Common Deposit Insurance, Cross-Border Banks and Welfare*

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Abstract

We study the effects of the introduction of a supranational authority responsible for common deposit insurance in a model of cross-border banks with both endogenous risk-taking and within-group risk-sharing possibilities. With national deposit insurance, local authorities inefficiently ring-fence resources flowing from healthy to impaired subsidiaries for high asset correlation. The anticipation of ring-fencing discourages cross-border bank integration. Common deposit insurance removes ring-fencing and encourages cross-border integration, but has an ambiguous impact on the banks' risk-taking incentives. Overall, common deposit insurance increases welfare when banks are sufficiently risky, but otherwise can lead to excessive cross-border integration and lower welfare.

JEL Classification: D8, G11, G2
Keywords: cross-border bank, common deposit insurance, intragroup support, ring-fencing, banking union

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1 Introduction

"An incomplete banking union is the reason why cross-border banking groups are ring-fenced along national lines and cross-border integration does not happen. But the absence of cross-border integration is one of the fundamental reasons why the banking union cannot be completed."

Andrea Enria, Chair of the Single Supervisory Mechanism, October 2023

Ten years after the Single Supervisory Mechanism (SSM) took responsibility for the supervision of the largest banks in the Euro area, the Banking Union project still lacks a common deposit insurance scheme.[1] While one of the objectives of the banking union was to foster cross-border bank activities (European Commission, 2012), they have barely increased over the past decade (ECB, 2022). From the SSM perspective, insufficient cross-border bank integration is the result of regulatory obstacles to the free movement of liquidity and capital across countries banks face under existing European bank legislation (Enria, 2023). Ring-fencing of local assets is in turn the countries' response to the lack of a common deposit insurance fund. So the argument goes, completing the banking union with common deposit insurance will both lead to the removal of ring-fencing and to more cross-border bank activities.

Policymakers' view on the positive impact of removing ring-fencing on cross-border bank integration is consistent with a large corporate finance literature on internal capital markets that highlights their benefits in terms of providing risk-sharing mechanisms at times of distress (Gopalan and Xie, 2011; Matvos and Seru, 2014; Santioni et al., 2020). However, the policy debate has so far abstracted from other insights of this literature that emphasize that ex post risk sharing opportunities can have adverse effects on ex ante investment decisions, dubbed as the dark side of internal capital markets (Scharfstein and Stein, 2000; Rajan et al., 2000). For banks, part of the cost of those unintended effects would be borne by the public through banks' access to the safety net, which warrants close attention from a policy perspective.

[1] In the meantime, a supranational authority responsible for the resolution of the largest banks in the euro area, the Single Resolution Board (SRB), was established in 2016.

This paper provides a theoretical contribution to the debate on common deposit insurance in a banking union, ring-fencing, and cross-border banking integration. We build a model that highlights the risk-sharing possibilities cross-border banks can achieve through an internal capital market, the extent to which they depend on the deposit insurance architecture, and their interaction with banks' risk-taking incentives. We address the following positive and normative questions: Does the introduction of common deposit insurance lead to more cross-border banking? Does it lead to an increase in welfare and/or a reduction in deposit insurance costs?

We find that when national funds provide deposit insurance and national authorities protect their respective funds' interests, ring-fencing of subsidiary resources arises when the correlation between the subsidiaries' assets is high. Ring-fencing limits the risk-sharing benefits of internal capital markets that cross-border banks can achieve and thereby discourages cross-border bank integration. When a common fund provides insurance to all depositors, the supranational authority responsible for the fund prefers not to impose restrictions on intragroup capital reallocation. This increases the benefits from internal capital markets and fosters cross-border bank integration. However, the expansion of risk-sharing possibilities affects cross-border banks' risk-taking incentives and, hence, deposit insurance costs, in an ambiguous manner: When the economy is riskier, banks reduce risk-taking as risk-sharing possibilities increase the franchise value of the group. Instead, when the economy is safer, banks increase risk-taking as the disciplining role of the ring-fencing threat disappears. The introduction of common deposit insurance may, as a result, reduce welfare despite enabling better risk-sharing and increasing cross-border integration. Our results shed new light on the interplay between the completion of the Euro area banking union and the cross-border integration of the banking sector, and on its welfare implications.

We consider an economy with two countries. In each country there is a continuum of bankers, each owning a standalone local bank. Each bank has access to local risky assets and is financed by insured deposits. Insurance on deposits is provided either by a *national* deposit insurance fund (DIF) that covers only deposits in its jurisdiction or by a *common* DIF that covers deposits in both countries. The DIF/s have supervisory powers on the standalone or subsidiary banks whose deposits they guarantee.

At an initial date, each bank from a country is matched with a bank from the other country, and their bankers choose whether to merge them into a cross-border bank (CBB). The merger cost differs across bank pairs.

Both standalone banks and the subsidiaries of CBBs can become impaired at an interim date, in which case the DIF responsible for their deposit insurance requires a recapitalization with the objective of reducing the expected costs it faces. Integrating the standalone banks in a CBB allows the bankers to benefit from risk-sharing possibilities within the group: Resources in a healthy unit can be used to recapitalize an impaired unit through an intragroup loan, enabling the bank to avoid raising costly external capital. Yet, the DIF responsible for the healthy unit's deposits may *ring-fence* resources in order to limit its own expected costs.

We first examine the impact of the DIF architecture on the occurrence of ring-fencing and on cross-border integration. We find that with national DIFs, ring-fencing of the healthy subsidiary's resources in a CBB arises if the correlation between the subsidiaries' asset payoffs is high. The DIF responsible for the healthy unit faces the following trade-off when authorizing the issuance of an intragroup loan. On the one hand, the intragroup loan increases its costs should both units simultaneously fail in the future and the unit receiving support defaults on the loan. On the other hand, the intragroup loan reduces its costs should the healthy unit fail in the future while the impaired unit does not and repays the loan (with interest). A higher correlation makes it more likely that both units simultaneously fail in the future and, thus, increases the expected cost for the DIF responsible for the healthy unit if an intragroup loan is issued. This leads to ring-fencing of the healthy subsidiary's resources. The severity of ring-fencing is increasing in the correlation, and for a sufficiently high level, the recapitalization of an impaired subsidiary must be done mostly through costly external equity issuance. Faced with a high cost of recapitalization, the CBB may prefer to let the unit be liquidated.

With a common DIF, by contrast, ring-fencing never arises. The common DIF is willing to allow a larger intragroup loan from a healthy subsidiary to an impaired one as this reduces the overall deposit insurance costs. Indeed, from the common DIF perspective, since the impaired unit defaults with a higher probability, the CBB is "foregoing" some limited liability protection at the group level when it grants an intragroup loan, which a common

DIF looks upon favourably. Notice that the larger intragroup loan leads to a redistribution in the deposit insurance costs across the subsidiaries: higher for the healthy unit, and lower for the impaired unit. While a common DIF is indifferent regarding such cost redistribution, national DIFs are not, which is the reason why ring-fencing emerges with national DIFs in the first place.

Removing ring-fencing through a common DIF enhances the within-group risk-sharing possibilities. As a result, merging two standalone banks is more valuable and more bankers do so. That is, a common DIF encourages cross-border bank integration.

We next analyze how the anticipation of ring-fencing (or the lack thereof) affects banks' risk-taking. At the initial date, each banker (or team of bankers) exerts unobservable effort in its standalone bank (or in the subsidiaries of a CBB) that reduces the probability of the bank (or the subsidiaries) becoming impaired. The elimination of ring-fencing with a common DIF has two opposing effects on the effort incentives in a CBB. On the one hand, effort in one subsidiary creates value not only for that subsidiary but also for the other subsidiary, which is more likely to obtain intragroup support and preserve its continuation value should it become impaired. This effect, which we dub as *franchise value effect*, increases effort and can be interpreted as the within-group manifestation of the last bank standing effect highlighted in Perotti and Suarez (2002).

There is also a negative *liquidation threat effect*: The elimination of ring-fencing allows an impaired subsidiary to continue without costly equity issuance, reducing the disciplining role of the liquidation (or recapitalization) threat on effort incentives. The relative strength of the two effects depends on the economy-wide intrinsic bank risk. When risk is higher, it is more likely that the subsidiaries of a CBB become impaired, which then increases the strength of the positive franchise value effect (stemming from the possibility to grant support to an impaired subsidiary) and reduces that of the negative liquidation threat effect (stemming from the possibility to receive support from a healthy subsidiary). As a consequence, a common DIF increases the bankers' effort in CBBs. The opposite happens if risk in the economy is lower: The establishment of a common DIF reduces the bankers' effort in CBBs.

We finally focus on normative aspects and analyze the impact of the introduction of a common DIF on welfare and deposit insurance costs. Welfare in the economy amounts to the overall value obtained by bankers from their ownership of standalone banks and CBBs net of the costs incurred by the DIF/s. When correlation across banks' assets is high and under national DIFs there is a ring-fencing problem, the introduction of a common DIF has two welfare effects. First, the enhanced ex-post intragroup risk-sharing possibilities, due to the removal of ring-fencing, increase the value bankers obtain from a CBB. This incentivizes more bankers (ex-ante) to set up a CBB. Second, the additional cross-border bank integration and the new effort choices of bankers in CBBs affect deposit insurance costs. This effect is ambiguous due to the aforementioned opposing effects and, crucially, is not internalized by bankers.

When risk in the economy is higher, the establishment of a common DIF leads to higher effort in CBBs, and has a positive spillover effect of reducing deposit insurance costs. In this case, a common DIF brings both more efficient risk-sharing ex-post and lower risk-taking ex-ante: Welfare increases and deposit insurance costs decrease. Notice that even though the common DIF leads to more cross-border bank integration, its level remains inefficiently low because bankers do not internalize that by creating a CBB they reduce deposit insurance costs. Too many banks remain standalone.

When risk in the economy is lower, by contrast, the establishment of a common DIF leads to lower effort in CBBs and this increases deposit insurance costs. We show that this effect can be strong enough to dominate the bankers' value gains, so that a common DIF can reduce welfare in the economy. Notably, the cross-border expansion brought by a common DIF also contributes to the welfare reduction. This is again because bankers do not internalize that by creating a CBB they increase deposit insurance costs. Thus we get excessive cross-border bank integration in the economy.

Our baseline model assumes that deposit insurance is granted for free or, equivalently, that bankers pay an upfront fee to the DIF/s that depends on the banks' fundamental riskiness but not on the organizational structure of their banks. We extend the model to allow for a fairly priced deposit insurance fee the banker pays at the initial date to the responsible DIF/s. Since each banker's effort depends on whether he sets up a CBB or not, the fee is made contingent on such choice. When deposit insurance is fairly priced, the cross-border integration choice becomes efficient given the DIF architecture. Still, privately and socially optimal effort choices remain misaligned and, as in the baseline model, for fundamentally safer banks a common DIF leads to more risk-taking by CBBs and can lead to welfare losses. The difference though is that in these cases the common DIF also reduces cross-border integration.

The results in our paper have important policy implications. First, when correlation in the banks' assets across countries is negative or low, ring-fencing along national lines is not an issue, and risk-sharing within banking groups is not hampered. A banking union with common deposit insurance does not add value precisely when from an ex-ante perspective risk-sharing gains are larger. Second, economic integration and a common monetary policy in the Euro area make it more likely that domestic bank assets are correlated across member countries of the currency union. Our model thus provides a theory of why ring-fencing might still be prevalent in the Euro area, and of the positive and normative implications of its elimination through the establishment of common deposit insurance. In this respect, we highlight the importance of reflecting on the risk-taking implications of changes in risk-sharing possibilities within banking groups, an issue that has been overlooked in the current policy debate. Absent such considerations, the welfare implications of initiatives to remove ring-fencing of cross-border banks cannot be fully assessed. From a practical perspective, our model suggests that in order to ensure that the establishment of a common DIF leads to welfare gains it might need to be accompanied by more supervisory scrutiny when risks in the economy are lower to deter the additional risk-taking incentives we identify.

Related literature Our paper belongs to a growing literature that studies how the establishment of supranational institutions affects cross-border bank integration and finds possible unintended effects. Calzolari et al. (2019) examines how a supranational supervisor that solves coordination problems in information acquisition by national supervisors affects banks' decisions to expand abroad and the organizational structure, branch or subsidiary, for their foreign activities. The authors find that supranational supervision may reduce welfare due to the banks' strategic choice of organization structure. The paper does not allow for a reallocation of resources across the subsidiaries during crises nor considers banks' risk-taking, whereas the interplay between these two elements is central in our paper. Colliard (2020) highlights the presence of strategic complementarities between centralized supervision and cross-border bank integration: centralized supervision allows banks to rely on more foreign funding; conversely, foreign funding increases cross-border externalities, which calls for centralized supervision. These complementarities may result in both too much centralization and integration, and too little. In our paper, a common DIF may also lead to too much integration and welfare losses due to a different risk-taking channel that is affected by the removal of ring-fencing obstacles in the within-group capital reallocation.

Our paper also relates to the literature on the resolution of multinational banks. Bolton and Oehmke (2019) analyze the optimality of different resolution regimes when national authorities have ring-fencing prerogatives. Instead, we focus on how removing ring-fencing through a supranational authority responsible for a common DIF affects banks' cross-border integration, risk-taking, and welfare. We also add to Bolton and Oehmke (2019) by highlighting how the correlation between the local assets of the cross-border bank affects ring-fencing by national authorities. Banal-Estanol et al. (2020) analyzes how different resolution approaches affect a trade-off between ex-post recapitalization of subsidiaries through debt bail-in and ex-ante financing capabilities. The paper abstracts from cross-border conflicts between national authorities.

Our analysis of the implications of common deposit insurance in a banking union is related to Segura and Vicente (2024), who focus on the optimal level of mutualization of deposit insurance across countries in a banking union subject to fiscal and bank moral hazard problems. The paper finds that risk-sharing across governments in the provision of deposit insurance may improve fiscal incentives, which is reminiscent of our findings that more risk-sharing within a banking group can improve bankers' effort incentives.

