increasing in $\lambda$ and decreasing in $i$. Consider the definition of $U(i,\lambda)$ in (11). As already stated, we have $u(i,p_c) \geq u(i,p_l) \geq u(i,0)$, so that $U(i,\lambda)$ is continuously increasing in $\lambda$, except at the discontinuity points $\lambda_1, \lambda_2, \lambda_3$. $U(i,\lambda)$ is not necessarily monotonic in $i$. However, near an equilibrium point, it is necessarily increasing in $i$, due to definition (12). This shows that the equilibrium interest rate $i^*(\lambda)$ is decreasing in $\lambda$, except at points such that $\lambda$ is equal to $\lambda_1, \lambda_2$, or $\lambda_3$ (note that these quantities themselves depend on $i$, so that there may for instance be several values of $\lambda$ for which $\lambda = \lambda_3$).
A.5 Proof of Lemma 3 and Proposition 3

Proof of Lemma 3. Differentiating the different expressions and rearranging gives:

\[ p'_l(i) = \frac{(1 - \ell)D}{[S(i + s) - (q(i + s) - D)(1 + i + s)]^2} \times q(i + s) = p'_l q(i + s) - D \frac{D}{(1 - \ell)} > 0 \]
\[ p'_c(i) = \frac{(1 - \ell)q'(i + s)[S(i + s) - (1 + i + s)q(i + s)]}{S(i + s)^2} < 0 \]
\[ k'_l(i) = (q(i + s) - D - sq'(i + s)) \int^p_0 pdF(p) > 0 \]
\[ k'_c(i) = q'(i + s)(1 + i + s) \int^p_0 \left( \frac{1 - \ell}{1 + i + s} - p \right) dF(p) < 0. \]

Proof of Proposition 3. As \( \lambda^* = \min(1, \max(\lambda_2, \lambda_3)) \), we need to show that both \( \lambda_2 \) and \( \lambda_3 \) are decreasing in \( i \). Consider \( \lambda_3 \). We have:

\[ \lambda_3(i) = \frac{k'_c(i)C'(k_c) - k'_l(i)C'(k_l)}{C(k_c) - C(k_l)} - \frac{p_c f(p_c) \times p'_c(i)}{\int^p_0 pdF(p)}. \quad (A.7) \]

As will be shown at the end of this proof, there exists a lower bound \( m_k > 0 \) on the slopes of \( k_c \) and \( k_l \) such that \( k'_c(i) \leq -m_k \) and \( k'_l(i) \geq m_k \). Similarly, there exists an upper bound \( m_p > 0 \) on the slopes of \( p_c \) and \( p_l \), such that \( p'_c(i) \geq -m_p \) and \( p'_l(i) \leq m_p \). Taking these bounds as given for the time being, we have:

\[ \frac{k'_c(i)C'(k_c) - k'_l(i)C'(k_l)}{C(k_c) - C(k_l)} \leq -m_k \times \frac{C'(k_c) + C'(k_l)}{C(k_c) - C(k_l)} \leq -m_k \times \frac{C'(k_c) - C'(k_l)}{C(k_c) - C(k_l)} = -m_k \beta. \]

Since \( p'_c(i) \geq -m_p \), in order to have a negative expression in (A.7), it is sufficient to have:

\[ \beta m_k \geq \frac{m_p \times p_c f(p_c)}{\int^p_0 pdF(p)}. \]

A sufficient condition for \( \lambda_3 \) to be decreasing in \( i \) is thus:

\[ \beta \geq \frac{m_p}{m_k} \times \sup_{i \in [i_{\min}, i_{\max}]} \left( \frac{p_c(i) f(p_c(i))}{\int^p_0 pdF(p)} \right). \quad (A.8) \]

Notice that \( m_k > 0 \), and the lowest possible value of \( p_c, p_c(i_{\max}) \), is also strictly larger than 0. This inequality thus gives us a positive and finite lower bound for \( \beta \).
I now consider $\lambda_2$. The term $\frac{C(k_c)}{n_{l-\pi_c}}$ is increasing in $i$, so that it’s enough to show that the log-derivative of $\frac{C(k_c)}{n_{l-\pi_c}}$ is negative, which writes as:

$$\frac{k'_c(i)C'(k_c)}{C(k_c)} - \frac{p_c f(p_c)p'_c(i) - p_l f(p_l)p'_l(i)}{\int_{p_l}^{p_c} pdF(p)} \leq 0$$

