# Common Deposit Insurance, Cross-Border Banks and Welfare*

Gyöngyi Lóránth
University of Vienna and CEPR

Anatoli Segura
Banca d'Italia and CEPR

Jing Zeng
University of Bonn and CEPR

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**Abstract**

We study the effects of the introduction of common deposit insurance across countries in a model of cross-border banks with both endogenous risk-taking and within group risk-sharing possibilities. With national deposit insurance, there is inefficient ring-fencing of resources from healthy to impaired subsidiaries for high asset correlation, which reduces 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 due to opposing franchise value and liquidation threat effects. Common deposit insurance is welfare increasing for risky enough banks, but otherwise leads 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 large banks in the euro area, setting the first milestone for the Euro area Banking Union, the 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 own funds 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 alleviating (ex ante) financing constraints (Gertner et al., 1994; Stein, 1997, 2003), and of providing (ex post) 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 from the literature that emphasize that ex post risk sharing possibilities within multidivision firms can have "dark side" effects on ex ante investment decisions (Scharfstein and Stein, 2000; Rajan et al., 2000). In the banking sector, 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 large 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 financial integration. We build a model that features as central element the interaction between the risk-sharing possibilities cross-border banks can achieve through an internal capital market and their 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, the fund responsible for the deposit insurance of a cross-border bank's healthy subsidiary ring-fences its resources to prevent they are used to recapitalize an impaired subsidiary if the correlation between the subsidiaries' loans is high. Ring-fencing limits the risk-sharing benefits cross-border banks achieve from an internal capital market and thereby reduces cross-border bank integration. When a common fund provides insurance for all deposits, the authority responsible for the fund's financial interests is indifferent regarding redistributions of deposit insurance costs across the subsidiaries of a cross-border bank in different countries, which removes barriers to the intragroup capital reallocation. A more valuable internal capital market then fosters cross-border bank integration. However, the expansion of risk-sharing possibilities affects the cross-border bank risk-taking and, hence, deposit insurance costs, in an ambiguous manner: Riskier banks reduce risk-taking as the franchise value of the group increases. Instead, 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 removing ring-fencing costs in the intervention of cross-border banks 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 banking sectors and on its welfare implications.

We consider an economy with two countries and a continuum of bankers owning a standalone local bank in each of them. Each banker can merge at the initial date its two standalone banks and set up a cross-border bank (CBB). Bankers differ in the cost they incur to merge their banks. Each local bank has risky assets and is financed with one unit of 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 all deposits.

Both standalone banks and the subsidiaries of CBBs can become impaired at the interim date, in which case the DIF responsible for their deposit insurance requires a recapitalization with the objective to reduce the costs it may face. Integrating the standalone banks in a CBB allows the banker 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 the costs of raising external capital. Yet, the DIF responsible for the healthy unit deposits may *ring-fence* some of the unit resources to avoid that intragroup support increases the costs it might face in the future.

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 loan payoffs is high. The DIF responsible for the healthy unit faces the following trade-off. On the one hand, the intragroup loan increases the costs it faces should both units simultaneously fail in the future and the unit receiving support default on the intragroup loan. On the other hand, the intragroup loan reduces the costs it faces should the healthy unit fail in the future while the impaired unit does not and is able to repay the intragroup loan. The first effect dominates for high correlation, which makes both units more likely to fail simultaneously in the future, leading the DIF responsible for the healthy unit to ring-fence some of its 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 with costly external equity issuance. The CBB finds the recapitalization too costly and hence prefers 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 because the impaired unit defaults with a higher probability. Indeed, from the common DIF perspective, the CBB is "foregoing" some limited liability protection at the group level when it grants an intragroup loan, which a common DIF looks at favourably. Notice that the larger intragroup loan the common DIF authorizes leads to a redistribution in the deposit insurance costs incurred across the subsidiaries: higher for the healthy unit, lower for the impaired unit. While a common DIF is indifferent regarding such cost redistribution, national DIFs are not, which is the reason why the protection of their national interests leads to ring-fencing.

For high correlation between a CBB subsidiaries, ring-fencing arises with national DIFs, limiting the value bankers obtain from a CBB's internal capital market. Removing ring-fencing through a common DIF enhances the within group risk-sharing possibilities. As a result, merging the two standalone banks is more valuable and more bankers do so. A common DIF thus encourages cross-border bank integration.

We next analyze how the anticipation of ring-fencing or the lack thereof affects banks' risk-taking. Each banker exerts at the initial date unobservable effort in its two banks (either standalone or subsidiaries of a CBB) that reduces the probability that they become impaired. The elimination of ring-fencing with a common DIF has two opposing effects on the effort exerted by a banker managing a CBB. On the one hand, effort in one unit creates value not only for that unit, but also for the other unit that is more likely to obtain intragroup support and preserve its continuation value should it be impaired. This effect, that 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 unit to continue upon receiving support, reducing the disciplining role of the threat of liquidation (or costly equity issuance) 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 franchise value effect (stemming from the possibility to grant support to an impaired unit) and reduces that of the liquidation threat effect (stemming from the possibility to receive support from a healthy unit). As a consequence, the elimination of ring-fencing implied by a common DIF increases the banker's effort in CBBs. The opposite happens if risk in the economy is lower: The establishment of a common DIF reduces the banker's 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 is high and with national DIFs there is a ring-fencing problem, the introduction of a common DIF removes ring-fencing and has two welfare effects. First, the enhanced ex-post intragroup risk-sharing possibilities increases the value bankers obtain from their CBBs. This leads more of them ex-ante to setup a CBB and to choose a new optimal effort level at their CBBs, which further increases bankers' overall value. Second, the additional cross-border bank integration and new effort in CBBs affects deposit insurance costs. This effect is ambiguous and, crucially, not internalized by bankers.

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

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 channel can be strong enough to dominate the bankers' value gains, so that a common DIF can reduce welfare in the economy. Interestingly, not only there is an expansion of cross-border integration while welfare in the economy gets reduced *but*, more than that, the cross-border expansion contributes to the welfare reduction. This is again because bankers' do not internalize that by creating a CBB they increase deposit insurance costs. There is hence excessive cross-border bank integration in the economy.

Our baseline model assumes that deposit insurance is granted for free or, equivalently, that bankers pay upfront a 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 and the cross-border integration choice becomes efficient given the

DIF architecture. Still, private 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 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 during crises when authorities protect national interests is not an issue and risk-sharing within banking groups is not hampered. There is thus no need for a banking union with common deposit insurance precisely when from an ex-ante perspective risk-sharing gains are larger. Second, economic integration and a common monetary policy in the Euro area makes it more likely that domestic bank assets are correlated across currency union member countries. 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. We highlight in this respect the importance of reflecting on the risk-taking implications of changes in risk-sharing possibilities within banking groups, which is an issue that has been overlooked in the policy debate. Otherwise, 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 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. (2018) analyzes 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 organization structure choice. The paper does not allow for a flexible within group capital market during crises nor endogenizes 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 analysis of cross-border bank integration under common deposit insurance complements a recent research avenue addressing other aspects of banking unions. Segura and Vicente (2024) 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 reduce fiscal risk, which is reminiscent of our findings that more risk-sharing within a banking group can lead to less bank risk-taking. Carletti et al. (2021) analyze a hub-and-spoke supervisory architecture in which a tough central authority takes decisions based on the information revealed by local supervisors. Conflicts between the two authorities may result in less information collection and more risk-taking by banks.