Our paper shares some intuitions from a large corporate finance literature that examines the role of internal capital markets in mitigating financial constraints in non-financial conglomerates (Gertner et al., 1994; Stein, 1997, 2003). Some contributions highlight a negative effect of internal capital markets on ex ante investment efficiency associated with their resource reallocation possibilities (Scharfstein and Stein, 2000; Rajan et al., 2000). The risk-taking implications of the within-group risk-sharing possibilities in financial conglomerates have been analyzed in a number of papers, highlighting opposing forces whose overall effect is generally ambiguous (Boot and Schmeits, 2000; Freixas et al., 2007). None of these papers considers cross-border dimensions and how they are affected by the architecture of deposit insurance schemes, which is the focus of our paper.

Our paper is also related to other contributions to the banking literature that highlight cross-border externalities due to conflicts of interest between national authorities and the implications of delegating supervision to a supranational agency. As a consequence of conflicts of interest, national authorities may choose suboptimal policies: capital requirements that are too low (Acharya, 2003; Dell'Ariccia and Marquez, 2006), too high (Saleem and Malherbe, 2024), underprovision of public funds to recapitalize failing banks (Freixas, 2003; Goodhart and Schoenmaker, 2009), or too coarse information sharing between supervisors (Holthausen and Rønde, 2004). Carletti et al. (2021) argues that delegating supervision to a central authority does not necessarily solve the issue of too little supervision and too much bank risk-taking if it has to rely on information collected by local supervisors.

Finally, this paper is related to contributions studying different motivations for banks' support to sponsored off-balance structures, including to avoid a run on the bank's short-term liabilities (Segura, 2017), to signal positive information about future investment opportunities (Segura and Zeng, 2020), to maintain sponsor reputation (Ordoñez, 2018), to conserve the fees associated with sponsored off-balance sheet activities (Parlatore, 2016), or as a form of collusion between the bank and investors (Gorton and Souleles, 2007; Kuncl, 2019).

2 The model

There are three dates $t = 0, 1, 2$ and two countries, A and B. There is no time discounting. There is a continuum of bankers in each country owning a standalone bank. Bankers are risk-neutral. Each bank is endowed with loans and funded with one unit of deposits that are fully insured by a deposit insurance fund (DIF) that supervises the bank and can take actions to protect its financial interests as we describe below.

At $t = 0$, one banker from each country is matched with a banker from the other country and they take the decision whether to merge their banks. For each banker pair, merger entails a disutility cost $\kappa \geq 0$ equally shared by the bankers, where κ differs across pairs and follows a distribution $F(.)$ with support in $[0, \infty)$. Merger creates a CBB with a bank holding company structure and two wholly owned subsidiaries, each subject to limited liability, and centralized decision-making. Establishing a CBB allows the bankers to benefit from risk-sharing possibilities as described later. We henceforth refer as bank $i \in A, B$ both to a standalone bank and to a subsidiary of a CBB located in country i.

Bank loans At $t = 0$, each bank has loans that generate a certain interim payoff $r > 0$ at $t = 1$, and a random final payoff that is $R > 0$ at $t = 2$ in case of success and 0 in case of failure.

For simplicity, we assume that only when both subsidiaries of a CBB succeed at $t = 2$ depositors in both countries can be paid in full:

Assumption 1. *$R + 2r < 2 < 2R + 2r$.*

The success probability of a bank's loans at $t = 2$ depends on its type. A healthy bank succeeds with high probability p_h, while an impaired bank with low probability p_ℓ, where $p_h > p_\ell$.

Bank type is realized at $t = 1$ and depends on an exogenous risk parameter γ and unobservable effort exerted by the banker at $t = 0$. The parameter $\gamma \in [\underline{\gamma}, \overline{\gamma}]$, where $0 < \underline{\gamma} < \frac{1}{2} < \overline{\gamma} < 1$, is assumed to be the same in both countries and proxies for the level of risks in the economy. That is, a larger (smaller) γ corresponds to lower (higher) bank loan default risk. We refer to this exogenous source of risk as economy-wide risk.[2] If a banker exerts effort $e \in [0, 1 - \overline{\gamma}]$, the probability that its bank is healthy at $t = 1$ is $\gamma + e$, and that it is impaired is $1 - (\gamma + e)$. The banker incurs a disutility cost $k(e)$ from exerting effort e in its bank. We make the following assumption on the cost function $k(\cdot)$ to ensure interior solutions and thresholds:

Assumption 2. *$k(0) = 0, k'(0) = 0, k'(\frac{1}{2} - \underline{\gamma}) > p_h(R + r - 1), k'(1 - \overline{\gamma}) > p_h(R + r - 1) + p_\ell R$, and $k''(e) > 0$ for all $e \in [0, 1 - \overline{\gamma}]$.*

The loan payoffs of the two matched banks can be correlated, and this correlation is one of the key parameters in the model. We capture such correlation by a parameter $\rho \in [\rho_0, 1]$,

[2]The bounds $\underline{\gamma}$ and $\overline{\gamma}$ ensure that all the probabilities described next lie within $[0, 1]$.

		Bank B	
		healthy (p_h)	impaired (p_ℓ)
Bank A	healthy (p_h)	$(\gamma + e) - q_0(\rho, e)$	$q_0(\rho, e)$
	impaired (p_ℓ)	$q_0(\rho, e)$	$1 - (\gamma + e) - q_0(\rho, e)$

Table 1: Joint probability distribution of bank types at $t = 1$ given effort e by the banker at $t = 0$.

		Bank B	
		R	0
Bank A	R	$p^B - q_1(\rho)$	$q_1(\rho) + (p^A - p^B)$
	0	$q_1(\rho)$	$1 - p^A - q_1(\rho)$

Table 2: Joint probability distribution of bank loan payoffs at $t = 2$ conditional on the banks' success probabilities p^A, p^B at $t = 1$, for $p^A \geq p^B$.

where $\rho_0 \in (-1, 0)$, that influences both the joint distribution of the banks' types at $t = 1$ and the joint distribution of their loan payoffs at $t = 2$ (conditional on their $t = 1$ types).[3]

Specifically, given an effort e implemented in the two banks, the probability that one of them is healthy and the other is impaired at $t = 1$ is $q_0(\rho, e) \equiv (1 - \rho)(\gamma + e)(1 - \gamma - e)$; the entire joint probability distribution of the banks' types at $t = 1$ is presented in Table 1. Our distributional assumptions imply that: *i)* $\rho = 0$ corresponds to independence, so that $\rho > 0$ ($\rho < 0$) corresponds to positive (negative) correlation; and *ii)* $\rho = 1$ corresponds to maximally positive correlation.

The joint probability distribution of the banks' final payoffs at $t = 2$ is analogously defined. Assuming that, conditional on the realized types at $t = 1$, bank A has (weakly) higher success probability than bank B, i.e., $p^A, p^B \in \{p_h, p_\ell\}$ and $p^A \geq p^B$, the probability that bank B succeeds while bank A fails at $t = 2$ is $q_1(\rho) \equiv (1 - \rho)p^B(1 - p^A)$; the joint probability distribution of the banks' final payoffs is presented in Table 2. Again, $\rho = 0$ captures independence, $\rho > 0$ positive correlation, and $\rho < 0$ negative correlation. The case in which unit A has (weakly) lower success probability than unit B is symmetrically defined.

[3]The lower bound $\rho_0 \in (-1, 0)$ in the correlation parameter ρ ensures that all $t = 1, 2$ joint probabilities described below lie within $[0, 1]$ for all $\rho \in [\rho_0, 1], \gamma \in [\underline{\gamma}, \overline{\gamma}]$ and $e \leq 1 - \overline{\gamma}$.

Deposit insurance architecture We consider two arrangements. With *national DIFs*, two national funds, DIF A and DIF B, provide deposit insurance for the banks (both standalone and subsidiaries) in their respective jurisdictions. Each DIF takes decisions at $t = 1$ non-cooperatively to minimize its own expected insurance costs. With a *common DIF*, there is a single DIF responsible for the deposit insurance payments of all banks. The single fund takes decisions at $t = 1$ in order to minimize its overall expected insurance costs.[4]

Bank recapitalization at $t = 1$ Each bank type is realized at $t = 1$ and the DIF responsible for the insurance of its deposits may require its *recapitalization*. Failure to comply with the request authorizes the DIF to *liquidate* the bank,[5] which results in a payoff L satisfying:

Assumption 3. *(i)* $p_\ell R > L$; *(ii)* $p_h > \frac{L}{1-r} > p_\ell$.

Part (i) of this assumption states that liquidation reduces the expected payoff of the impaired bank's loans. Part (ii) of the assumption states that liquidation lowers the expected deposit insurance cost for an impaired bank but not for a healthy bank.

A standalone bank can only be recapitalized through external equity issuance. We assume that issuing equity is costly as investors require an excess rate of return $c > 0$. A subsidiary of a CBB can, in addition, benefit from the *support* from the other subsidiary, which we model as an intragroup loan whose repayment is junior to that of deposits.[6]

Formally, a recapitalization plan for subsidiary $i \in \{A, B\}$ of a CBB is a tuple (x, s, S) consisting of: *i)* the funds $x \geq 0$ that the CBB raises through an external equity issuance against a share of its $t = 2$ profits and then injects into subsidiary i; and *ii)* the intragroup loan described by an injection of funds s from subsidiary $j \neq i$ into subsidiary i in exchange for a promised repayment S from subsidiary i to subsidiary j at $t = 2$ which is

[4]The current incomplete Euro area banking union, in which deposit insurance remains at the national level, would correspond to a national DIF architecture in our model

[5]Liquidation can involve removing the banking license to the bank, selling its assets and shutting down its activities. More generally, the intervention could be any action that protects the interests of DIFs, e.g., restrictions on investing in certain assets, mandatory disposals of non-performing loans or divestment requirements from some noncore businesses.

[6]As final loan payoffs are either R or 0, the exact security junior to deposits used to repay cross-unit support is irrelevant.

Subsidiary A

Assets	**Liabilities**
Asset A of quality p_A	Deposits (1)
Intragroup loan to subsidiary B (s, S)	Equity
Cash $(r - s)$	

Subsidiary B

Assets	**Liabilities**
Asset B of quality p_B	Deposits (1)
Cash $(r + x + s)$	Intragroup loan from subsidiary A (s, S)
	Equity

Figure 1: Balance sheets of subsidiaries A and B given a recapitalization plan (x, s, S) for subsidiary B.

junior to outstanding deposits. The resulting balance sheets of the two subsidiaries are illustrated in Figure 1. Notice that the recapitalization plan $(x, s, S) = (0, 0, 0)$ amounts to no recapitalization.

The intragroup loan can affect the costs faced by the DIF responsible for the subsidiary that provides the loan. We assume that the DIF has the power to constrain or even prohibit the transfer of resources, which we refer to as regulatory *ring-fencing*.[7] To highlight the tension between cross-unit support and ring-fencing, we assume that:

Assumption 4. *(i)* $r \geq \frac{L-p_\ell}{p_h-2p_\ell}$, *and (ii)* $c \geq \frac{1-p_\ell}{L-p_\ell(1-r)}(p_\ell R - L)$.

As will become clear later, the first condition implies that a healthy subsidiary has an interim payoff large enough to recapitalize and avoid the liquidation of an impaired subsidiary. The second condition instead implies that the cost of external equity is so high that recapitalization of an impaired standalone bank using only external equity is not feasible.

Timeline The sequence of events and decisions are summarized in Figure 2.

3 Ring-fencing and cross-border bank integration

In this section, we first characterize the equilibrium of the DIF intervention and recapitalization game at $t = 1$ for a standalone bank and for a CBB under different DIF architectures. We then consider bankers' decision to set up a CBB and discuss how the DIF architectures affect cross-border bank integration.

[7] This could be interpreted as breaching the subsidiary's capital requirement due to the issuance of a risky intragroup loan

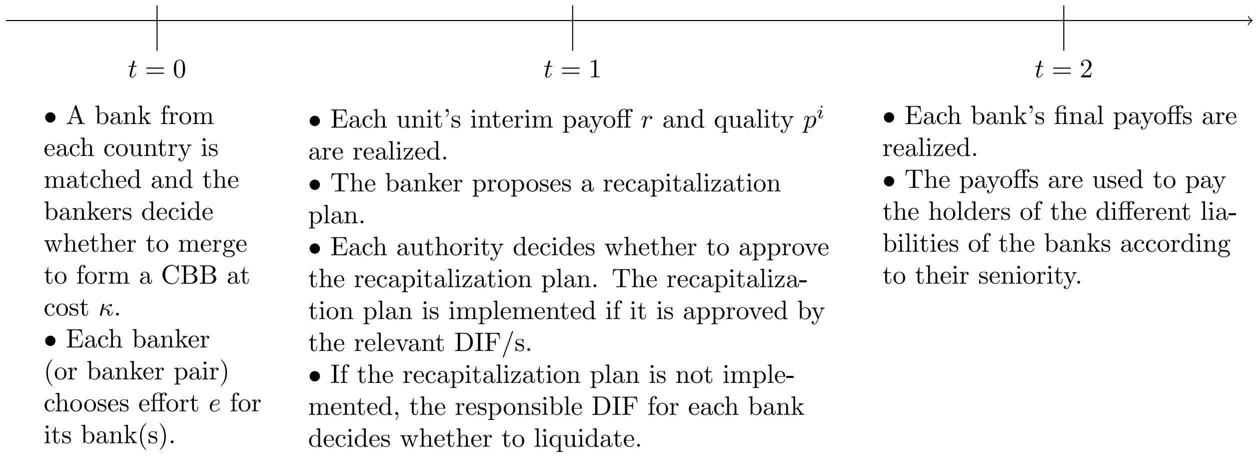


Figure 2: Time line.

3.1 DIF intervention in a standalone bank

Suppose a banker operates a standalone bank. Let $p \in \{p_h, p_\ell\}$ be the probability that the bank succeeds at $t = 2$, which is realized at $t = 1$.

Independently of the DIF architecture, the intervention decision of the responsible DIF at $t = 1$ is based on the comparison between the expected costs it incurs if the bank is allowed to continue and these if it is liquidated. Continuation is thus allowed when:

$$(1 - p)(1 - r) \leq 1 - L - r, \tag{1}$$

where the loan interim payoff r contributes to reducing deposit insurance costs in both cases and therefore appears on both sides in the inequality. Assumption 3 implies that condition (1) is satisfied if and only if the bank is healthy.