Since $k'_c(i) \leq -m_k$, $\frac{C'(k_c)}{C(k_c)} \geq \beta$, $p'_c(i) \geq -m_p$, and $p'_l(i) \leq m_p$, it is sufficient to have:

$$\beta \geq \frac{m_p}{m_k} \sup_{i \in [i_{min},i_{max}]} \left( \frac{p_c(i)f(p_c(i)) + p_l(i)f(p_l(i))}{\int_{p_l(i)}^{p_c(i)} pdF(p)} \right). \quad (A.9)$$

Under Assumption H1, we have $p_l < p_c$ for any $i \in [i_{min}, i_{max}]$, so that the right-hand side of (A.9) is a finite expression, so that there exists a finite and positive lower bound for $\beta$ such that $\lambda_2'(i)$ is necessarily negative. $\bar{\beta}$ is thus given by the maximum of the right-hand sides of (A.8) and (A.9).

I conclude the proof by computing the positive bounds $m_k$ and $m_p$. We want to find a higher bound $m_k$ on the slope of $k_c$ and $k_l$ relative to $i$. Write:

$$|k'_c(i)| = \varepsilon(i + s)q(i + s) \int_0^{p_c(i)} \left( \frac{1 - \ell}{1 + i + s} - p \right) dF(p) \geq \inf_{i \in [i_{min},i_{max}]} \varepsilon(i + s) \times D \times \int_0^{p} (p - p) dF(p),$$

with $p = \frac{(1 - \ell)D}{S(i_{min} + s)} < p_l(i) \leq p_c(i) \leq \frac{1 - \ell}{1 + i + s}$ and $\varepsilon(r) = -\frac{q'(r)(1 + r)}{q(r)}$.

As for $k'_l(i)$, using (A.7), since $q'(i + s) < 0$ we have:

$$k'_l(i) \geq [q(i) - D] \int_0^{p_l(i)} pdF(p) \geq [q(i_{max}) - D] \int_0^{p} pdF(p).$$
We thus have \( \min(k'_i(i), |k'_c(i)|) \geq m_k > 0 \), with:

\[
m_k = \min \left( \left[ q(i_{\max}) - D \right] \int_0^2 p dF(p), \inf_{i \in [i_{\min}, i_{\max}]} \varepsilon(i + s) \times D \times \int_0^2 (p - p)dF(p) \right) > 0. \tag{A.10}
\]

Finally, I want to find a higher bound \( m_p \) on the slope of \( p_c \) and \( p_l \) relative to \( i \). We can write \( |p'_c(i)| \) as:

\[
|p'_c(i)| = \frac{p_c^2}{1 - \ell} \times \varepsilon(i + s) \times \left( \frac{S(i + s)}{(1 + i + s)q(i + s)} - 1 \right).
\]

Using the fact that \( S(r)/q(r)(1 + r) \) decreases in \( r \), and \( p_c(i) \) decreases in \( i \), we have:

\[
|p'_c(i)| \leq \frac{p_c(i_{\min})^2}{1 - \ell} \times \sup_{i \in [i_{\min}, i_{\max}]} \varepsilon(i + s) \times \left( \frac{S(i_{\min} + s)}{(1 + i_{\min} + s)q(i_{\min} + s)} - 1 \right). \tag{A.11}
\]

Considering \( p_l \):

\[
p'_l(i) = p_l^2 \frac{q(i + s) - D}{D(1 - \ell)} \leq p_c(i_{\min})^2 \frac{q(i_{\min} + s) - D}{D(1 - \ell)}.
\]

We thus have \( 0 < \max(p'_l(i), |p'_c(i)|) \leq m_p \), with:

\[
m_p = \frac{p_c(i_{\min})^2}{1 - \ell} \times \max \left( \frac{q(i_{\min} + s) - D}{D}, \sup_{i \in [i_{\min}, i_{\max}]} \varepsilon(i + s) \times \left( \frac{S(i_{\min} + s)}{(1 + i_{\min} + s)q(i_{\min} + s)} - 1 \right) \right). \tag{A.12}
\]

Note in particular that the sup of \( \varepsilon(i + s) \) cannot be zero as \( i_{\max} \) is not infinite, so that \( m_p \) is necessarily finite.