Our paper also relates to the analysis of the resolution of multinational banks in Bolton and Oehmke (2019). The paper shows that a Single-Point-Of-Entry resolution allows for a more efficient risk-sharing within banking groups during crises than a Multiple-Point-Of-Entry resolution, but might be infeasible if national regulators follow local interests. In our paper, limits to efficient risk-sharing also emerge in the form of ring-fencing by national deposit insurance funds, which motivates the introduction of common deposit insurance to overcome them. We also add to Bolton and Oehmke (2019) by highlighting how correlation between the local assets of the multinational bank affects ring-fencing by national authorities.

Our paper shares some intuitions from a large corporate finance literature that examines the role of internal capital markets in mitigating financial constraints in firm conglomerates (Gertner et al., 1994; Stein, 1997, 2003). Some contributions highlight a negative effect on ex ante investment efficiency associated with the resource allocation possibilities associated with the internal capital market (Scharfstein and Stein, 2000; Rajan et al., 2000). The risk-taking implications of the within group risk-sharing possibilities enabled by a financial conglomerate have been analyzed in several papers, highlighting opposed forces whose overall efffect is generally ambiguous (Boot and Schmeits, 2000; Freixas et al., 2007). None of these papers consider cross-border dimensions and how they get 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 that result from conflicts of interests between national authorities. As a consequence, 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).

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 no time discounting. There is a continuum of bankers. Each banker owns a standalone bank in each of the countries A and B. Each bank is endowed with loans and funded with one unit of deposits that are fully insured by a DIF as described next.

At $t = 0$, each banker can incur a disutility cost $\kappa \geq 0$ to merge its two standalone banks and form a CBB under a bank holding company structure with two wholly owned subsidiaries, subject to limited liability, and centralized decision-making. Establishing a CBB allows the banker to benefit from risk-sharing possibilities across its two banks as described later. Bankers differ only in their cost $\kappa$ of setting up a CBB, which follows a distribution $F(.)$ with support in $[0, \infty)$.[2] We henceforth refer with the term bank $i \in A, B$ both to a standalone national 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 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 banks of a banker succeed at $t = 2$ there are sufficient payoffs to pay back their overall deposits:

**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 loans succeed with high probability $p_h$, while those of an impaired bank with low probability $p_\ell$, where $p_h > p_\ell$.

Each bank type is realized at $t = 1$ and depends on an exogenous economy-wide risk parameter $\gamma$ and an unobservable effort exerted by the banker at $t = 0$. The parameter $\gamma \in [\underline{\gamma}, \overline{\gamma}] \subset [0, 1]$ proxies for the risks in the economy, a larger (smaller) $\gamma$ corresponding to lower (higher) bank loan default risk in the economy.[3] If a banker exerts effort $e \in [0, 1 - \overline{\gamma}]$ in one of its banks, the probability that the bank is healthy at $t = 1$ is $\gamma + e$, and that of being impaired is $1 - (\gamma + e)$. The banker incurs a disutility cost $k(e)$ from exerting effort $e$ in a bank satisfying:

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

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

[2]We have assumed that a single banker holds two standalone banks in different countries only to streamline the exposition. Equivalently, we could assume that: *i)* there are two measure one local bankers with a single standalone bank in one of the countries; *ii)* bankers in different countries are matched at $t =$ and can decide to merge their standalone banks at a cost $\kappa$ that solves the agency frictions allowing the resulting CBB to take centralized decisions.

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

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

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 $p^A \geq p^B$.

Specifically, given an effort $e$ in the two banks, the probability that one of them is healthy and the other is impaired at $t = 1$ is $q_0(\rho, e) \equiv (1 - \rho)(\gamma + e)(1 - \gamma - e)$, and the entire joint probability distribution of the banks' types at $t = 1$ is presented in Table 1. Our assumptions imply that: *i)* $\rho = 0$ corresponds to independence, so that $\rho > 0$ ($\rho < 0$) corresponds to positive (negative) correlation; *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 $q_1(\rho) \equiv (1 - \rho)p^B(1 - p^A)$, and the joint probability distribution of the banks' final payoffs is presented in Table 2. As for the $t = 1$ joint probabilities, $\rho = 0, \rho > 0, \rho < 0$, capture independence, positive correlation and negative correlation, respectively. The case in which unit A has (weakly) lower success probability than unit B is symmetrically defined.[4]

**Deposit insurance architecture** We consider two possibilities. With *national DIFs*, two national funds, DIF A and DIF B, provide deposit insurance for the banks (both stan-

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

dalone and subsidiaries) in their own jurisdictions. Each DIF takes decisions at $t = 1$ non-cooperatively to minimize own insurance costs. With *common DIF*, there is a single DIF responsible for deposit insurance payments of all banks. The single fund takes decisions at $t = 1$ in order to minimize its expected costs. The current incomplete Euro area banking union, in which deposit insurance remains at at the national level, would correspond to a national DIF architecture in our model.

**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 allows 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 loans. Part ($ii$) of the assumption states that liquidation lowers the expected deposit insurance cost for an impaired bank but not that 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 *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 $t = 2$ that is 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 whatsoever.

[5]Liquidation can involve removing the banking licence 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 non core businesses.

[6]As final loan payoffs are either $R$ or 0, the exact security used in 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) |
| | Intragroup loan from subsidiary A $(s, S)$ |
| Cash $(r + x + s\ )$ | Equity |

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

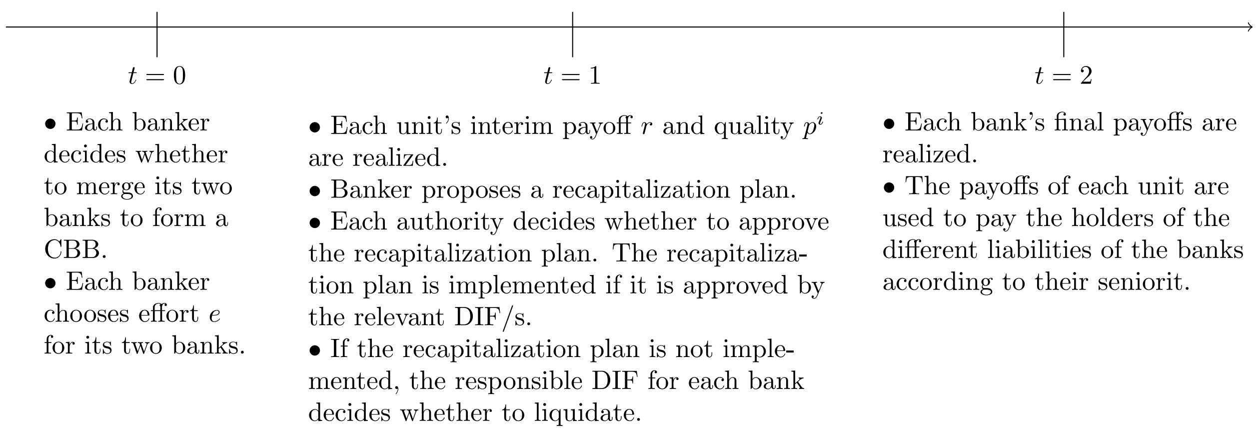



Figure 2: Time line.