Consider now an impaired bank. Its banker might want to recapitalize it through an external equity issuance to avoid its liquidation, upon which he would receive a zero payoff. An external equity issuance x is accepted by the DIF if and only if its expected cost is lower with recapitalization than upon liquidation, that is, if

$$C_1^{SA}(x) \equiv (1 - p_\ell)\left[1 - (r + x)\right]^+ \leq 1 - L - r. \tag{2}$$

Since the equity injection x reduces the costs for the DIF under continuation, a sufficiently large recapitalization x avoids liquidation. However, part (ii) of Assumption 4 implies (after some algebra) that the banker is not able to raise those funds because the excess cost c of external equity is too large. The next result follows.

Lemma 1 (Intervention of standalone impaired bank)**.** *Consider a standalone bank that is impaired at $t = 1$. Regardless of the DIF architecture, the banker is unable to raise the minimum external equity for continuation required by the responsible DIF, and the bank is liquidated.*

3.2 DIF intervention in a CBB

We now consider a CBB and characterize the equilibrium of the DIF intervention and recapitalization game at $t = 1$ under each of the DIF architectures.

We focus on the scenario in which one of the subsidiaries is healthy and the other one is impaired. This is when cross-unit support and ring-fencing may arise. In any other scenarios, one can easily show that either there is no liquidation threat or there is no possibility of cross-unit support and outcomes are as in the standalone case described in Section 3.1.

3.2.1 National DIF: cross-unit support and ring-fencing

For concreteness, we assume that at $t = 1$ subsidiary A is healthy and subsidiary B is impaired. Their success probabilities in case of continuation are $p^A = p_h, p^B = p_\ell$. We have established in Section 3.1 that, in the absence of a recapitalization, DIF B would liquidate subsidiary B.

The bankers of this CBB may propose a recapitalization plan that consists of an external equity issuance x and *an intragroup loan* (s, S) satisfying two budget constraints. First, the loan size s should not exceed unit A's available funds at $t = 1$:

$$s \leq r. \tag{3}$$

Second, subsidiary B must be able to repay the promise on the intragroup loan in case it succeeds at $t = 2$:

$$S \leq R + r + x + s - 1. \tag{4}$$

The expression on the right-hand side accounts both for the overall fund injection $x + s$ in subsidiary B at $t = 1$ and the seniority of deposit repayments at $t = 2$.[8]

The recapitalization plan (x, s, S) is accepted by DIF B if and only if:

$$C_1^B(x, s) \equiv (1 - p_\ell) \left[1 - (r + x + s)\right]^+ \leq 1 - L - r. \tag{5}$$

The expression, analogous to the one for the standalone case in (2), accounts for the reduction in costs for DIF B due to the external *and* internal capital injections in the subsidiary. This implies that from DIF B's perspective, recapitalization through an external equity issuance and an intragroup loan are perfect substitutes. Hence, DIF B requires a strictly positive minimum overall recapitalization $x + s$ in order not to liquidate subsidiary B.

We turn to DIF A. If the recapitalization plan is accepted, the expected costs for DIF A are given by:

$$C_1^A(s, S|\rho) \equiv \left[1 - p_h - (1 - \rho)p_\ell(1 - p_h)\right] \left[1 - (r - s)\right]^+ + (1-\rho)p_\ell(1-p_h) \left[1 - (r - s + S)\right]^+ , \tag{6}$$

The two terms capture the deposit insurance costs DIF A incurs when subsidiary A fails at $t = 2$, depending on whether subsidiary B fails or succeeds at that date, respectively. Recall that the joint probabilities of those two events are as described in Table 2. The cost in each of the contingencies accounts for the cross-unit transfer s, which reduces the available resources at subsidiary A. In case subsidiary B succeeds, the insurance cost accounts also for the intragroup loan repayment S, which increases the available resources at subsidiary A.

If $r - s + S \leq 1$,[9] we can rewrite (6) in a more compact form and the following condition for DIF A to approve the recapitalization plan follows:

$$C_1^A(s, S|\rho) = (1 - p_h)(1 - r) + (1 - p_h)s - (1 - \rho)p_\ell(1 - p_h)S \leq (1 - p_h)(1 - r), \tag{7}$$

where the right-hand side of the inequality captures the costs for DIF A in case the recapitalization plan is rejected. The second and third terms on the left-hand side of (7) account

[8]The recapitalization plan (x, s, S) must also satisfy an equity issuance feasibility constraint stating that the value of the residual claim of the CBB exceeds the value $x(1 + c)$ investors require in order to provide the amount x of external equity included in the plan. This constraint is never binding in the optimal recapitalization problem because the CBB's residual claim has a strictly positive value with no recapitalization. See the proof of Proposition 1 for details.

[9]We argue in the proof of Proposition 1 this is the case in the equilibrium of the recapitalization game.

for the costs and benefits for DIF A from the intragroup loan, respectively. Notice that the benefit is decreasing in the correlation ρ between the two subsidiaries' loan payoffs because a larger correlation makes it less likely that subsidiary B succeeds when subsidiary A fails.

The opposite signs on the intragroup loan s in the DIF B and DIF A approval conditions (5) and (7) highlight the conflict between the two DIFs that can give rise to *ring-fencing*: DIF A may not allow a recapitalization plan that involves a large intragroup loan s , forcing the bank to meet the requirement by DIF B with costly external capital issuance, $x > 0$.

We now turn to the bankers' optimal recapitalization decision. Unless a recapitalization plan is approved by both of the DIFs, it is not undertaken and subsidiary B is liquidated. The bankers' expected payoff from the CBB as of $t = 1$ is then given by:

$$\underline{\Pi}_1^{CBB} = (p_h R + r - 1) + (1 - p_h)(1 - r), \tag{8}$$

which captures that the bankers only preserve the equity value of subsidiary A. This amounts to the asset value net of its nominal deposit liability plus the deposit insurance subsidy enjoyed by subsidiary A.

If a recapitalization plan is approved by both DIFs, the bankers' expected payoff from the CBB as of $t = 1$ is:

$$\Pi_1^{CBB}(x, s, S) = (p_h R + r - 1) + (p_\ell R + r - 1) + C_1^A(s, S|\rho) + C_1^B(x, s) - xc. \tag{9}$$

The first two terms in the decomposition above capture the asset values of each subsidiary net of their deposit liabilities. The third and fourth terms account for the value of the deposit insurance subsidies. The final term captures the cost of raising external equity at an excess return $c > 0$.

Subtracting (8) from (9), we have that the payoff difference for the bankers between a recapitalization plan that is approved and no recapitalization is:

$$\begin{aligned}\Pi_1^{CBB}(x, s, S) - \underline{\Pi}_1^{CBB} =& (p_\ell R - L) - \left[(1 - p_h)(1 - r) - C_1^A(s, S|\rho)\right] \\ & - \left[(1 - L - r) - C_1^B(x, s)\right] - xc. \end{aligned} \tag{10}$$

The payoff difference is composed of four terms. The first one, which is positive, captures the value gains from the continuation of subsidiary B. The second and third terms, which are weakly negative from (5) and (7), capture the portion of this value gains that is appropriated by the DIFs, which reduce the bankers' payoff. Finally, the fourth term accounts for the excess return required by equity investors, which also reduces the payoff for the banker.

The payoff decomposition in (10) highlights that the bankers prefer a recapitalization plan that: *i)* leaves no gains for DIFs; and *ii)* relies as little as possible on external equity. The next proposition characterizes the solution to the banker's recapitalization problem.

Proposition 1 (National DIFs: cross-unit support and ring-fencing)**.** *Suppose at $t = 1$ a CBB has a healthy subsidiary A and an impaired subsidiary B. Under national DIFs, there exist $\underline{\rho}, \overline{\rho} \in (0, 1)$, with $\underline{\rho} < \overline{\rho}$, such that the unique equilibrium of the DIF intervention game at $t = 1$ is as follows:*

- *If $\rho \leq \underline{\rho}$: There is no ring-fencing and subsidiary B is not liquidated. The CBB's recapitalization consists of no external equity issuance, $x^*(\rho) = 0$, an intra-group loan of size*

$$s^*(\rho) = \bar{s} \equiv \frac{L - p_\ell(1 - r)}{1 - p_\ell}, \tag{11}$$

  and a promised repayment $S^*(\rho)$ increasing in ρ.

- *If $\rho > \underline{\rho}$: There is ring-fencing. Moreover:*
  - *For $\rho \in (\underline{\rho}, \overline{\rho})$, subsidiary B is not liquidated. The CBB's recapitalization consists of an intra-group loan with size $s^*(\rho) < \bar{s}$ and external equity issuance $x^*(\rho) = \bar{s} - s^*(\rho)$, where $s^*(\rho)$ is decreasing in ρ and $x^*(\rho)$ is increasing in ρ. The promised repayment of the intra-group loan $S^*(\rho)$ is decreasing in ρ.*
  - *For $\rho \geq \overline{\rho}$, no recapitalization is undertaken and subsidiary B is liquidated.*

The results of the proposition are illustrated in Figure 3. For a negative or small correlation between the two subsidiaries' loan payoffs ($\rho \leq \underline{\rho}$), there is no ring-fencing. Subsidiary B is recapitalized entirely through an intragroup loan from subsidiary A ($s^*(\rho) = \bar{s}$ and $x^*(\rho) = 0$), and the bankers avoid the costly issuance of equity. As correlation increases, it becomes less likely that the repayment of the intragroup loan contributes to reducing the

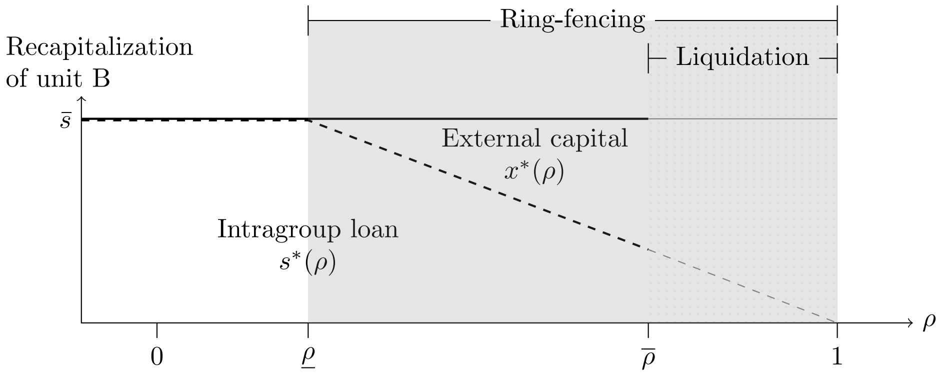


Figure 3: The severity of ring-fencing under national DIFs. $\bar{s} = x^*(\rho) + s^*(\rho)$ (the solid line) is the overall recapitalization of subsidiary B that avoids its liquidation, whereas $s^*(\rho)$ is the recapitalization provided through cross-unit support (dashed line). For $\rho \leq \underline{\rho}$, there is no ring-fencing and all the recapitalization is provided through cross-unit support $s^*(\rho) = \bar{s}$. For $\rho > \underline{\rho}$, there is ring-fencing. Subsidiary B is recapitalized for $\rho \in (\underline{\rho}, \overline{\rho})$ through a combination of limited voluntary support $s^*(\rho) < \bar{s}$ and external capital $x^*(\rho) = \bar{s} - s^*(\rho) > 0$, and is liquidated for $\rho \geq \overline{\rho}$.

costs faced by DIF A (see the second term of $C_1^A(\cdot)$ given in (7)). As a result, the promised repayment on the intragroup loan $S^*(\rho)$ increases in order to obtain approval from DIF A.

The above intuition underpins the emergence of *ring-fencing* for high correlation ($\rho > \underline{\rho}$). In this case, DIF A does not approve the intragroup loan of size $\bar{s}$ even when the promised repayment exhausts the residual payoff of subsidiary B (that is, when S reaches the upper bound given in (4) for $s = \bar{s}$ and $x = 0$). As a result, the intragroup loan size approved by DIF A constitutes only a partial recapitalization ($s^*(\rho) < \bar{s}$), which is decreasing in the correlation. Ring-fencing therefore constrains the bankers to rely (partially) on costly external equity to avoid the liquidation of subsidiary B, and the more so the larger the correlation. Moreover, such ring-fencing reduces the bankers' expected payoff. For intermediate levels of correlation ($\rho \in (\underline{\rho}, \overline{\rho}]$), the bankers still find it optimal to recapitalize the impaired subsidiary. For high enough correlation ($\rho > \overline{\rho}$), this is no longer the case and the subsidiary is liquidated.

3.2.2 Common DIF: cross-unit support without ring-fencing

We now consider a common DIF. We again focus on a healthy subsidiary A and an impaired subsidiary B at $t = 1$.

As in the standalone case in Section 3.1, in the absence of a recapitalization, the common DIF liquidates subsidiary B. A recapitalization offer (x, s, S) from the bankers has to satisfy the following approval condition for a common DIF:

$$\underbrace{C_1^A(s, S|\rho)}_{\text{Subsidiary A}} + \underbrace{C_1^B(x, s)}_{\text{Subsidiary B}} \leq \underbrace{(1 - p_h)(1 - r)}_{\text{Subsidiary A}} + \underbrace{(1 - L - r)}_{\text{Subsidiary B}}. \tag{12}$$

Notice that the single approval condition for a common DIF is implied by the two national approval conditions (5) and (7). Hence, if a recapitalization plan is approved with national DIFs, it is also approved with a common DIF. The converse is not true as the common DIF would approve a recapitalization that reduces overall deposit insurance costs, even if it were to increase those associated with *one* of the subsidiaries.

The bankers' expected payoff from the CBB as of $t = 1$ if a recapitalization (x, s, S) is approved is given by (9) while it is given by (8) if it is not. The bankers' optimal recapitalization problem is thus analogous to that under national DIFs discussed in Section 3.2.1 with the difference that national approval conditions (5) and (7) are replaced with the single condition (12).