### A.6 Proof of Proposition 4

Denote equilibrium 0 the candidate equilibrium with \( \lambda^* = 0 \) and equilibrium 1 the one with \( \lambda^* = 1 \).

In equilibrium 0 we have \( i = i_{\max} \). If we have \( k_c(i_{\max}) \leq \bar{k} \), then the bank will choose \( k = k_c \) for any value of \( \lambda \). As a result, foreign investors expect that the bank is never inspected, so that \( i \) needs to be equal to \( i_{\max} \). Since both supervisors choose not to inspect, any value of \( \lambda \) is optimal from the central supervisor’s perspective. The only condition for such an equilibrium is thus to have \( k_c(i_{\max}) \leq \bar{k} \).
In equilibrium 1, we have \( i = i_{\text{full}} \) that satisfies:

\[
F(p_c(i_{\text{full}}))(1 - \ell) + (1 + i_{\text{full}}) \int_{p_c(i_{\text{full}})}^{1} pdF(p) = 1. \tag{A.13}
\]

We need \( k_c(i_{\text{full}}) \geq \bar{k} \) for the bank to have a positive cost \( \bar{C} \) to avoid a central inspection. If this cost is larger than \( s \int_{0}^{1} pdF(p) \), then we know for sure that it is never worth paying for the bank. As a result, the bank chooses \( k = 0 \) for any value of \( \lambda \), and it is optimal for the central supervisor to choose \( \lambda = 1 \). If the central supervisor always inspects, foreign investors ask for \( i = i_{\text{full}} \).

To have both equilibria simultaneously, we simply need \( \bar{k} \in [k_c(i_{\text{max}}), k_c(i_{\text{full}})] \) and \( \bar{C} \geq s \int_{0}^{1} pdF(p) \). It is always possible to find such values of \( \bar{k} \) and \( \bar{C} \) since \( k_c(i_{\text{max}}) < k_c(i_{\text{full}}) \) (Lemma 3).

References


Carletti, E., G. Dell’Ariccia, and R. Marquez (2016): “Supervisory Incentives in a Banking Union,” Discussion paper. 6


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


B Supplementary Appendix for “Optimal Supervisory Architecture and Financial Integration in a Banking Union”

For online publication only.

B.1 Extension: Banks with positive capital

I consider a simple extension of the model in which banks can raise capital at some positive cost.

Assume that a bank has raised $K$ units of capital. It thus has $L$ units of loans, financed by $K$ in capital and $L - K$ in deposits/debt at an interest rate of $i$. If, after learning $p$, the bank liquidates its loans, it receives a payoff equal to:

$$\max(0, L(1 - \ell) - (L - K)(1 + i)) = \max(0, K(1 + i) - L(\ell + i)).$$  \hspace{1cm} (B.1)

This payoff is positive if and only if:

$$\frac{K}{L} > \frac{\ell + i}{1 + i}. \hspace{1cm} (B.2)$$

As long as $K$ is too low for (B.2) to hold, the bank never liquidates its assets voluntarily, and the model is fundamentally unchanged. Otherwise, the bank will compare the payoff from liquidating the assets to the payoff from keeping them. Not liquidating gives:

$$p[sL + K(1 + i)] + (1 - p) \times 0.$$ \hspace{1cm} (B.3)

The bank thus liquidates if and only if it learns that $p$ is lower than $p_b$, with:

$$p_b = \frac{K(1 + i) - L(\ell + i)}{sL + K(1 + i)}. \hspace{1cm} (B.4)$$

How does this affect the incentives of both supervisors? Denoting $D_h$ the home debt and
$D_f$ the foreign debt, with $D_h + D_f + K = L$, for the local supervisor we have:

\[
\hat{W}_t = K(1+i) - L(\ell + i) + D_h(1+i) \quad \text{(B.5)}
\]

\[
\hat{W}_1 = S(r) - D_f(1+i) \quad \text{(B.6)}
\]

\[
p_l = \frac{\hat{W}_t}{\hat{W}_1} = \frac{K(1+i) - L(\ell + i) + D_h(1+i)}{S(r) - D_f(1+i)}. \quad \text{(B.7)}
\]

$p_l$ is increasing in $D_h$ and decreasing in $D_f$. Moreover, remember that $S(r) \geq (1+r)L$.