The intragroup loan can affect the costs faced by the DIF responsible for the healthy subsidiary, which has the power to *ring-fence* the bank's resources to prohibit its issuance.[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 entirely with external equity is not feasible.

**Timeline** The sequence of events and decisions are summarized in Figure 2. At $t = 0$, for a given DIF architecture, each banker decides whether to merge its two standalone banks

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

and exerts effort on its banks. At $t = 1$, after banks interim loan payoff and types are realized, the decisions of the players are as follows. The bankers propose a recapitalization plan for their banks, which can include some intragroup loan in case they have set up a CBB. Each recapitalization plan is implemented if it is approved by all the relevant DIF/s. If a recapitalization plan is not implemented, the responsible DIF for each bank decides whether to liquidate it or not. At $t = 2$, unliquidated banks' loan payoffs are realized and used to pay the holders of the different liabilities of the banks according to their seniority. The responsible DIF/s meet their insurance obligations both at $t = 1$ and at $t = 2$.

# 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 a banker's decision to setup a CBB and discuss how the DIF architectures affect cross-border bank integration.

## 3.1 DIF intervention in a standalone bank

Suppose a banker operates two standalone banks and consider one of them at $t = 1$. Let $p \in \{p_h, p_\ell\}$ be the probability that the bank succeeds at $t = 2$.

Independently of the DIF architecture, the decision of the responsible DIF is based on the comparison between the expected costs it incurs if the bank is allowed to continue and those if it is liquidated. Continuation is thus allowed when:

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

where in both sides in the inequality above the loan interim payoff $r$ contributes to reduce deposit insurance costs. 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 get zero value. An external equity issuance $x$ is accepted by the DIF if and only if the expected cost it faces is lower with recapitalization than upon liquidation, that is, if

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

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 $t = 1$ and any DIF architecture. The banker is not able 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 with two subsidiary banks and characterize the equilibrium of the DIF intervention and bank 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 prove that 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 banker may propose a recapitalization plan that consists of an external equity issuance $x$ *and* an intragroup loan $(s, S)$. The recapitalization plan is accepted by DIF B if and only if:

$$C_1^B(x, s) \equiv (1 - p_\ell)\,[1 - (r + x + s)]^+ \le 1 - L - r. \tag{3}$$

The expression, analogous to that 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, expected costs for DIF A from deposit insurance on subsidiary A are given by:

$$C_1^A(s, S|\rho) \equiv [1 - p_h - (1-\rho)p_\ell(1-p_h)]\,[1-(r-s)]^+ + (1-\rho)p_\ell(1-p_h)\,[1-(r-s)+S]^+ , \tag{4}$$

The two terms capture the insurance costs DIF A incurs when subsidiary A fails at $t = 2$ depending on whether subsidiary B succeeds or not at that date. The joint probabilities of those two events are as described in Table 2. The insurance cost in each of the contingencies accounts for the cross-unit transfer $s$, which reduces available resources at subsidiary A. In case of success of subsidiary B, the insurance cost accounts also for the intragroup loan repayment $S$, which increases available resources at subsidiary A.

If $r - s + S \leq 1$,[8] we can rewrite (4) in a more compact form and the following condition for DIF A to approve the recapitalization plan follows:

$$C_1^A(s, S|\rho) = (1-p_h)(1-r) + (1-p_h)s - (1-\rho)p_\ell(1-p_h)S \leq (1-p_h)(1-r), \tag{5}$$

where the right-hand side of the inequality captures the costs for DIF A in case of rejection of the recapitalization plan. The second and third terms in the left-hand side of (5) account for the costs and benefits for DIF A from the intragroup loan, respectively. Notice that the benefit is decreasing in the correlation $\rho$ between the two subsidiaries' loan payoffs because larger correlation makes less likely that subsidiary B succeeds when subsidiary A fails.

The opposite effect of the size $s$ of the intragroup loan in the DIF B and DIF A approval conditions (3) and (5), respectively, highlights the conflict between the two that can give rise to *ring-fencing*: DIF A may not allow a recapitalization plan that involves a large enough

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

intragroup loan $s$ that meets the requirement by DIF B with no costly external capital issuance, $x = 0$.

We turn to the banker's optimal recapitalization decision.[9] If a recapitalization plan is not approved by any of the DIFs, it is not undertaken and subsidiary B is liquidated. The banker's value from the CBB as of $t = 1$ is thus given by:

$$\underline{\Pi}_1^{CBB} = (p_h R + r - 1) + (1 - p_h)(1 - r), \tag{6}$$

which captures that the banker only preserves the equity value of subsidiary A. This amounts to the asset value net of its nominal deposit liability plus the deposit insurance subsidy subsidiary A enjoys.

If a recapitalization plan is approved by both DIFs, the banker's value from the CBB as of $t = 1$ is:

$$\Pi_1^{CBB}(x, s, S) = (p_h R + r - 1) + (p_\ell R + r - 1) + C_1^A(s, S|\rho) + C_1^B(x, s) - xc. \tag{7}$$

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 (6) from (7), we have that the value difference for the banker between a recapitalization plan that is approved and no recapitalization is:

$$\begin{aligned} \Pi_1^{CBB}(x, s, S) - \underline{\Pi}_1^{CBB} =& (p_\ell R - L) - \big[(1 - p_h)(1 - r) - C_1^A(s, S|\rho)\big] \\ & - \big[(1 - L - r) - C_1^B(x, s)\big] - xc. \end{aligned} \tag{8}$$

The value 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 term, which are

[9] In addition to the approval conditions (3) and (5), the recapitalization plan must also satisfy three other constraints: *i)* the budget constraint at $t = 1$, $s \leq r$, which states that the size of the intragroup loan is bounded from above by subsidiary A's interim payoff; *ii)* the budget constraints at $t = 2$, $S \leq R + (r + x + s) - 1$, which states that the promised repayment on the intragroup loan is bounded from above by subsidiary B's available cash in case of success at $t = 2$ net of the deposit repayments; and *iii)* an equity issuance feasibility constraint stating that the value of the residual claim of the CBB in case of implementation of the recapitalization plan exceeds the value $x(1 + c)$ investors require in order to provide the amount $x$ of external equity included in the plan. All these conditions are satisfied by the optimal recapitalization plan presented in Proposition 1, and details can be found in the proof of that formal result.

weakly negative from (3) and (5), capture the value gains from the continuation appropriated by the DIFs, which reduce the banker's value. Finally, the fourth term accounts for the excess return required by equity investors, which also reduces the value for the banker.