The bankers' optimal recapitalization plan may have multiple pay-off equivalent solutions that only differ in how the overall insurance costs are distributed across the deposits of the two subsidiaries.[10] In the case of multiplicity, and without loss of generality, we focus for the sake of concreteness on the optimal recapitalization plan that leads to the lowest redistribution in the deposit insurance costs across subsidiaries relative to the no-recapitalization outcome.

The next proposition characterizes the solution to the optimal recapitalization problem.

Proposition 2 (Common DIF: cross-unit support without ring-fencing)**.** *Suppose at $t = 1$ a CBB has a healthy subsidiary A and an impaired subsidiary B. With common DIF, the CBBs' optimal recapitalization ensures the continuation of subsidiary B, binds the common DIF's approval condition (12), and involves no external equity issuance, $x^{**} = 0$.*

In addition, the optimal intragroup loan $(s^{**}(\rho), S^{**}(\rho))$ satisfies:

- *For $\rho \leq \underline{\rho}$: $s^{**}(\rho) = \bar{s} = s^*(\rho)$ and $S^{**}(\rho) = S^*(\rho)$.*

[10] Two recapitalization plans are payoff equivalent if, conditional on their implementation, they lead to the same bankers' payoff from the CBB and costs for the common deposit insurance fund.

- *For $\rho > \underline{\rho}$: $s^{**}(\rho) > \bar{s}$ and $S^{**}(\rho) = 1 - r + s^{**}(\rho)$, and hence $s^{**}(\rho) > s^{*}(\rho)$ for $\rho \in (\underline{\rho}, \overline{\rho})$. Moreover, $s^{**}(\rho)$ is strictly increasing in ρ.*

Proposition 2 states that ring-fencing never arises with a common DIF and the CBB recapitalizes the impaired subsidiary without costly external equity, $x^{**} = 0$.

For low correlation across subsidiaries ($\rho \leq \underline{\rho}$), ring-fencing does not arise with national DIFs and the optimal recapitalization with national DIFs remains optimal with common DIF. This is due to two reasons. First, such a plan ensures that the cost of the insurance of *each* subsidiary's deposits is the same with and without recapitalization. A fortiori, the overall cost of deposit insurance is the same with and without recapitalization, and the recapitalization is approved by the common DIF. Second, the recapitalization plan does not feature a costly equity issuance. We hence have from the value difference decomposition in (10) that the recapitalization maximizes the bankers' expected payoff.

For higher correlation between the two subsidiaries ($\rho > \underline{\rho}$), the recapitalization of subsidiary B involves an intragroup loan of larger size with a common DIF relative to that with national DIFs, $s^{**}(\rho) > \bar{s} > s^{*}(\rho)$. To understand this result, consider $\rho \in (\underline{\rho}, \overline{\rho})$, so that with national DIFs the recapitalization $(x^{*}(\rho) > 0, s^{*}(\rho), S^{*}(\rho))$ ensures the continuation of the impaired subsidiary B despite some ring-fencing. If the CBB increases the size s of the intragroup loan above $s^{*}(\rho)$, there are larger deposit insurance costs if subsidiary A fails at $t = 2$, which happens with a probability $1 - p_h$. This comes at the benefit of reducing the deposit insurance costs by the same amount if subsidiary B fails at $t = 2$, which happens with a larger probability $1 - p_l$. The increase in the size of the intragroup loan thus reduces the expected costs the common DIF faces. Intuitively, by transferring resources from a relatively safe unit to a riskier unit, the CBB is foregoing some limited liability protection to the benefit of the insurance provider, the common DIF. The reduction in the costs for the common DIF allows the CBB to reduce the external equity contribution to zero and recapitalize the impaired subsidiary only by using an intragroup loan $s^{**}(\rho) > s^{*}(\rho), x^{**}(\rho) = 0$. In particular, this can also be achieved when the correlation across subsidiaries is so large, $\rho > \overline{\rho}$, that with national DIFs ring-fencing would be so severe that the impaired subsidiary would be liquidated.

Notice that the CBB's optimal recapitalization is approved by the common DIF but would be rejected under national DIFs by the DIF responsible for the deposits of the healthy subsidiary, which would ring-fence some of the resources. In other words, some redistribution of costs associated with the insurance of the subsidiaries' deposits is necessary to avoid the liquidation of the impaired subsidiary without recourse to external equity issuance.

Finally, Proposition 2 states that the optimal size $s^{**}(\rho)$ of the intragroup loan is increasing in the correlation between the subsidiaries. This is because, as correlation increases, there is a reduced likelihood that an intragroup loan is repaid by subsidiary B when subsidiary A fails at $t = 2$, which is the contingency in which the common DIF is the residual claimant. This needs to be offset with a larger injection of funds at $t = 1$ from the safer to the riskier subsidiary to ensure the costs for the common DIF do not increase relative to those with no recapitalization.

3.3 Cross-border bank integration

We now turn to the decision of two bankers that have been matched at $t = 0$ to form a CBB given their merger cost κ.

Suppose that the bankers keep their banks as standalone. Each banker's expected payoff from a standalone bank as a function of effort e is given by:

$$\Pi_0^{SA}(e) = (\gamma + e)p_h(R + r - 1) - k(e). \tag{13}$$

This expression takes into account that a standalone bank continues at $t = 1$ only if it is healthy, which happens with probability $\gamma + e$.

Suppose that the bankers choose to set up a CBB. The bankers' expected payoff from a CBB depends on their effort e and the amount of external equity the CBB x issues to recapitalize an impaired subsidiary at $t = 1$. In equilibrium, the amount of external equity x captures the level of ring-fencing and depends on the DIF architecture as described by Propositions 1 and 2: with national DIFs we have $x = x^*(\rho)$, where for the case $\rho > \overline{\rho}$, in which the impaired subsidiary would be liquidated and $x^*(\rho)$ was not defined, we adopt the convention $x^*(\rho) = \infty$; with a common DIF we have $x = x^{**} = 0$ for all ρ.

Using (13), we have that bankers' expected payoff from the CBB as a function of their effort e in each subsidiary for a ring-fencing level x is given by:

$$\Pi_0^{CBB}(e,x|\kappa) \equiv 2\Pi_0^{SA}(e) - \kappa \\ + \underbrace{2(1-\rho)(\gamma+e)(1-\gamma-e)}_{\text{Probability of intragroup support}} \underbrace{[(p_\ell R - L) - xc]^+}_{\text{Support gains}}, \tag{14}$$

The first line of this expression represents the expected payoff the bankers would obtain from the standalone banks net of the setup cost. The second line represents the increase in the bankers' expected profit due to the intragroup support, which is equal to the product of the probability of support and the value gains for the bankers conditional on support. The latter amounts to the loan value gains implied by the continuation of an impaired subsidiary, $p_\ell R - L$, net of the excess cost of the external equity issuance, xc.[11] Notice from (14) that the bankers' value from a CBB is decreasing both in the ring-fencing level x and in the CBB setup cost κ.

We thus have that the bankers find it optimal to set up a CBB when their cost κ is below a threshold κ' defined by:

$$\max_e \Pi_0^{CBB}(e,x|\kappa') = 2\max_e \Pi_0^{SA}(e). \tag{15}$$

In addition, the reduction in support gains due to ring-fencing implies that the threshold κ' defined above is decreasing in the ring-fencing level x. The next result follows.

Proposition 3 (Expansion of cross-border bank integration with a common DIF)**.** *Let κ^* be the threshold such that with national DIFs bankers set up a CBB if and only if their setup cost satisfies $\kappa \le \kappa^*$, and κ^{**} be the analogous threshold with a common DIF. We have $\kappa^* \le \kappa^{**}$ and strictly so if and only if $\rho \in (\underline{\rho}, 1)$.*

This result states that a common DIF expands cross-border bank integration when under national DIFs cross-unit support would be constrained by ring-fencing. Intuitively, the common DIF allows the CBB to use only internal resources to recapitalize an impaired unit and thereby save on costly external equity. This makes cross-border banking more profitable

[11]The superscript "+" on the expression for support gains in (14) and our convention on the value of x when there is liquidation of the impaired subsidiary with national DIFs, ensure support gains for the bankers are zero in that case.

and, thus, fosters integration. As economic integration and a common monetary policy in the Euro area makes it more likely that domestic bank assets are correlated across member countries of the currency union (Brasili and Vulpes, 2009), these results are in line with the statements in Enria (2023): common deposit insurance in the Euro area banking union would foster cross-border bank integration.

4 Risk-taking and Welfare

In this section, we characterize the bankers' effort or, equivalently, risk-taking decisions at $t = 0$ under the two DIF architectures. We then analyze the welfare implications of moving from national DIFs to a common DIF, taking into account its effect on bankers' optimal cross-border integration and risk-taking decisions.

4.1 Risk-taking at $t = 0$

Consider first a banker that keeps his bank as a standalone. The banker's effort maximizes the value $\Pi_0^{SA}(e)$ he obtains from the bank, which is given by (13). The optimal effort choice e^{SA}, which equalizes the marginal cost and benefit of effort, satisfies the following first order condition:

$$k'(e) = p_h(R + r - 1). \tag{16}$$

If instead two matched bankers set up a CBB, the effort in each subsidiary maximizes the value $\Pi_0^{CBB}(e, x|\kappa)$ given by (14), where the ring-fencing level x in the cross-unit support satisfies: $x = x^*(\rho)$ with national DIFs and $x^{**} = 0$ with a common DIF. The optimal effort choice for a given x satisfies:

$$\begin{aligned} k'(e) = {} & p_h(R + r - 1) + \\ & + \underbrace{(1-\rho)\left[\overbrace{(1-(\gamma+e))}^{\text{Franchise value eff.}} - \overbrace{(\gamma+e)}^{\text{Liq. threat eff.}}\right]}_{\text{Change in support probability}} \times \underbrace{[(p_\ell R - L) - xc]^+}_{\text{Support gains}}. \end{aligned} \tag{17}$$

Notice that the bankers' cost κ of setting up a CBB does not appear on the right-hand side of the expression as it is independent of effort. The bankers' effort in a CBB hence does not depend on the setup cost. The first term on the right-hand side of (17) represents the marginal benefit of effort in the absence of cross-unit support and coincides with the right-hand side of (16). The second term on the right-hand side of (17) captures the additional effect on effort stemming from the possibility of cross-unit support: this is the product of the change in the probability of support caused by a marginal change in effort and the value the bankers obtain from avoiding liquidation through support.

Three aspects of this term are worth noting. First, exerting effort in a subsidiary affects the support probability in two opposing ways (captured by the central factor in the second term on the right-hand side of (17)). On the one hand, the possibility of *providing* support *increases* the marginal benefit of effort in a given subsidiary: higher effort raises the probability of being able to support the other subsidiary in case of impairment, which occurs with probability $1 - (\gamma + e)$. We refer to this as the *franchise value effect* as the value of effort in each subsidiary increases due to the possibility of preserving the value of the other subsidiary. This effect is stronger when the economy is intrinsically riskier (that is, if γ is lower): the marginal benefit of effort in one subsidiary increases when there is a higher probability that the other subsidiary is impaired.

On the other hand, the possibility of *receiving* support *reduces* the marginal benefit of effort in a given subsidiary. This is because an impaired subsidiary may avoid liquidation via cross-unit support from the other subsidiary if the latter is healthy, which occurs with probability $\gamma + e$. We refer to this as the *liquidation threat effect* as cross-unit support erodes the effort incentives provided by the liquidation of an impaired bank, which leaves zero residual value to the bankers. Notice that this effect is stronger when the economy is less risky (that is, if γ is higher): the marginal benefit of effort in one subsidiary decreases when there is a higher probability that the other subsidiary is healthy and hence able to grant support.

Second, the effect of cross-unit support (in absolute terms) on effort is proportional to the value the bankers obtain from support (captured by the right-most factor in the second term on the right-hand side of (17)). Since the ex-post gains from support are decreasing in the ring-fencing level, the absolute value of the overall support effect on effort is larger with a common DIF than with national DIFs.

Third, the effect of cross-unit support on effort gets reduced as the correlation increases between the two subsidiaries. Higher correlation makes it ex ante less likely that one subsidiary is healthy while the other is impaired, thereby reducing the probability of cross-unit support (captured by the left-most factor in the second term on the right-hand side of (17)). Additionally, with national DIFs the effect of cross-unit support on effort at higher correlations is further dampened as ring-fencing (recall that $x^*(\rho)$ is increasing in ρ from Proposition 1). This reduces the ex-post gains from support for the bankers (captured by the right-most factor in the second term on the right-hand side of (17)).

The following proposition summarizes how the bankers' risk-taking behavior depends on their banks' organizational structure and the DIF architecture.

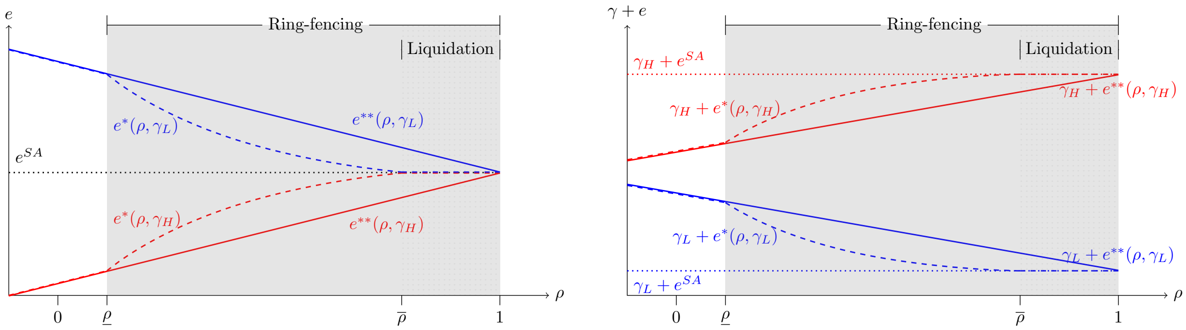
Proposition 4 (Bankers' risk-taking decision given organizational structure and DIF architecture)**.** *Let e^{SA} denote the bankers' optimal effort in a standalone bank, and $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ the bankers' optimal effort in the subsidiaries of a CBB with national DIFs and a common DIF, respectively. There exists a risk threshold $\hat{\gamma} \in \left(\underline{\gamma}, \bar{\gamma}\right)$ independent of ρ, such that:*

- *If $\gamma \leq \hat{\gamma}$, then $e^{SA} \leq e^*(\rho, \gamma) \leq e^{**}(\rho, \gamma)$, with $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ decreasing in ρ;*
- *If $\gamma \geq \hat{\gamma}$, then $e^{SA} \geq e^*(\rho, \gamma) \geq e^{**}(\rho, \gamma)$, with $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ increasing in ρ.*

Moreover, $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ are decreasing in γ, while the probabilities that each subsidiary is healthy at $t = 1$, $\gamma + e^{SA}$, $\gamma + e^*(\rho, \gamma)$ and $\gamma + e^{**}(\rho, \gamma)$ are increasing in γ.