A lower bound on $p_l$ is thus obtained when $D_h = 0$, $D_f = L - K$, and $S(r) = (1+r)L$. Substituting these values in (B.7), we obtain $p_b$. This shows that we always have $p_l \geq p_b$: the local supervisor wants more liquidations than the bank. Conversely, a higher bound on $p_l$ is obtained when replacing $D_f$ with 0 and $D_h$ with $L - K$, which gives $p_c$.

We thus have $p_b \leq p_l \leq p_c$, and the trade-off between local and central supervision remains qualitatively similar to what we have in the initial model. An interesting difference is that now the bank can raise capital in order to discourage supervisors from inspecting the bank. To see this, remember that the central supervisor will not inspect if the cost is greater than some threshold $k_c$. However, inspecting is useless when $p < p_b$, since the bank would liquidate the assets even without an inspection. In this model, we have:

\[
k_c = W_1 \int_{p_b}^{p_c} (p_c - p) dF(p). \quad \text{(B.8)}
\]

Note that $p_b$ is increasing in $K$: a better-capitalized bank will choose to liquidates problem loans more often, which reduces the value of inspecting for both supervisors and thus decreases $k_l$ and $k_c$. Increasing capital then serves as a substitute to increasing the bank’s complexity, as both discourage supervisors from inspecting. Choosing an interior $\lambda$ can still be optimal for the central supervisor in such a setup, and the optimal $\lambda$ will depend on how the cost of raising additional equity compares to the cost of increasing complexity. While this is an interesting additional element in the model, the economic intuition behind the model’s main results are otherwise not affected. In particular, the ability of the bank to raise capital should not affect the complementarity between market integration and centralized supervision.
B.2 Extension: Supply of savings

Consider a more general specification for the supply of savings by home and foreign investors. The home country is denoted by index \( h \), and the foreign country by \( f \). Investors in country \( i \in \{ h, f \} \) have a wealth \( M_i \), and can lend \( D_i \) to banks. The amount \( M_i - D_i \) that is not lent to banks yields a utility \( V(M_i - D_i) \), with \( V' \geq 0, V'' \leq 0 \). I assume that the foreign country is richer, that is \( W_f > W_h \).

In equilibrium, investors in both countries must be indifferent between lending a marginal unit to the bank or keeping it. For a given interest rate \( i \) and for a given \( \lambda \), the endogenous values of \( D_h \) and \( D_f \) are given by:

\[
V'(W_h - D_h) = V'(W_f - D_f) = U(i, \lambda).
\] (B.9)

To close the equilibrium, we also need to have \( D_h + D_f = q(i + s) \). Since \( W_h > W_f \), (B.9) implies that \( D_h > D_f \). All results related to supervision are unaffected by this new modeling of the investors’ behavior. The only result that may be affected is Lemma 3, on which Proposition 3 is based. The important property that is needed here is that when \( U(i, \lambda) \) increases, either through an increase in \( i \) or an increase in \( \lambda \), then \( D_h \) should increase more than \( D_f \), so that the proportion of the banks’ liabilities that are held by foreigners increases, weakening the incentives of the local supervisor. Indeed, in equilibrium we have:

\[
\frac{D_f}{D_h + D_f} = \frac{W_f - V''^{-1}(U)}{W_f + W_h - 2V''^{-1}(U)}.
\]

Differentiating this expression with respect to \( U \) shows that it is increasing when \( W_h > W_f \), as I have assumed.

The conclusion from this extension is that the simple modeling used in the paper can be seen more generally as referring to a situation in which the supply of savings is more elastic in the foreign country than in the home country, which is obtained for instance if the foreign country is richer. The baseline model corresponds to an extreme case in which the supply of savings is totally inelastic and equal to \( D \) in the home country, and perfectly elastic in the foreign country, with \( V'(W_f - D_f) = 1 \) for any \( f \).