The value decomposition in (8) highlights that the banker prefers 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 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, $x^*(\rho) = 0$, and an intra-group loan of size*

$$s^*(\rho) = \bar{s} \equiv \frac{L - p_\ell(1 - r)}{1 - p_\ell}, \tag{9}$$

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

- *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 with $s^*(\rho) < \bar{s}$ and external equity issuance $x^*(\rho) = \bar{s} - s^*(\rho)$, where $s^*(\rho)$ is decreasing in $\rho$ and $x^*(\rho)$ is increasing in $\rho$. The promised repayment of the intra-group loan $S^*(\rho)$ is decreasing in $\rho$.*

  – *For $\rho \geq \overline{\rho}$, no recapitalization is undertaken and subsidiary B is liquidated.*

The results in 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 banker avoids the costly issuance of equity. As correlation increases, it becomes less likely that the repayment of the intragroup loan contributes to reducing the

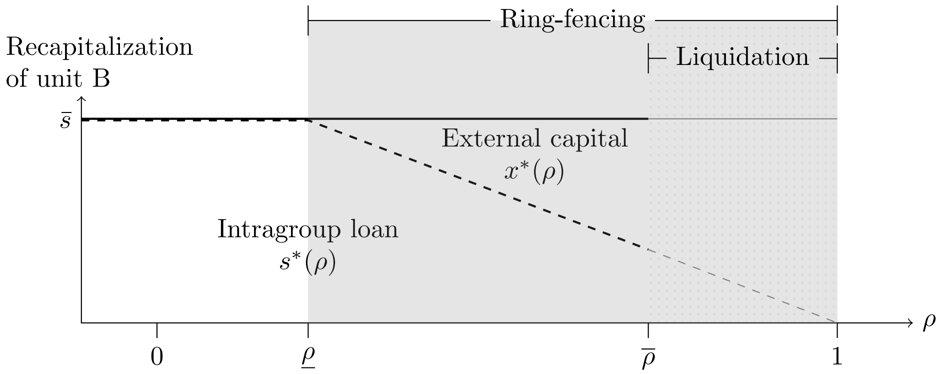



Figure 3: The severity of ring-fencing under national DIFs. $\bar{s} = x^*(\rho) + s^*(\rho)$ (the solid line) is the overall recapitalization of subsidiary B that avoids its liquidation, whereas $s^*(\rho)$ is the recapitalization provided through cross-unit support (dashed line). For $\rho \leq \underline{\rho}$, 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 (5)). 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 its promised repayment is large enough to eliminate any costs for DIF A when subsidiary A fails and subsidiary B succeeds at $t = 2$. As a result, the intragroup loan size approved by DIF A constitutes only a partial recapitalization ($s^*(\rho) < \bar{s}$), that is decreasing in correlation. Ring-fencing therefore constrains the banker to rely on costly external equity to avoid the liquidation of subsidiary B, and the more so the larger correlation. This reduces the banker's value. For intermediate levels of correlation ($\rho \in (\underline{\rho}, \overline{\rho}]$), the banker finds 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. The banker might thus try to avoid that outcome through a recapitalization $(x, s, S)$. Using the recapitalization approval conditions for the national DIF architecture in (3) and (5), we have that the common DIF accepts the recapitalization if and only if:

$$\underbrace{C_1^A(s, S|\rho)}_{\text{subsidiary A}} + \underbrace{C_1^B(x, s)}_{\text{subsidiary B}} \leq \underbrace{(1 - p_h)(1 - r)}_{\text{subsidiary A}} + \underbrace{(1 - L - r)}_{\text{subsidiary B}}. \tag{10}$$

Notice that the single approval condition for a common DIF is implied by the two national approval conditions (3) and (5). 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 banker's value from the CBB as of $t = 1$ if a recapitalization $(x, s, S)$ is approved is given by (7) while it is given by (6) if it is not. The banker's optimal recapitalization problem is thus analogous to that under national DIFs discussed in Section 3.2.1 with the difference that national approval conditions (3) and (5) are replaced with the single condition (10).

The banker's optimal recapitalization plan may have multiple pay-off equivalent solutions that only differ in how overall insurance costs are distributed across the deposits of the two subsidiaries.[10] In 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. Recall the objects $\underline{\rho}, \overline{\rho}$, $\bar{s}$, and optimal intragroup loan $s^*(\rho), S^*(\rho)$ with national DIFs as described in Proposition 1. With common DIF, the CBBs' optimal recapitalization ensures the continuation of subsidiary B, binds the common DIF's approval condition (10), and involves no external equity issuance, $x^{**} = 0$.*

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

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

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

- *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* $\rho$.

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 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 does not feature a costly equity issuance. We hence have from the value difference decomposition in (8) that the recapitalization maximizes the banker's value.

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 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 by the same amount the deposit insurance costs 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 in a recapitalization that is approved by the common DIF. The banker finds thus optimal to a large enough intragroup loan that is authorized without any external equity issuance, $s^{**}(\rho) > s^*(\rho), x^{**}(\rho) = 0$. Importantly, 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 of 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 need 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 bankers' decision at $t = 0$ to merge their two standalone banks and form a CBB. Consider a banker with a disutility cost of setting up a CBB given by $\kappa$. The banker compares his value as of $t = 0$ from the two standalone banks with that of a CBB.

Suppose that the banker keeps the two banks as standalone. The value he obtains as a function of his effort $e$ in each of the banks is given by:

$$\Pi_0^{SA}(e) = 2(\gamma + e)p_h(R + r - 1) - 2k(e). \tag{11}$$

This expression takes into account that the standalone banks continue at $t = 1$ only if they are healthy, which happens with probability $\gamma + e$.

Suppose that the banker sets up a CBB. Let $x$ denote the equilibrium amount of external equity the banker issues to supplement intragroup loans in the recapitalization of an impaired subsidiary when the other is healthy at $t = 1$. This variable captures the level of ring-fencing, and its value 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 $x^{**} = 0$ for all $\rho$.

Using (11), we have that the value the banker obtains from the CBB as a function of his effort $e$ in each subsidiary for a ring-fencing level $x$ is given by:

$$\Pi_0^{CBB}(e, x|\kappa) \equiv \Pi_0^{SA}(e) - \kappa + \underbrace{2(1-\rho)(\gamma+e)(1-\gamma-e)}_{\text{Probability of intragroup support}} \underbrace{[(p_\ell R - L) - xc]^+}_{\text{Support gains}}, \tag{12}$$

The first line of this expression represents the value the banker would obtain from the standalone banks net of the setup cost. The second line represents the increase in banker's value due to intragroup support. This amounts to the product of the probability of support and the value gains for the banker conditional on support given the recapitalization with external equity issuance $x$. The latter amount to the loan value gains implied by continuation, $p_\ell R - L$, net of the excess cost of the external equity issuance, $xc$.[11] Notice from (12) that the banker's value from a CBB is decreasing both in the ring-fencing level $x$ and in the CBB setup cost $\kappa$.