The proposition shows that cross-unit support in a CBB can enhance or undermine the bankers' effort depending on the economy-wide risk, γ, and that the effects are (in both directions) stronger with a common DIF. These results are illustrated in Figure 4.

When risk is higher ($\gamma \leq \hat{\gamma}$, illustrated by the blue lines in Figure 4), the positive franchise value effect of support in a CBB dominates. Effort is higher in a CBB (solid and dashed lines) than in standalone banks. Regardless of the DIF architecture, the bankers' effort in the subsidiaries of a CBB decreases with the correlation between them because this reduces the likelihood that one subsidiary is healthy while the other is impaired at $t = 1$. For negative or low correlation ($\rho \leq \underline{\rho}$), effort in the CBB is independent of the DIF architecture because



(a) Bank effort choice

(b) Prob. of healthy unit

Figure 4: Panels (a) and (b) illustrate the bankers' optimal effort choice, e, and the resulting probability that each unit is healthy, $\gamma + e$, respectively, against the correlation ρ for two values of economy-wide risk γ, γ_H (in red) and γ_L (in blue), where $\gamma_H > \hat{\gamma} > \gamma_L$. The dotted lines illustrate the corresponding values for standalone banks, the dashed lines for a CBB with national DIFs, and the solid lines for a CBB with a common DIF.

ring-fencing does not emerge with national DIFs. As the correlation increases ($\rho \geq \underline{\rho}$), ring-fencing occurs with national DIFs and becomes progressively more severe, further reducing the effort with national DIFs relative to a common DIF. For sufficiently high correlation ($\rho > \overline{\rho}$), ring-fencing with national DIFs is so severe that cross-unit support in a CBB does not emerge, resulting in a low effort level that is identical to that in standalone banks. As the correlation between the two subsidiaries becomes closer to perfect ($\rho = 1$), effort in a CBB with a common DIF also approaches that in standalone banks because the ex-ante probability of cross-unit support tends to zero.

When risk in the economy is lower ($\gamma \geq \hat{\gamma}$), the liquidation threat effect dominates. As a result, all effects are reversed, as illustrated by the red lines in Figure 4. Bankers choose higher risk in CBBs than in standalone banks, and more so with a common DIF than with national DIFs.

4.2 Welfare implications of the introduction of a common DIF

In this section, we assess the welfare implications of a shift from national DIFs to a common DIF. Welfare in our economy amounts to the overall value the bankers obtain net of the costs incurred by the DIF/s.[12] Bankers do not internalize the effect of their $t = 0$ decisions on the cost to the DIF/s, which opens up room for misalignment between private and socially optimal decisions.

If a banker operates a standalone bank, the $t = 0$ costs of the insurance on its bank's deposits for effort e are given by

$$C_0(e) = (\gamma + e)(1 - p_h)(1 - r) + (1 - \gamma - e)(1 - L - r). \tag{18}$$

The expression captures the insurance costs in case the bank is healthy and impaired at $t = 1$ weighted by the probability of each state. Recall that if the bank becomes impaired there is no recapitalization.

If two matched bankers operate a CBB, we have that if a recapitalization of an impaired subsidiary takes place at $t = 1$, the authorization constraint of each national DIF or that of the common DIF are binding (Proposition 1 and 2). This means that the expected costs as of $t = 1$ for the DIF/s coincide with those in the absence of a recapitalization. Thus, the deposit insurance costs as of $t = 0$ for each unit of the CBB correspond to (18) for a given effort e. Hence, the CBB set-up choice and the DIF architecture affect the overall cost of deposit insurance only through their effects on the bankers' effort.

We now write total welfare in the economy as follows. Given the ring-fencing level x, the CBB set-up cost threshold κ' below which bankers integrate their standalone banks, and the effort e of bankers that set up a CBB, total welfare is the integral over banker pairs' CBB setup costs:

$$W(x, \kappa', e) = \int_0^{\kappa'} \left[\Pi_0^{CBB}(e, x|\kappa) - 2C_0(e)\right] dF(\kappa) + \int_{\kappa'}^{\infty} 2\left[\Pi_0^{SA}(e^{SA}) - C_0(e^{SA})\right] dF(\kappa). \tag{19}$$

Using the characterization of the tuple (x, κ', e) for the two DIF architectures in Propositions 1, 2 and 4, we can prove the following proposition, which constitutes the main contribution of the paper.

[12]Notice that: i) bank depositors are always repaid in full; and ii) the eventual investors in external equity of the CBB are repaid their opportunity cost of funds, so that the utility of these agents does not need to be included in the overall welfare in the economy.

Proposition 5 (Welfare impact of the establishment of a common DIF)**.** *Moving from national DIFs to a common DIF changes the overall welfare in the economy in the following way:*

- *If $\rho \leq \underline{\rho}$ or $\rho = 1$, there is no welfare change.*
- *If $\rho \in (\underline{\rho}, 1)$, let $\hat{\gamma} \in \left(\underline{\gamma}, \overline{\gamma}\right)$ be the economy-wide risk threshold defined in Proposition 4. We have that:*
    - *if $\gamma \leq \hat{\gamma}$, welfare increases.*
    - *if $\gamma > \hat{\gamma}$, there exist distributions $F(\kappa)$ of the CBB set-up cost such that welfare strictly decreases.*

Proposition 5 characterizes the welfare implications of the establishment of a common DIF. The results highlight that fostering cross-border bank integration through a common DIF might not always be welfare enhancing.

The first result of the proposition is that if the correlation across the banks in the two countries is small enough ($\rho \leq \underline{\rho}$), then the DIF architecture is irrelevant. This is because national DIFs do not ring-fence subsidiaries during crises. In addition, when the correlation is one, the DIF architecture also does not matter because the two subsidiaries of a CBB are impaired at the same time.

When the correlation across banks in the two countries is large enough yet imperfect ($\rho \in (\underline{\rho}, 1)$), CBBs face a ring-fencing problem with national DIFs during crises. A common DIF solves this problem and affects welfare through a number of channels. To gain intuitions, we can use (19) to decompose the welfare effect from the establishment of a common DIF as follows:

$$\Delta W = \underbrace{\int_0^{\kappa*} \left[\underbrace{\left(\Pi_0^{CBB}(e^{**}, x=0|\kappa) - \Pi_0^{CBB}(e^{*}, x^{*}|\kappa)\right)}_{\text{Ex-post support gains (+)}} + \underbrace{2\left(C_0(e^{*}) - C_0(e^{**})\right)}_{\text{Ex-ante effort (+/-)}} \right] dF(\kappa)}_{\text{Intensive margin: CBB merge irrespective DIF architecture}} + \\ + \underbrace{\int_{\kappa^*}^{\kappa^{**}} \left[\underbrace{\left(\Pi_0^{CBB}(e^{**}, x=0|\kappa) - 2\Pi_0^{SA}(e^{SA})\right)}_{\text{Ex-post support gains (+)}} + \underbrace{2\left(C_0(e^{SA}) - C_0(e^{**})\right)}_{\text{Ex-ante effort (+/-)}} \right] dF(\kappa)}_{\text{Extensive margin: CBB merge due to common DIF}} \tag{20}$$

The first term in the decomposition of the welfare accounts for the intensive margin effect that applies to banker pairs with low set-up cost (with type $\kappa \leq \kappa^*$), who merge their banks irrespective of the DIF architecture. The elimination of ring-fencing implied by a common DIF has two welfare effects along this margin. First, the enhanced ex-post intragroup risk-sharing possibilities increase the payoffs the bankers obtain from their CBBs and lead to a new optimally chosen effort level that further increases their payoffs (first term in intensive margin). The change in bankers' effort in turn affects deposit insurance costs (second term in intensive margin). These costs are reduced (contributing to a welfare increase) if bankers exert higher effort with a common DIF, which from Proposition 4 is the case only when risk in the economy is higher, that is, for $\gamma \leq \hat{\gamma}$.

The second term in (20) instead captures the welfare impact from the establishment of a common DIF through the extensive margin, corresponding to banker pairs with intermediate CBB set-up cost (with type $\kappa \in (\kappa^*, \kappa^{**})$, who keep their banks as standalone with national DIFs but set up a CBB with a common DIF. There are two welfare effects that are analogous to those on the intensive margin.

Figure 5 graphically illustrates the intensive and extensive margins of the welfare effects in (20) for different values of the economy-wide risk. Recall that banker pairs' payoffs always increase with a common DIF in both the intensive and the extension margins. When the economy is riskier ($\gamma < \hat{\gamma}$), a common DIF leads to higher bankers' effort along the two relevant margins, reducing deposit insurance costs. This is because, in this case, the positive franchise value effect on effort incentives associated with the removal of ring-fencing dominates the liquidation threat effect. Ex-post risk-sharing gains and ex-ante risk-taking in-

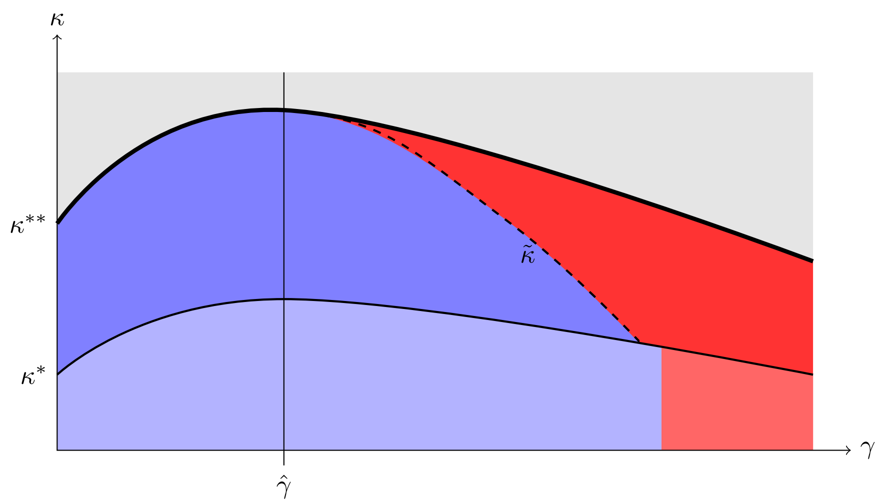


Figure 5: Welfare associated with banker pairs under common DIF versus national DIFs for $\rho \in (\underline{\rho}, 1)$. The figure considers different values of economy-wide risk in the economy (γ, horizontal axis) and banker pairs' CBB setup costs (κ, vertical axis). In the grey shaded area, welfare is identical under both DIF architectures (because banks remain standalone). In the (dark or light) blue shaded areas, welfare is higher with common DIF, whereas in the (dark or light) red shaded areas, welfare is lower with common DIF. In the light blue and light red shaded areas, cross-border integration always occurs, whereas in the dark blue and dark red shaded areas, cross-border integration occurs only with common DIF.

centives are aligned and welfare in the economy increases when a common DIF is established regardless of the distribution $F(\kappa)$ of CBB set-up costs.

In contrast, when the economy is safer ($\gamma > \hat{\gamma}$), a common DIF leads to lower bankers' effort along the two relevant margins, increasing deposit insurance costs. This is because, in this case, the negative liquidation threat effect on effort incentives associated with the removal of ring-fencing dominates. Ex-post risk-sharing gains and ex-ante risk-taking incentives are no longer aligned, which opens up room for welfare reductions. Indeed, the welfare generated by some of the banker pairs is lower with a common DIF (the dark and light red areas in Figure 5). If a sufficiently large measure of bankers is concentrated in those pairs, welfare in the economy falls when a common DIF is introduced, as stated in Proposition 5.

When the economy-wide risk is low, the cross-border banking expansions that policymakers argued would result from the establishment of a common DIF in the Euro area (Enria, 2023) might be concurrent with welfare reductions. This is an important implication of our model that brings a new argument to the policy debate. More strikingly, when risk is low, cross-border banking expansions are not only concurrent with but also contribute to welfare reductions: Some of the banker pairs in the extensive margin region reduce welfare when a common DIF is established. This is the case for banker pairs with costs close to the upper CBB set-up threshold with common DIF, κ^{**}. These bankers obtain only a small additional payoff increase when they set up a CBB following the establishment of a common DIF. Yet, the new organizational structure induces them to reduce effort. The negative impact on deposit insurance costs dominates the (small) private payoff increases but is neglected by the bankers, resulting in welfare reducing cross-border bank integration.

The same mechanisms that lead to excessive cross-border bank expansions when the economy is safer ($\gamma > \hat{\gamma}$), also result in too little cross-border banking when the economy is riskier ($\gamma < \hat{\gamma}$). While the establishment of a common DIF leads to more cross-border bank mergers there are still some banker pairs that find it optimal to keep their banks as standalone even though setting up a CBB would be socially efficient (the banker pairs with CBB set-up cost just above the threshold κ^{**}). This is because the bankers neglect that by setting up a CBB they would increase their effort and reduce deposit insurance costs.

The value of cross-border integration and correlation We conclude the section with a brief discussion of the benefits of cross-border integration and its dependence on correlation between the two countries. A way to measure the value of cross-border integration is to compare our baseline economy with a benchmark economy in which cross-border mergers are not possible and all banks remain standalone.

For the sake of concreteness, we focus on risky economies $\gamma \leq \hat{\gamma}$, in which we know from the previous analysis that a change from national DIFs to a common DIF increases welfare. Given a DIF architecture, we define the value of cross-border integration as the difference in welfare between the model equilibrium and the benchmark case in which all banks remain standalone. We can obtain the following result from Proposition 1, 2, 3 and 4 and the CBB payoff expression in (14).

Corollary 1 (Value of cross-border integration and correlation). *For $\gamma \leq \hat{\gamma}$, the value of cross-border integration is strictly decreasing with the correlation ρ across the countries under both DIF architectures. Moreover, it is independent of the DIF architecture for $\rho \leq \underline{\rho}$.*

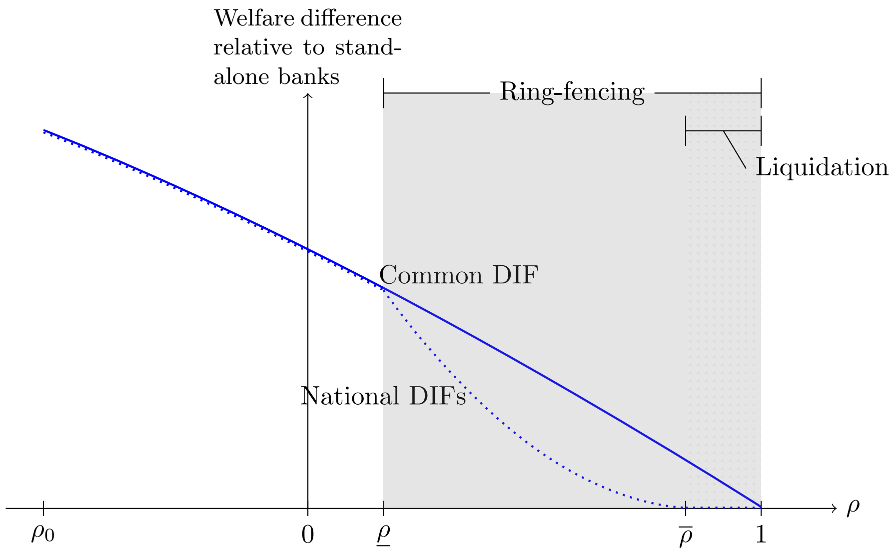


Figure 6: The value of cross-border integration under the two DIF architectures for $\gamma \leq \hat{\gamma}$.

This result, illustrated in Figure 6, states that precisely when the value of cross-border integration is higher (when the correlation ρ is lower, possibly negative), the DIF architecture does not matter for welfare. This is because of two reasons. First, from an ex ante perspective, when correlation is low (or even negative) the probability of cross-unit support within a CBB is higher (see the second term in (14)). As a result, the value of the internal capital market in a CBB increases. Second, from an ex post perspective, when correlation is low the conflicts between national DIFs during crises can be reconciled and ring-fencing does not emerge. The two DIF architectures are thus able to ensure maximum CBB value preservation during crises.

The corollary provides an irrelevance result with important policy implications: There is no need to create a banking union with a common DIF precisely when the gains from cross-border banking are more important. A "divine coincidence" ensures that when the CBB internal market is more valuable its functioning is not hampered by authorities protecting their national interest.

5 Robustness and extensions

5.1 Fairly priced deposit insurance

In this section, we discuss the effect of subjecting banks to fairly priced deposit insurance. We assume bankers are required to pay out of their own funds an actuarially fair deposit insurance premium at $t = 0$ to the relevant DIF/s. The premium depends both on the banks' organizational structure and on the DIF architecture, and correctly anticipates how the two affect the bankers' optimal effort choice at $t = 0$.

For a given DIF architecture and banks' organizational structure, the payment of the deposit insurance premium at $t = 0$ does not affect the recapitalization game at $t = 1$. Hence, it does not affect either the bankers' optimal effort at $t = 0$. The deposit insurance premium thus only impacts the bankers' decision to set up a CBB and by construction aligns it with the social welfare maximizing one. In other words, the fairly priced premium makes the cross-border integration decision always efficient irrespective of the DIF architecture.

By contrast, fairly priced deposit insurance cannot address the bankers' unobservable effort problem, which as standard in the presence of agency frictions leads to too low effort levels. Hence, the DIF architecture keeps on affecting overall welfare through its effect on bankers' effort, and the welfare impact of the establishment of a common DIF remains ambiguous.

Figure 7 graphically illustrates the effects of the establishment of a common DIF in the presence of fairly priced deposit insurance (under both DIF architectures). The solid lines represent the CBB set-up cost thresholds under the two DIF architectures with fairly priced premia, while dashed lines represent the analogous thresholds without them (which correspond to the solid lines in Figure 5). Compared to the baseline model, when the economy is riskier ($\gamma < \hat{\gamma}$), the CBB set-up cost thresholds shift upwards as bankers get rewarded for setting up a CBB through a reduction in the deposit insurance premium that accounts for the increase in effort; analogously, when the economy is safer ($\gamma > \hat{\gamma}$), the CBB set-up cost thresholds shift downwards as deposit insurance premia for CBBs decrease to account for the fact that bankers exert more effort in CBBs.

The figure also shows that, contrary to the case of no deposit insurance premia, the

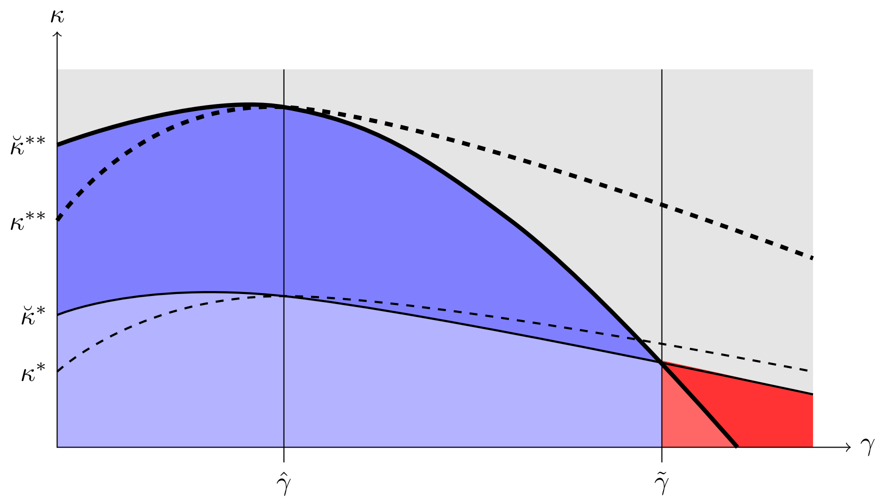


Figure 7: Welfare associated with banker pairs under a common DIF versus national DIFs for $\rho \in (\underline{\rho}, \overline{\rho})$ and fairly priced deposit insurance. The figure considers different values of economy-wide risk (γ, horizontal axis) and banker pairs' CBB setup costs (κ, vertical axis). $\breve{\kappa}^{*}$ and $\breve{\kappa}^{**}$ (solid lines) are the upper thresholds of the CBB merger costs such that banker pairs with lower costs setup a CBB under national DIFs and a common DIF, respectively, while κ^{*} and κ^{**} (dashed lines) are the analogous thresholds in the absence of deposit insurance premia given in Proposition 3. In the grey shaded area, welfare is identical under both DIF architectures. In the (dark or light) blue shaded areas, welfare is higher with a common DIF, whereas in the (dark or light) red shaded areas, welfare is lower with a common DIF. In the light blue and light red shaded areas, cross-border integration always occurs. In the dark blue shaded area, cross-border integration occurs only with a common DIF, whereas in the dark red shaded area, cross-border integration occurs only with national DIFs.

establishment of a common DIF may lead to a reduction in cross-border integration. This can happen for very safe economies as illustrated by the dark red shaded area in Figure 7. Notice that when such reduction of cross-border integration happens, the establishment of a common DIF also reduces welfare.

5.2 The DIFs' objective function

In the baseline model, we have assumed that the objective of the agent we refer to as DIF is to minimize costs. A prominent example of such type of agent is the Federal Deposit Insurance Corporation, which in the US is also responsible for the supervision of small- and medium-sized banks. In other jurisdictions, the supervision and resolution of banks are assigned to specific authorities that are legally different from the national deposit insurance funds. However, Demirgüç-Kunt et al. (2015) find that 57 percent of supervisory authorities in the world have responsibilities that include minimizing losses or risk to the deposit insurance funds in their jurisdictions. In addition to protecting depositors' claims, supervisors may also care about the supply of bank loans to the economy. Our model easily lends itself to such variation.

In particular, let us assume that the DIF/s' objective in our model is more generally that of maximizing a weighted average of the value of the banks' assets in their jurisdiction/s minus the expected deposit insurance cost they face, with $\phi \geq 0$ denoting the relative weight put on the former.[13]

This change in the DIF/s' objective functions changes their incentives to liquidate an impaired bank and thus affects the CBB's recapitalization behaviour. The DIF/s' concern for banks' asset value makes it more likely that a DIF responsible for an impaired bank approves a recapitalization plan compared to the baseline model. Importantly, this additional concern does not affect how a national DIF responsible for a healthy subsidiary perceives cross-unit support. Therefore, while the parameter space for which ring-fencing arises would get reduced, Propositions 1 and all subsequent results would remain qualitatively for ϕ not too large.

5.3 Other forms of support provision

In the baseline model, we have assumed that the support from a healthy subsidiary to an impaired subsidiary can only be provided in the form of a cash injection at $t = 1$ (against a future repayment). An alternative way to provide support to the distressed subsidiary would be by means of a guarantee issued by the healthy subsidiary.

Specifically, suppose the healthy subsidiary A in a CBB provides support to the impaired subsidiary B with a combination of: *i)* $s \leq r$ units of cash; and *ii)* a guarantee up to $g \leq 1$ of subsidiary B's deposits, which is settled at $t = 2$ and is junior to the repayment of subsidiary A's deposits. Under national DIFs, the approval condition by DIF B for a recapitalization

[13]In order to ensure that, in the absence of any recapitalization, a DIF prefers to liquidate a bank if and only if it is impaired, we need to slightly modify Part (ii) of Assumption 3 as follows: $p_h > \frac{(1+\phi)L}{\phi R+1-r} > p_\ell$.

plan is given by $\tilde{C}_1^B(x,s,g) \leq 1 - L - r$, where

$$\tilde{C}_1^B(x,s,g) \equiv C_1^B(x,s) - \underbrace{[(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)]}_{\text{Subs. A succeeds while Subs. B fails}}[g-(r+x+s)]^+ \,, \qquad (21)$$

and $C_1^B(x,s)$ is defined in (5). The approval condition given by (21) extends the one in the baseline model in (5) by including an additional term capturing the value of the guarantee to DIF B. Notice that the guarantee must satisfy the additional budget constraint:

$$[g-(r+x+s)]^+ \leq R + r - s - 1, \qquad (22)$$

where the left-hand side is the amount of transfer needed to settle the guarantee, and the right-hand side is the residual funds available at $t = 1$ in a successful subsidiary A after paying off its depositors. We have hence from (5) and (21) that the guarantee relaxes DIF B's authorization constraint relative to the baseline model, but (22) imposes an upper bound on how much the constraint is relaxed.[14] Moreover, the extent to which the constraint is relaxed decreases with correlation across the subsidiaries, so that ring-fencing will still arise with national DIFs, albeit at a higher level of correlation. Therefore, all results in the baseline model would qualitatively remain.

5.4 Ex ante arrangement and time-consistent DIF interventions

In the baseline model, we assume that the CBB only arranges to recapitalize an impaired subsidiary at $t = 1$. In practice, a CBB could arrange at $t = 0$ contingent transfers across subsidiaries that take place at $t = 1$. As long as the DIF/s cannot commit not to intervene at $t = 1$ to protect its financial interests, such ex ante arrangements would be subject to the same approval constraints as described in Section 3. Only if national DIFs could credibly commit to allow contractually agreed cross-unit transfers even when that leads them to suffer ex post some financial losses, the national DIF architecture would replicate the common DIF one.

In practice, the credibility not to ring-fence might depend on the size of the expected redistribution of deposit insurance costs across the two national funds upon the ex ante

[14]Notice that the issuance of a guarantee that is junior to subsidiary A's deposits has no effect on DIF A approval decision relative to the baseline model.

contractually agreed internal recapitalization scheme. Introducing some bounds on ex post redistribution between national funds would amount to an intermediate architecture lying between the two polar ones considered in the baseline model (no redistribution at all with national DIFs, and possibly unbounded redistribution across countries of deposit insurance costs with a common DIF).

6 Conclusion

Intragroup support within a cross-border bank allows for more efficient central liquidity and capital management. However, national authorities protecting their own deposit insurance funds tend to ring-fence resources within national boundaries, raising concerns about the overall welfare implications of these actions and the need to overcome them through international cooperation. Even in the Euro area banking union ring-fencing remains a problem and is perceived to be a major obstacle to the emergence of pan-European banks (Bénassy-Quéré et al., 2018; Lautenschläger, 2019; Enria and Fernandez-Bollo, 2020). It has been argued that introducing a common deposit insurance fund would solve at the same time the issue of ring-fencing and the lack of cross-border integration (Enria, 2023).

The paper provides a framework to inform this debate. We build a model that puts at its core the interplay between risk-taking by cross-border banks and the within-group risk-sharing opportunities allowed by the deposit insurance architecture.

We show that ring-fencing of a CBB arises when deposit insurance is provided at the national level for high correlation between the subsidiaries' assets. Ring-fencing in turn discourages cross-border bank integration. The establishment of a single deposit insurance fund that covers the deposits of all the banks removes ring-fencing practices. The expansion of risk-sharing opportunities within banking groups leads to more cross-border bank integration.

However, the welfare consequences of the removal of ring-fencing through common deposit insurance are non-trivial. Banks do not internalize the effect of their risk-taking and cross-border integration decisions on deposit insurance costs, which gives rise to potential misalignment between private and socially optimal choices. We find that in economies in which risks are intrinsically higher, common deposit insurance leads to more cross-border bank integration, *less* risk-taking, and *higher* welfare. However, when risks in the economy are lower, common deposit insurance still leads to more cross-border bank integration, but *more* risk-taking and sometimes to *lower* welfare.