We have thus that the banker finds it optimal to set up a CBB when its cost $\kappa$ is below a threshold $\kappa'$ which is unequivocally determined by:

$$\max_e \Pi_0^{CBB}(e, x|\kappa') = \max_e \Pi_0^{SA}(e). \tag{13}$$

In addition, the reduction in support gains due to ring-fencing implies that the threshold $\kappa'$ above defined 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 $\kappa^*$ be the threshold such that with national DIFs a banker sets up a CBB if and only if its setup cost is $\kappa \leq \kappa^*$, and $\kappa^{**}$ the analogous threshold with a common DIF. We have $\kappa^* \leq \kappa^{**}$ and strictly so if and only if $\rho \in (\underline{\rho}, 1)$.*

[11]The superscript "+" on the expression for support gains in (12) and our convention on the value of $x$ when there is liquidation of the impaired subsidiary with national DIFs, ensure support gains for the banker are zero in that case.

The 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 does not engage in ring-fencing and affords larger possibilities for self-insurance within a CBB through intragroup resource allocation. This makes cross-border banking more profitable and fosters its expansion. Taking into account that economic integration and a common monetary policy in the Euro area makes it more likely that domestic bank assets are correlated across the currency union member countries, these results confirm the statements in Enria (2023) that common deposit insruance 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 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 the bankers' optimal cross-border integration and risk-taking decisions.

## 4.1 Risk-taking at $t = 0$

We analyze in this section the bankers' effort choice when he keeps his banks as standalone and when he merges them in a CBB.

Consider first a banker that keeps his banks as standalone. The banker's effort maximizes the value $\Pi_0^{SA}(e)$ he obtains from the two banks, which is given by (11). The optimal effort choice $e^{SA}$ thus satisfies the following first order condition, that equalizes the marginal cost and benefit of effort:

$$k'(e) = p_h(R + r - 1). \tag{14}$$

If instead the banker sets up a CBB, his effort at each subsidiary maximizes the value $\Pi_0^{CBB}(e, x|\kappa)$ given by (12), 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:

$$k'(e) = p_h(R + r - 1) + \\ + \underbrace{(1-\rho)\left[\overbrace{(1-(\gamma+e))}^{\text{other subs. impaired}} - \overbrace{(\gamma+e)}^{\text{other subs. healthy}}\right]}_{\text{Change in support probability}} \times \underbrace{[(p_\ell R - L) - x]^+}_{\text{Support gains}}. \tag{15}$$

Notice that in the right-hand side of the expression above does not appear the banker's cost $\kappa$ to set up a CBB, as this is a sunk cost when the effort choice is taken. The banker's effort on a CBB hence does not depend on its setup cost. The first term on the right-hand side of (15) represents the marginal benefit of effort in the absence of cross-unit support and coincides with the right-hand side of (14). The second term on the right-hand side of (15) represents the additional effect on effort due to the possibility of cross-unit support and is the product of the marginal change in the probability of cross-unit support associated with a marginal change in effort and the value the banker obtains from avoiding liquidation through intragroup support. Three aspects of this term are worth noting.

First, there are two opposing effects that go through the effect of effort in a given subsidiary on the probability of (providing or receiving) support (captured by the central factor in the second term on the right-hand side of (15)). On the one hand, the possibility of *providing* support when the other subsidiary is impaired *increases* the marginal benefit of effort on a given subsidiary: effort increases the probability of being able to support the other subsidiary in case the latter is impaired, which occurs with probability $1-(\gamma+e)$. We refer to this as the *franchise value effect* as the value of effort at each subsidiary increases due to the possibility to preserve the value of the other subsidiary. This effect is stronger for fundamentally weaker banks (that is, if $\gamma$ 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* voluntary support *reduces* the marginal benefit of effort on 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 impaired banks, which, recall, leaves a zero residual value to the banker. Notice that this effect is stronger for fundamentally safer banks (that is, if $\gamma$ 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 absolute value of the effect of cross-unit support on effort is proportional to the value the banker obtains conditional on support taking place (captured by the right-most factor in the second term on the right-hand side of (15)). Since the ex-post gains from support are decreasing in the ring-fencing level, the magnitude of the support effect is larger with a common DIF than with national DIFs.

Third, the absolute value of the effect of cross-unit support on effort gets reduced with the correlation between the two subsidiaries. This is because a 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 (15)). Additionally, with national DIFs the effect of cross-unit support on effort is further dampened as correlation increases because of the ensuing increase in ring-fencing (recall that $x^*(\rho)$ is increasing in $\rho$ from Propostion 1). This reduces the ex-post gains from support for the banker (captured by the right-most factor in the second term on the right-hand side of (15)).

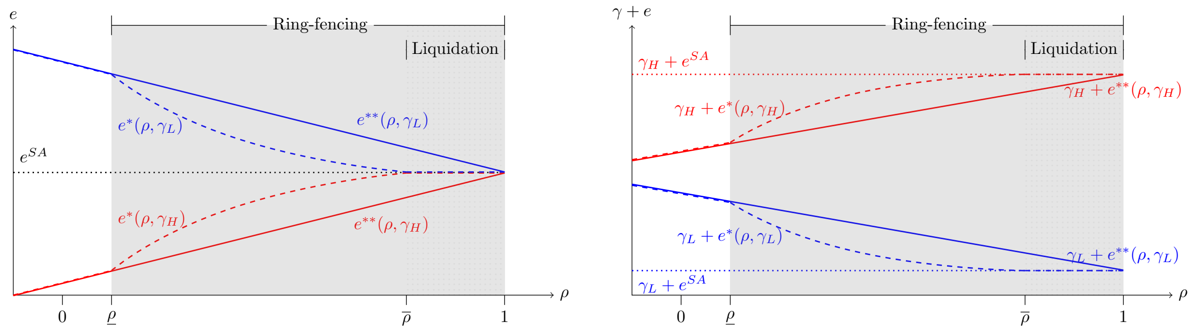
The following proposition summarizes how the banker's risk-taking behavior depends on its banks' organizational structure and the DIF architecture.

**Proposition 4** (Banker's risk-taking decision given organizational structure and DIF architecture)**.** *Let $e^{SA}$ denote the banker's optimal effort in a standalone bank and $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ the banker's optimal efforts in the subsidiaries of a CBB with national DIFs and a common DIF, respectively. There exists a threshold $\hat{\gamma}$ independent of $\rho$, 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 $\rho$;*
- *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 $\rho$.*

*Moreover, $e^*(\rho, \gamma)$ and $e^{**}(\rho, \gamma)$ are decreasing in $\gamma$, 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 $\gamma$.*

The proposition shows that cross-unit support in a CBB can enhance or undermine the banker's effort depending on the banks' fundamental risk, $\gamma$, and that the effects are (in both directions) stronger with a common DIF that does not respond with ring-fencing to intragroup support. These results are illustrated in Figure 4.