Appendices

A Proofs

A.1 Proof of Proposition 1

Let us define $\underline{\rho}$ as the solution to

$$\frac{L - p_\ell(1-r)}{1-p_\ell}\frac{1}{(1-\rho)p_\ell} = R + r + \frac{L - p_\ell(1-r)}{1-p_\ell} - 1. \tag{23}$$

$\underline{\rho} \in (0,1)$ exists and is unique, because the left-hand side of (23) is strictly smaller than the right-hand side for $\rho = 0$ by Part (ii) of Assumption 3, is strictly greater than the right-hand side for $\rho = 1$, and is strictly increasing in ρ.

We proceed in two steps. We first solve for the bankers' optimal recapitalization plan that ensures the continuation of both subsidiaries. We then compare the bankers' expected payoff under such recapitalization plan to that without recapitalization, in order to derive the conditions for which the bankers prefer not to recapitalize.

The bankers' optimal recapitalization plan that ensures the continuation of both subsidiaries. The bankers' optimization problem is to maximize their expected payoff as of $t = 1$, which is given by (9), subject to the two authorities' approval requirements given by (5) and (6), the budget constraints (3) and (4), and the non-negativity constraint $x \geq 0$.

We first try to rewrite the optimization problem by showing that any solution must satisfy $r + x + s \leq 1$ and $r - s + S \leq 1$. Suppose first by way of contradiction that $r + x + s \geq 1$, which implies that $C_1^B(x, s) = 0$ and constraint (5) is slack, and that $x + s > 0$ as $r < 1$. It is therefore possible to decrease $x + s$ by decreasing either x or s by $\epsilon > 0$. For ϵ sufficiently small, this strictly increases the bankers' expected payoff while keeping all constraints satisfied. Next, notice that $r - s + S \leq 1$ is implied by the budget constraint (4) and Part (i) of Assumption 1.

We can thus replace the approval condition by DIF B in the optimization problem with

$$(1 - p_\ell)\left[1 - (r + x + s)\right] \leq 1 - L - r, \tag{24}$$

and replace the approval condition by DIF A given by (6) with (7) subject to an additional constraint

$$r + x + s \leq 1. \tag{25}$$

That is, the bankers' optimization problem is equivalently defined as maximizing the objective function given by (9), subject to the DIF approval conditions (24) and (7), the additional constraint (25), the budget constraints (3) and (4) and the non-negativity constraint $x \geq 0$.

We solve this alternative problem in two steps below. (i) We first define a simplified problem that drops the budget constraints (3) and (4) and the additional constraint (25), and show that the solution to this simplified problem indeed satisfies constraints (25) and (3), but only satisfies the budget constraint (4) if and only if $\rho \leq \underline{\rho}$. This implies that the solution to this simplified problem is also the solution to the original problem for $\rho \leq \underline{\rho}$. (ii) As the previous step implies that the budget constraint (4) binds for $\rho > \underline{\rho}$, we define a second simplified problem that drops the budget constraint (3) and the additional constraint (25), and binds the budget constraint (4). We can show that the solution to this simplified problem indeed satisfies the budget constraint (3) and the additional constraint (25) for $\rho > \underline{\rho}$ and thus is also the solution to the original problem.

(i) Consider the simplified problem given by the objective function (9), the approval constraints (7) and (24), and the non-negativity constraint $x \geq 0$. Let us denote the Lagrangian multipliers on the approval requirements of DIF A and B in (7) and (24), respectively, by μ^i for $i \in \{A, B\}$, and that on the non-negativity constraint on x by ξ . We derive the following first order conditions with respect to x, s, and S, respectively:

$$-(1 - p_\ell)(1 - \mu^B) - c + \xi = 0, \tag{26}$$

$$(1 - p_h)(1 - \mu^A) - (1 - p_\ell)(1 - \mu^B) = 0, \tag{27}$$

$$-(1 - \rho)p_\ell(1 - p_h)(1 - \mu^A) = 0, \tag{28}$$

and their respective complementary slackness conditions. We can now characterize the solution to this simplified optimization problem. (28) implies that $\mu^A = 1$ and therefore the constraint (7) binds by complementary slackness. $\mu^A = 1$ and (27) then imply that $\mu^B = 1$ and therefore (5) binds by complementary slackness. $\mu^B = 1$ and (26) imply that $\xi = c > 0$ and therefore $x = 0$ by complementary slackness. Imposing $x = 0$, a binding constraint (24) implies that $s = \bar{s} \equiv \frac{L - p_\ell(1-r)}{1-p_\ell}$, and a binding constraint (7) in turn implies that $S = \frac{s}{(1-\rho)p_\ell} = \frac{1}{(1-\rho)p_\ell}\frac{L-p_\ell(1-r)}{1-p_\ell}$.

Notice that this solution satisfies the budget constraint (3), as $\bar{s} = \frac{L-p_\ell(1-r)}{1-p_\ell} < r$ by Part (i) of Assumption 4. This then implies the additional constraint (25), from $r + x + s < 2r < 2 - R < 1$ by the first inequality of Assumption 1. This solution also satisfies the budget constraint (4) if and only if $\rho \leq \underline{\rho}$, where $\underline{\rho}$ is defined as the solution to (23). It is therefore also the solution to the overall optimization problem for $\rho \leq \underline{\rho}$.

(ii) Consider the simplified problem given by the objective function (9), the approval constraints (7) and (24), the non-negativity constraint $x \geq 0$, and a binding budget constraint (4) for $\rho > \underline{\rho}$. After substituting the binding constraint (4) into the objective function and the remaining constraints to eliminate S, we derive the following first order conditions with respect to x and s, respectively:

$$-(1-p_\ell)(1-\mu^B) - c + \xi = 0, \tag{29}$$

$$[1-(1-\rho)p_\ell]\,(1-p_h)(1-\mu^A) - (1-p_\ell)(1-\mu^B) = 0, \tag{30}$$

and their respective complementary slackness conditions, where the Lagrangian multipliers are similarly as defined above. (30) implies that either $\mu^A, \mu^B \leq 1$, or $\mu^A, \mu^B > 1$. We consider these two cases separately.

- Suppose $\mu^A, \mu^B \leq 1$. Then (29) implies $\xi > 0$ and therefore $x = 0$ by complementary slackness. Moreover, recall that the term multiplying $(1-\mu^A)$ in (30) is the joint probability that both units fail simultaneously. This term is thus strictly smaller than $(1-p_\ell)$, the unconditional probability that unit B fails. Therefore, (30) implies that either $\mu^B = \mu^A = 1$, or $\mu^B > \mu^A \geq 0$. In either case, $\mu^B > 0$ and therefore the approval constraint (24) binds by complementary slackness. $x = 0$ and a binding constraint (24) then imply $s = \frac{L-p_\ell(1-r)}{1-p_\ell}$, the same as in Case (i). However, the analysis in Case (i) shows that the value of S that binds the approval constraint (7) violates the budget constraint (4) for $\rho > \underline{\rho}$. However, since lowering S tightens the constraint (7), there exists no S that satisfies both the constraint (7) and the budget constraint (4) for $\rho > \underline{\rho}$.

- Suppose $\mu^A, \mu^B > 1$. This implies that the approval constraints (7) and (24) bind by complementary slackness. It is easy to verify that $s = \frac{(1-\rho)p_\ell(R+r-1+L-p_\ell R)}{1-p_\ell}$, $x = \bar{s} - s$ and $S = R + r + \bar{s} - 1$ satisfy (29)–(30) and bind all constraints. This is therefore a solution to the optimization problem.

To summarize, the solution to the optimization problem defined by the objective function (9), the budget constraints (3) and (4), the approval constraints (5) and (6), and the non-negativity constraint $x \geq 0$ is

$$s^*(\rho) = \begin{cases} \bar{s} \equiv \frac{L-p_\ell(1-r)}{1-p_\ell}, & \text{if } \rho \leq \underline{\rho}, \\ \frac{(1-\rho)p_\ell(R+r-1+L-p_\ell R)}{1-p_\ell}, & \text{if } \rho > \underline{\rho}, \end{cases}$$
$$S^*(\rho) = \begin{cases} \frac{\bar{s}}{(1-\rho)p_\ell}, & \text{if } \rho \leq \underline{\rho}, \\ R + r + \bar{s} - 1, & \text{if } \rho > \underline{\rho}, \end{cases}$$
$$x^*(\rho) = \bar{s} - s^*(\rho). \tag{31}$$

The bankers' decision to recapitalize. The bankers prefer not to recapitalize the impaired subsidiary if and only if the expected payoff difference given by (10) is negative when evaluated at the optimal recapitalization plan that ensures the continuation of both units given by (31). Using the fact that this recapitalization plan binds the constraints (7) and (24), (10) evaluated at the solution given by (31) is equal to

$$\Pi_1(x^*(\rho), 0, s^*(\rho), S^*(\rho)) - \underline{\Pi}_1 = (p_\ell R - L) - x^*(\rho)c. \tag{32}$$

Recall that $x^*(\rho) > 0$ if and only if $\rho > \underline{\rho}$ as shown previously, and that $x^*(\rho)$ is strictly increasing in ρ for all $\rho > \underline{\rho}$. It follows that there exists a unique threshold $\overline{\rho}$, such that the banker recapitalizes the bank if and only if $\rho \leq \overline{\rho}$, where $\overline{\rho}$ is defined as the solution to $(p_\ell R - L) - x_h^*(\rho)c = 0$, or the solution to

$$(p_\ell R - L) - \left[\frac{L - p_\ell(1-r)}{1-p_\ell} - \frac{(1-\rho)p_\ell}{1-(1-\rho)p_\ell}(1-r)\right] c = 0. \tag{33}$$

Notice that $\overline{\rho} \in (\underline{\rho}, 1)$, because the left-hand side of the above expression (i) is strictly decreasing in ρ, (ii) is strictly positive for $\overline{\rho} = \underline{\rho}$, in which case the second term in the above expression is equal to zero, and (iii) is strictly negative for $\overline{\rho} = 1$ by Part (*ii*) of Assumption 4.

Finally, recall that, as stated in Footnote 8, we have omitted the feasibility constraint of equity issuance. It is immediate that, for all $\rho \leq \overline{\rho}$, the fact that the bank finds it optimal to recapitalize the bank implies that $\Pi_1(\cdot) > 0$ and thus equity issuance is feasible.

A.2 Proof of Proposition 2

Let us consider the bankers' optimal recapitalization plan that ensures the continuation of both subsidiaries. It maximizes the banker's expected payoff given in (9), subject to the common DIF's approval condition (12), the budget constraints (3) and (4), and the non-negativity constraint $x \geq 0$.

Notice that the recapitalization plan given in Proposition 2 satisfies all constraints, and, in particular, satisfies the constraint (12) with equality, and has $x = 0$. The existence of such a recapitalization plan has two implications. First, since any optimal recapitalization plan that ensures the continuation of both units leaves a weakly higher expected payoff for the bankers, any such recapitalization binds (12) and has $x = 0$. Second, it implies that the bankers always find it optimal to recapitalize the impaired subsidiary.

Thus, we can focus on characterizing the bankers' optimal recapitalization plan, which must satisfy $x = 0$ and bind (12). Following similar arguments as those in the proof of Proposition 1, we replace the expression for $C_1^B(x^B, s)$ in (12) given by (5) with that in (24), and replace the expression for $C_1^A(x^A, s, S \mid \rho)$ in (6) with that in (24) and the additional constraint (25). After imposing $x = 0$, a binding constraint (12) can be expressed as follows:

$$(1 - p_\ell)(1 - r - s) + (1 - p_h)(1 - r + s) - (1 - \rho)p_\ell(1 - p_h)S \\ = (1 - L - r) + (1 - p_h)(1 - r). \qquad (34)$$

Since there exists a continuum of (s, S) that satisfy (34), we now solve for the pair (s, S) that minimizes the redistribution between the two deposit insurance costs incurred in the two countries. Consider the following two cases.

- $\rho \leq \underline{\rho}$. In this case, it is easy to verify that $s^* = \bar{s}$ and $S^*(\rho) = \frac{\bar{s}}{(1-\rho)p_\ell}$ satisfy all constraints. Moreover, since it does not lead to any redistribution, i.e. (5) and (6) are both satisfied with equality, this is also the recapitalization plan that minimizes redistribution between the deposit insurance costs incurred in the two countries.

- $\rho > \underline{\rho}$. In this case, the budget constraint (4), $x^B = 0$ and (34) imply that s must satisfy

$$(1 - p_\ell)(1 - r - s) + (1 - p_h)s - (1 - \rho)p_\ell(1 - p_h)(R + r + s - 1) \leq 1 - L - r. \quad (35)$$

Since the left-hand side of (35) is strictly decreasing in s, (35) is equivalent to $s \geq s^{**}(\rho)$, where $s^{**}(\rho)$ is defined as the solution to (35) with equality. As the expected deposit insurance cost for subsidiary B is strictly decreasing in s and that of subsidiary A is strictly increasing in s, the recapitalization plan that minimizes redistribution between the costs incurred in the two countries has $s = s^{**}(\rho)$ and $S = S^{**}(\rho) = 1 - r + s^{**}(\rho)$.

Moreover, since the left-hand side of (35) is strictly increasing in ρ, we have that $s^{**}(\rho)$ is strictly increasing in ρ for all $\rho > \underline{\rho}$. In addition, since (35) holds with equality as $\rho \to \underline{\rho}$, where $\underline{\rho}$ is defined in (23), it follows that $s^{**}(\rho) > s^*(\rho)$ for all $\rho > \underline{\rho}$.

Finally, we verify that the budget constraint (3) and the additional constraint (25) are indeed satisfied. We have (3) as $s^{**}(\rho) \leq s^{**}(1) = \frac{L - p_\ell(1-r)}{p_h - p_\ell} < r$, where the equality follows from (35) and the last inequality follows from Part (i) of Assumption 4. This and Assumption 1 then implies (25) as $r + x^{**} + s^{**}(\rho) < 2r < 1$, where $x^{**} = 0$.

A.3 Proof of Proposition 3

Recall that κ^* and κ^{**} are defined through (15) for $x = x^*(\rho)$ and $x = 0$, respectively. The properties of κ^* and κ^{**} characterized in this proposition then follow from the properties of $x^*(\rho)$ defined in Proposition 1 and the Envelope Theorem.

A.4 Proof of Proposition 4

We first show that equilibrium effort levels e^{SA}, $e^*(\rho, \gamma)$, and $e^{**}(\rho, \gamma)$ characterized by the first order conditions exist and are unique. Consider first e^{SA} characterized by (16). The second order condition is satisfied as $k''(e) > 0$ by Assumption 2. Moreover, Assumption 2 implies that $e^{SA} \in (0, 1-\gamma)$, because the left-hand side of (16) is strictly increasing in e, is strictly less than the right-hand side for $e = 0$, and is strictly greater than the right-hand side for $e = 1-\gamma \geq 1-\overline{\gamma}$. Consider next $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ characterized by (17). Following similar arguments, Assumption 2 implies that $e^*(\rho,\gamma)$, $e^{**}(\rho,\gamma) \in (0, 1-\gamma]$ exist and are unique.

We now derive a series of properties of e^{SA}, $e^*(\rho,\gamma)$, and $e^{**}(\rho,\gamma)$ using their definitions in (16) and (17).

(i) $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are decreasing in γ. To see this, we have

$$\frac{\partial e^*(\rho,\gamma)}{\partial \gamma} = \begin{cases} \frac{-2(1-\rho)(p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^*(\rho,\gamma))} \in (-1,0), & \text{if } \rho < \underline{\rho}, \\ \frac{-2(1-\rho)\left[(p_\ell R-L)-x_h^*(\rho)c\right]}{2(1-\rho)[(p_\ell R-L)-x^*(\rho)c]+k''(e^*(\rho,\gamma))} \in (-1,0), & \text{if } \rho \in (\underline{\rho},\overline{\rho}), \\ 0, & \text{if } \rho > \overline{\rho}. \end{cases} \tag{36}$$

$$\frac{\partial e^{**}(\rho,\gamma)}{\partial \gamma} = \frac{-2(1-\rho)(p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^{**}(\rho,\gamma))} \in (-1,0), \tag{37}$$

where we have used the result of Proposition 1 that $x^*(\rho) = 0$ for $\rho \leq \underline{\rho}$ and $x^*(\rho) \in (0, p_\ell R - L)$ for $\rho \in (\underline{\rho},\overline{\rho})$.

(ii) $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are decreasing in ρ if and only if $\gamma \leq \hat{\gamma}$, where $\hat{\gamma}$ is defined such that $\hat{\gamma} + e^*(\rho,\hat{\gamma}) = \frac{1}{2}$, i.e.,

$$k'(\frac{1}{2}-\hat{\gamma}) = p_h(R+r-1). \tag{38}$$

Notice that $\overline{\gamma} > \frac{1}{2}$ and Assumption 2 imply that $\hat{\gamma} \in (\underline{\gamma},\overline{\gamma})$. Moreover, (38) implies that $\hat{\gamma} + e^{SA} = \hat{\gamma} + e^*(\rho,\hat{\gamma}) = \hat{\gamma} + e^{**}(\rho,\hat{\gamma}) = \frac{1}{2}$.

To prove this property, we first derive the following:

$$\frac{\partial e^*(\rho,\gamma)}{\partial \rho} = \begin{cases} \frac{-[1-2(\gamma+e^*(\rho,\gamma))](p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^*(\rho,\gamma))}, & \text{if } \rho \leq \underline{\rho}, \\ \frac{-[1-2(\gamma+e^*(\rho,\gamma)]\left(\left[(p_\ell R-L)-x_h^*(\rho)c\right]+\frac{\partial x^*(\rho)}{\partial \rho}c\right)}{2(1-\rho)\left[(p_\ell R-L)-x_h^*(\rho)c\right]+k''(e^*(\rho,\gamma))}, & \text{if } \rho \in (\underline{\rho},\overline{\rho}), \\ 0, & \text{if } \rho > \overline{\rho}, \end{cases} \tag{39}$$

$$\frac{\partial e^{**}(\rho,\gamma)}{\partial \rho} = \frac{-\left[1-2(\gamma+e^{**}(\rho,\gamma)\right](p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^{**}(\rho,\gamma))}. \tag{40}$$

By Proposition 1, we have $\frac{\partial x^*(\rho)}{\partial \rho} > 0$ for $\rho \in (\underline{\rho},\overline{\rho})$ and $\frac{\partial x^*(\rho)}{\partial \rho} = 0$ otherwise. Therefore (39) and (40) imply that $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are increasing in ρ if and only if $\gamma +$

$e^*(\rho,\gamma) \geq \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \geq \frac{1}{2}$, respectively. By the definition of $\hat{\gamma}$ given in (38), if $\gamma \leq \hat{\gamma}$, we have $\gamma + e^*(\rho,\gamma) \geq \gamma + e^*(0,\gamma) \leq \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \leq \gamma + e^{**}(0,\gamma) \geq \frac{1}{2}$ for all ρ; if $\gamma \geq \hat{\gamma}$, we have $\gamma + e^*(\rho,\gamma) \leq \gamma + e^*(0,\gamma) \geq \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \geq \gamma + e^{**}(0,\gamma) \leq \frac{1}{2}$ for all ρ. This and (39)–(40) then imply that $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are decreasing in ρ if and only if $\gamma \leq \hat{\gamma}$.

(iii) If $\gamma \leq \hat{\gamma}$, we have $e^{SA} \leq e^*(\rho,\gamma) \leq e^{**}(\rho,\gamma)$, whereas if $\gamma \geq \hat{\gamma}$, we have $e^{SA} \geq e^*(\rho,\gamma) \geq e^{**}(\rho,\gamma)$. This follows from the definitions of e^{SA}, $e^*(\rho,\gamma)$, and $e^{**}(\rho,\gamma)$ in (16) and (17), and Property (ii) derived above that $\gamma + e^{SA}$, $\gamma + e^*(\rho,\gamma)$, $\gamma + e^{**}(\rho,\gamma) \geq \frac{1}{2}$ if and only if $\gamma \leq \hat{\gamma}$.

(iv) $\gamma + e^{SA}$, $\gamma + e^*(\rho,\gamma)$, $\gamma + e^{**}(\rho,\gamma)$ are increasing in γ. This follows immediately from (36) and (37).

A.5 Proof of Proposition 5

Let us denote by $W^{CBB}(e,x|\kappa)$ the welfare generated by a pair of matched bankers of type κ that set up a CBB and $W^{SA}(e)$ the welfare these bankers generate when they keep their banks as standalone. We have:

$$W^{CBB}(e,x|\kappa) = \Pi_0^{CBB}(e,x|\kappa) - 2C_0(e), \tag{41}$$

$$W^{SA} = 2\Pi_0^{SA}(e^{SA}) - 2C_0(e^{SA}), \tag{42}$$

where $\Pi_0^{SA}(\cdot)$ and $\Pi_0^{CBB}(\cdot)$ are defined in (13) and (14), respectively, and $C_0(\cdot)$ is defined in (18).

For $\rho \leq \underline{\rho}$, the welfare generated by a pair of bankers for any κ under their optimal CBB set-up decision is identical under both deposit insurance architectures, and hence welfare in the economy is identical under both deposit insurance architectures as stated in the proposition. To see this, notice first that $\kappa^* = \kappa^{**}$ in this case by Proposition 3. Therefore, if $\kappa > \kappa^*$, then the welfare generated by the pair of bankers is identical under both deposit insurance architectures as the banks remain standalone. If $\kappa \leq \kappa^*$, the pair of bankers set up a CBB under both deposit insurance architectures and we have $W^{CBB}(e^*(\rho,\gamma); x^*(\rho)|\kappa) = W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa)$. This follows because $x^*(\rho) = 0$ by Proposition 1, which implies $e^{**}(\rho,\gamma) = e^*(\rho,\gamma)$ by (17).

For $\rho = 1$, the welfare generated by a pair of bankers is again identical under both deposit insurance architectures for all κ, and hence welfare in the economy is identical under both deposit insurance architectures as stated in the proposition. This is because we again have $\kappa^* = \kappa^{**}$ by Proposition 3. Moreover, $W^{CBB}(e^*(\rho,\gamma), x^*(\rho)|\kappa) = W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa)$ because $\Pi_0^{CBB}(e, x)$ given in (14) does not depend on x, and $e^{**}(\rho,\gamma) = e^*(\rho,\gamma)$ by (17).

It remains to compare welfare in the economy under national and common DIF architectures for $\rho \in (\underline{\rho}, 1)$. We first consider $\gamma \leq \hat{\gamma}$ and show that welfare in the economy strictly increases when moving from national DIFs to a common DIF. To see this, we show that welfare generated by a pair of matched bankers is higher under a common DIF than under national DIFs for all κ, and strictly so for all $\kappa \leq \kappa^{**}$.

- If $\kappa > \kappa^{**}$, the bankers keep their banks standalone and the welfare they generate is identical under both deposit insurance architectures.

- If $\kappa \in (\kappa^*, \kappa^{**}]$, the bankers keep their banks standalone under national DIFs but form a CBB under a common DIF. We thus have that the welfare they generate is strictly higher under a common DIF than under national DIFs. This is because (i) $\Pi_0^{CBB}(e^{**}(\rho,\gamma), 0) = \max_e \Pi_0^{CBB}(e, 0) > \max_e 2\pi^{SA}(e) = 2\Pi_0^{SA}(e^{SA})$, where $\Pi_0^{SA}(e)$ and $\Pi_0^{CBB}(e, x)$ are defined in (13) and (14), respectively; and (ii) $C_0(e^{**}(\rho,\gamma)) \leq C_0(e^{SA})$, where $C_0(e)$ is given by (18), which follows because $C_0(e)$ is strictly decreasing in e and $e^{**}(\rho,\gamma) \geq e^{SA}$ for all $\gamma \leq \hat{\gamma}$ by Proposition 4. Therefore we have $W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa) \geq W^{SA}$ for all $\kappa \in (\kappa^*, \kappa^{**}]$.

- If $\kappa \leq \kappa^*$, the bankers form a CBB under both deposit insurance architectures. We again have that the welfare they generate is strictly higher under a common DIF than under national DIFs as $W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa) - W^{CBB}(e^*(\rho,\gamma), x^*(\rho)|\kappa) > 0$ for all $\rho \in (\underline{\rho}, 1)$ and $\gamma \leq \hat{\gamma}$. This is because (i) $\Pi_0^{CBB}(e^{**}(\rho,\gamma), 0) = \max_e \Pi_0^{CBB}(e, 0) > \max_e \Pi_0^{CBB}(e, x^*(\rho)) = \Pi_0^{CBB}(e^*(\rho,\gamma), x^*(\rho))$, where $\Pi_0^{CBB}(e, x)$ is defined in (14) and the inequality follows because $x^*(\rho) > 0$ for all $\rho \in (\underline{\rho}, 1)$ by Proposition 1, and (ii) $C_0(e^{**}(\rho,\gamma)) \leq C_0(e^*(\rho,\gamma))$, which follows because $C_0(e)$ is strictly decreasing in e and $e^{**}(\rho,\gamma) \geq e^*(\rho,\gamma)$ for all $\gamma \leq \hat{\gamma}$ by Proposition 4.

Next, we show that for $\gamma > \hat{\gamma}$, there exists κ such that the welfare generated by a pair of bankers with merger cost κ decreases when moving from national DIFs to a common DIF. This then implies that there exist distributions of κ such that welfare in the economy decreases when moving from national DIFs to a common DIF, as stated in the proposition. Consider $\kappa \in (\kappa^*, \kappa^{**})$, so that the pair of bankers remain standalone under national DIFs but form a CBB under a common DIF. Notice that bankers' payoff difference $\Pi_0^{CBB} - 2\Pi_0^{SA}$ is strictly decreasing in κ and is equal to 0 for $\kappa = \kappa^{**}$, while the deposit insurance costs are strictly lower under a common DIF because effort is lower $e^*(\rho, \gamma) < e^{**}(\rho, \gamma)$ by Proposition 4. This implies that the welfare difference $W^{CBB}(e^{**}(\rho, \gamma), 0 \mid \kappa) - W^{SA}$ is strictly decreasing in κ and is strictly negative at $\kappa = \kappa^{**}$. Therefore there exists merger cost $\kappa \in (\kappa^*, \kappa^{**}]$ such that the welfare generated by a pair of bankers with merger cost κ decreases when moving from national DIFs to a common DIF.

A.6 Proof of Corollary 1

The first derivative of welfare, given in (19), with respect to ρ is

$$\frac{\partial W(x, \kappa', e)}{\partial \rho} = \int_0^{\kappa'} \frac{\partial W^{CBB}(e, x \mid \kappa)}{\partial \rho} dF(\kappa) + \frac{\partial \kappa'}{\partial \rho} \left[W^{CBB}(e, x, \mid \kappa') - W^{SA} \right] f(\kappa'). \tag{43}$$

The first term represents the intensive margin in the bank pairs that form a CBB, and the second term represents the extensive margin in the bank pairs that change their organizational structure as ρ changes. Notice that there is no intensive margin in the bank pairs that remain standalone, as the welfare they generate is independent of ρ.

The first term in (43) is negative under both deposit insurance architectures for $\gamma \leq \hat{\gamma}$ because $W^{CBB}(e^{**}(\rho, \gamma), 0 \mid \kappa)$ and $W^{CBB}(e^*(\rho, \gamma), x^*(\rho) \mid \kappa)$ are both decreasing in ρ. This follows because, first, the bank's expected profit in equilibrium is decreasing in ρ. Second, the expected deposit insurance cost depends on ρ only through the bankers' effort, where $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ are decreasing in ρ for $\gamma \leq \hat{\gamma}$ by Proposition 4. Therefore the expected deposit insurance cost is increasing in ρ.

The second term in (43) is also negative under both deposit insurance architectures for $\gamma \leq \hat{\gamma}$. This is because, first, since a CBB's expected payoff in equilibrium is decreasing in ρ, the thresholds κ^* and κ^{**} are both decreasing in ρ. Second, welfare generated by a pair of banks is higher if they form a CBB than if they remain standalone as we have argued in the proof of Proposition 5.

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