(a) Bank effort choice

(b) Prob. of healthy unit

Figure 4: Panels (a) and (b) illustrate the banker's optimal effort choice, $e$, and the resulting probability that each unit is healthy, $\gamma + e$, respectively, against the correlation $\rho$ for two values of $\gamma$, $\gamma_H$ (in red) and $\gamma_L$ (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.

For fundamentally riskier banks ($\gamma \leq \hat{\gamma}$, 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 banker's 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 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.

For fundamentally safer banks ($\gamma \geq \hat{\gamma}$), the liquidation threat effect dominates. As a result, all effects are reversed, as illustrated by the red lines in Figure 4. CBBs thus choose higher risk-taking than standallone banks, and the 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 from their two banks net of the costs incurred by the DIF/s.[12] The banker does not internalize the effect of his $t = 0$ decisions on the cost to the DIF/s, which leaves the room open for a misalignment between private and socially optimal decisions, the extent of which could be affected by the DIF architecture.

If a banker operates standalone banks, the costs as of $t = 0$ of the insurance on the banks' deposits as a function of the banker's effort $e$ are given by

$$C_0(e) = 2(\gamma + e)(1 - p_h)(1 - r) + 2(1 - \gamma - e)(1 - L - r). \tag{16}$$

The expression captures the insurance costs in case the banks are healthy and impaired at $t = 1$ weighted by the probability of each state given the banker's effort.

If a banker operates a CBB, we have that if a recapitalization of an impaired subsidiary is conducted, then 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 $t = 1$ the DIF/s face coincide with those in absence of a recapitalization. The overall costs of deposit insurance to the CBB, hence, do not depend on the DIF architecture and coincide with those given by (16) and thus only depend on the banker's effort.

Let $x$ be the ring-fencing level in CBB cross-unit support, $\kappa'$ the CBB set-up cost threshold below which bankers integrate their two banks, and $e$ the effort of bankers' that set-up a CBB. Welfare in the economy can be written as the following integral over banker types:

$$W(x, \kappa', e) = \int_0^{\kappa'} \left[\Pi_0^{CBB}(e, x|\kappa) - C_0(e)\right] dF(\kappa) + \int_{\kappa'}^{\infty} \left[\Pi_0^{SA}(e^{SA}) - C_0(e^{SA})\right] dF(\kappa). \tag{17}$$

[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.

The tuple $(x, \kappa', e)$ that determines welfare is an equilibrium object that depends on the DIF architecture as stated in Propositions 1 and 2 for $x$, Proposition 3 for $\kappa'$, and Proposition 4 for $e$.

We can prove the following proposition, which constitutes the main contribution of the paper.

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

- *If $\rho \leq \underline{\rho}$ or $\rho = 1$, there is no welfare change.*
- *If $\rho \in (\underline{\rho}, 1)$, there exists $\gamma^* > \hat{\gamma}$, where $\hat{\gamma}$ is defined in Proposition 4, such that*
    - *if $\gamma \leq \gamma^*$, welfare increases with a common DIF, and strictly so if $\gamma < \gamma^*$;*
    - *if $\gamma > \gamma^*$, welfare is strictly reduced with a common DIF.*

Proposition 5 characterizes under which conditions the establishment of a common DIF has a positive welfare impact, when it destroys welfare, and when it has no impact whatsoever. 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 correlation across the banks in the two countries is not positive and large enough ($\rho \leq \underline{\rho}$), then the DIF architecture is irrelevant. This is because national DIFs do not ring-fence subisidiaries' resources during crises.

More trivially, the proposition states that if correlation across the banks is perfect, then the DIF architecture is also irrelevant. In this case, there are no risk-sharing possibilities across the two subsidiaries of a CBB so ring-fencing with national DIFs would be an off equilibrium contingency.

When correlation across the banks in the two countries is large enough−albeit not one− ($\rho \in (\underline{\rho}, 1)$), CBBs experience a ring-fencing problem with national DIFs during crises. A common DIF solves this problem and affects welfare through multiple channels. To gain intuition on the results in Proposition 5, we can use (17) to write the welfare effect from the establishment of a common DIF as:

$$\Delta W = \underbrace{\int_0^{\kappa*} \left[ \underbrace{\left(\Pi_0^{CBB}(e^{**}, x=0|\kappa) - \Pi_0^{CBB}(e^*, x^*|\kappa)\right)}_{\text{Ex-post support gains (+)}} + \underbrace{2\left(C_0(e^*) - C_0(e^{**})\right)}_{\text{Ex-ante effort (+/-)}} \right] dF(\kappa)}_{\text{Intensive margin: CBB merge irrespective DIF architecture}} + \underbrace{+ \int_{\kappa^*}^{\kappa^{**}} \left[ \underbrace{\left(\Pi_0^{CBB}(e^{**}, x=0|\kappa) - \Pi_0^{SA}(e^{SA})\right)}_{\text{Ex-post support gains (+)}} + \underbrace{2\left(C_0(e^{SA}) - C_0(e^{**})\right)}_{\text{Ex-ante effort (+/-)}} \right] dF(\kappa)}_{\text{Extensive margin: CBB merge due to common DIF}} \tag{18}$$

The first term in the decomposition of the welfare impact accounts for the intensive margin effect: bankers' with low CBB set-up cost that with national DIFs merge their two banks (with type $\kappa \leq \kappa^*$), keep on doing with a common DIF. 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 increases the value these bankers obtain from their CBBs, leading them to optimally set ex-ante a new effort level that further increases their value (first term in intensive margin). The change in bankers' ex-ante effort in turn affects deposit insurance costs (second term in intensive margin). These costs get reduced (and welfare increased) if the bankers exert higher effort with a common DIF, which from Proposition 4 is the case only when banks are fundamentally riskier, that is for $\gamma \leq \hat{\gamma}$.

The second term in (18) instead captures the extensive margin effect from the establishment of a common DIF: bankers' with intermediate CBB set-up cost (with type $\kappa \in (\kappa^*, \kappa^{**})$ keep their banks as standalone with national DIFs but set-up a CBB with a common DIF. There are two analogous welfare effects along this margin. The enhancement of intragroup risk-sharing possibilities under a CBB increases the value these bankers obtain from their two banks (first term), and leads to a new ex-ante effort choice that affects deposit insurance costs (second term). Again, deposit insurance costs get reduced only when banks are fundamentally riskier, that is for $\gamma \leq \hat{\gamma}$.

Figure 5 graphically exhibits the intensive and extensive margin welfare effects in (18) for different values of the banks' fundamental strength. Recall that banker's value increases with a common DIF for types in the intensive and extensive margin regions. When banks are fundamentally riskier ($\gamma < \hat{\gamma}$), a common DIF leads to higher bankers' effort along the

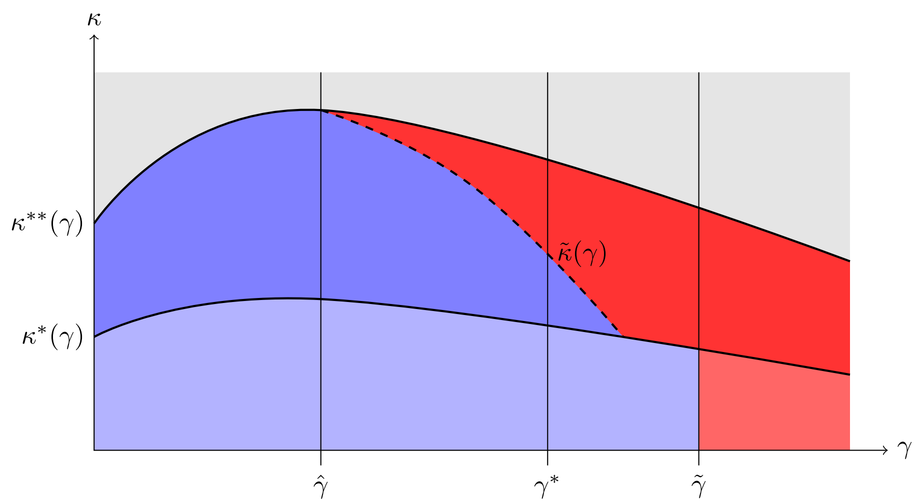



Figure 5: Welfare associated with each banker type under with common DIF versus national DIFs $\rho \in (\underline{\rho}, 1)$ for different values of fundamental bank strength ($\gamma$, horizontal axis) and CBB setup costs ($\kappa$, vertical axis). In the grey shaded area, welfare is identical under both DIF architectures (because banks remain stand-alone). 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.

two relevant margins, which reduces 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. Ex-post risk-sharing gains and ex-ante risk-taking incentives are aligned and welfare in the economy increases when a common DIF is established.

In contrast, when banks are fundamentally safer ($\gamma > \hat{\gamma}$), a common DIF leads to higher bankers' effort along the two relevant margins, which increases 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 not anymore aligned. Figure 5 shows that for a sufficiently high fiscal strength ($\gamma > \tilde{\gamma}$), the increase in deposit insurance costs associated with larger risk-taking dominates the bankers' value gains for all bank types in the intensive and extensive margins.[13] By continuity, there is a banks' fundamental strength threshold $\gamma^* \in (\hat{\gamma}, \tilde{\gamma})$ exactly above which welfare in the economy decreases when a common DIF is established.

[13]The existence of the threshold $\tilde{\gamma}$ in Figure 5 is shown in the proof of Proposition 5.

Notice that the possibility that a common DIF reduces welfare despite fostering cross-border banking results from the fact that the bankers' choices maximize their own value but neglect their impact on deposit insurance costs. Both the CBB set-up decision and the effort choice are, hence, generally inefficient. In particular, when banks are fundamentally safer ($\gamma > \hat{\gamma}$), all the banker types in dark shaded red in Figure 5 set-up a CBB only under a common DIF and they destroy welfare by doing so.

Conversely, when banks are fundamentally riskier ($\gamma < \hat{\gamma}$), there is a problem of too little cross-border integration that the establishment of a common DIF only partially solves. Banker types just above the dark shaded blue area in Figure 5 decide to keep their banks as stand-alone but welfare would increase if they were to set-up a CBB.

# 5 Robustness and extensions

## 5.1 Cross-border integration and fairly priced deposit insurance

As discussed at the end of the previous section, bankers' decision to set-up a CBB is generally inefficient as it does not take into account the costs faced by the DIF/s. This can result in either too much cross-border integration (for fundamentally safer banks) or too little (for fundamentally riskier banks) regardless of the DIF architecture.

The problem of an inefficient cross-border integration decision could be solved by requiring bankers to pay out of their own funds an actuarially fair deposit insurance premium at $t = 0$ to the relevant DIF/s. The premium should depend both on the banks' organizational structure and on the DIF architecture, and should correctly anticipate how the two affect the banker's optimal effort choice at $t = 0$.

Given a DIF architecture and a banks' organizational structure, the payment of a deposit insurance premium at $t = 0$ does not affect the recapitalization game at $t = 1$. Hence, it does not affect either the banker's optimal effort at $t = 0$. The payment of a fairly-priced deposit insurance premium, thus only affects 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.

However, the banker's privately optimal effort is lower than the socially optimal effort level as standard in presence of agency frictions and external financing and the DIF architecture keeps on affecting welfare through its effect on bankers' effort. It is possible to prove that for fundamentally safer banks we still have as in the baseline model that the establishment of a common DIF leads to more risk-taking by CBBs and reduces welfare (analogous to Proposition 5). In contrast to the baseline model, the reduction in welfare comes with lower cross-border integration (Proposition 3 is not anymore valid).

While our results on the welfare impact of the introduction of a common DIF are robust to the presence of fairly priced deposit insurance fees, those on the cross-border bank integration implications are not. In any case, our model highlights that fairly priced deposit insurance fees need account for the organizational structure of the banks on top of their fundamental risk characteristics: the fee differential between CBBs and standalone banks with same fundamentals can be either positive or negative depending on whether banks are fundamentally safer or weaker, respectively. Finally, the fee needs also be adjusted to the DIF architecture to account how different risk-sharing possibilities ex-post affect risk-taking ex-ante.

## 5.2 The DIFs' objective function

In the baseline model, we have assumed that the objective of the agent we refer as DIF is to minimize the costs they might face. 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 is 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 modification.

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. [14]

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 to approve 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, as the failure of the recapitalization plan does not lead to the liquidation of the bank it is responsible for. Therefore, while the parameter space for which ring-fencing arises would get reduced, Propositions 1 and all subsequent results remain qualitatively for $\phi$ 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 loan that involves a cash injection at $t = 1$. An alternative way to provide support to the distressed subsidiary would be by means of a guarantee issued by the healthy subsidiary.

Specifically, suppose bank A (the healthy subsidiary) in a CBB provides support to bank B (the impaired subsidiary) with a combination of i) $s \leq r$ units of cash and ii) a guarantee up to $g \leq 1$ of bank B's deposits, which is settled at $t = 2$ and is junior to bank A's deposits. Under national DIFs, the approval condition by DIF B for a recapitalization plan is given by $\tilde{C}_1^B(x, s, g) \leq 1 - L - r$, where

$$\tilde{C}_1^B(x, s, g) \equiv C_1^B(x, s) - \underbrace{[(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)]}_{\text{Bank A succeeds while Bank B fails}} [g - (r + x + s)]^+ , \qquad (19)$$

and $C_1^B(x, s)$ is defined in (3). The approval condition given by (3) extends that in the baseline model by including an additional term capturing the value of the guarantee to DIF B. Notice that the guarantee must satisfy the additional budget constraint:

$$[g - (r + x + s)]^+ \leq R + r - s - 1, \qquad (20)$$

[14] 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: $p_h > \frac{(1+\phi)L}{\phi R + 1 - r} > p_\ell$

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 in bank A after paying off its depositors. We have hence from (19) that the guarantee relaxed DIF B's authorization constraint, but (20) imposes an upper bound on how importantly the constraint is relaxed. Moreover, an increase in correlation between the subsidiaries reduces the value of the guarantee for DIF B.

From the perspective of DIF A, the issuance of a guarantee that is junior to bank A's deposits has no effect on its approval decision relative to the baseline model.

Similarly, the approval condition for a recapitalization plan by a common DIF is given by (10) with the term $C_1^B(x,s)$ replaced with $\tilde{C}_1^B(x,s,g)$. Finally, if a recapitalization plan is approved by the relevant DIF/s, the banker's value from the CBB as of $t=1$ is given by (7) with the term $C_1^B(x,s)$ replaced with $\tilde{C}_1^B(x,s,g)$.

The additional guarantee relaxes DIF B's approval condition and does not affect the banker's objective function or the other constraints directly. Since the extent by which the constraint is relaxed decreases with correlation across the banks, ring-fencing will still arise with national DIFs, albeit at a higher level of correlation. Therefore, while the parameter space for which ring-fencing should arise reduces, Propositions 1 and all subsequent results would qualitatively remain.

## 5.4 Ex ante arrangement and time-consistent DIF intervention

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 can 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 to protect own interests might depend on the size of the expected redistribution of deposit insurance costs across the two national funds upon the ex ante contractually agreed internal recapitalization scheme. So this type of arrangements would amount to an intermediate architecture lying between the two polar ones the baseline model considers.

# 6 Conclusion

Intragroup support within a cross-border bank allows for a more efficient central liquidity and capital management. However, national authorities and legislations tend to ring-fence resources within cross-border banking groups within national boundaries, raising concerns on 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 for the emergence of pan-European banks. Several voices have argued for the need to complete the banking union with a common deposit insurance scheme to eliminate ring-fencing prerogatives in national legislation and foster cross-border bank 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 misalignments 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 *more* 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 *less* welfare.

# Appendix

*Proof of Proposition 1.* Let us define $\underline{\rho}$ as the solution to

$$\frac{L - p_\ell(1-r)}{1-p_\ell}\frac{1}{(1-\rho)p_\ell} = 1 - r + \frac{L - p_\ell(1-r)}{1-p_\ell}. \tag{21}$$

$\underline{\rho} \in (0,1)$ exists and is unique, because the left-hand side of (21) 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 $\rho$.

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

**The banker's optimal recapitalization plan that ensures the continuation of both subsidiaries.** The banker's optimization problem is to maximize his expected payoff as of $t = 1$, which is given by (7), subject to the two authorities' approval requirements given by (3) and (4), and the non-negativity constraint $x \geq 0$.

We first simplify 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 (3) 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 $\epsilon$ sufficiently small, this strictly increases the bank's expected payoff while keeping all constraints satisfied. Suppose next that $r - s + S > 1$, then we can decrease $S$ until $r - s + S = 1$ without affecting the bank's expected payoff or any of the constraints.

The optimization problem can thus be alternatively written as maximizing (7), subject to the approval condition by DIF B expressed as

$$(1 - p_\ell)\left[1 - (r + x + s)\right] \leq 1 - L - r, \tag{22}$$

the approval condition by DIF A given by (5), two additional constraints

$$r + x + s \leq 1, \tag{23}$$

$$r - s + S \leq 1, \tag{24}$$

and the non-negativity constraint $x \geq 0$. We solve this alternative problem in three steps below. (i) We first drop the additional constraints (23) and (24), and show that the solution to this simplified problem indeed satisfies the additional constraint (23), but only satisfies the additional constraint (24) if and only if $\rho \leq \underline{\rho}$. (ii) We then impose a binding constraint $r - s + S = 1$ and solve for the solution to this problem for $\rho > \underline{\rho}$.

(i) Consider the simplified problem given by the objective function (7), the approval constraints (5) and (22), and the non-negativity constraint $x \geq 0$. Let us denote the Lagrangian multipliers on the approval requirements of authority A and B in (5) and (22), respectively, by $\mu^i$ for $i \in \{A, B\}$, and that on the non-negativity constraint on $x$ by $\xi$ . We derive the following first order conditions with respect to $x$, $s$, and $S$, respectively:

$$-(1-p_\ell)(1-\mu^B) - c + \xi = 0, \tag{25}$$

$$(1-p_h)(1-\mu^A) - (1-p_\ell)(1-\mu^B) = 0, \tag{26}$$

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

and their respective complementary slackness conditions. We can now characterize the solution to this simplified optimization problem. (27) implies that $\mu^A = 1$ and therefore the constraint (5) binds by complementary slackness. $\mu^A = 1$ and (26) then imply that $\mu^B = 1$ and therefore (3) binds by complementary slackness. $\mu^B = 1$ and (25) imply that $\xi = c > 0$ and therefore $x = 0$ by complementary slackness. Imposing $x = 0$, a binding constraint (22) implies that $s = \bar{s} \equiv \frac{L - p_\ell(1-r)}{1-p_\ell}$, and a binding constraint (5) 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 additional constraint (23), as $\bar{s} = \frac{L-p_\ell(1-r)}{1-p_\ell} < r$ by Part (i) of Assumption 4, which then implies $r + x + s < 2r < 2 - R < 1$ by the first inequality of Assumption 1. This solution also satisfies the additional constraint (24) if and only if $\rho \leq \underline{\rho}$, where $\underline{\rho}$ is defined as the solution to (21). 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 (7), the approval constraints (5) and (22), the non-negativity constraint $x \geq 0$, and a binding additional constraint (24) for $\rho > \underline{\rho}$. After substituting the binding constraint $r - s + S = 1$ 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:

$$-(1-p_\ell)(1-\mu^B) - c + \xi = 0, \tag{28}$$

$$[1-(1-\rho)p_\ell]\,(1-p_h)(1-\mu^A) - (1-p_\ell)(1-\mu^B) = 0, \tag{29}$$

and their respective complementary slackness conditions, where the Lagrangian multipliers are similarly as defined above. (29) implies that either $\mu^A, \mu^B \leq 1$, or $\mu^A, \mu^B > 1$. We consider these to cases separately.

- Suppose $\mu^A, \mu^B \leq 1$. Then (28) implies $\xi > 0$ and therefore $x = 0$ by complementary slackness. Moreover, recall that the term multiplying $(1-\mu^A)$ in (29) is the joint probability that both units fail simultaneous. This term is thus strictly smaller than $(1-p_\ell)$, the unconditional probability that unit B fails. Therefore, (29) 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 (22) binds by complementary slackness. $x = 0$ and a binding constraint (22) 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 $S$ that binds the approval constraint (5) violates the additional constraint (24) for $\rho > \underline{\rho}$. However, since lowering $S$ tightens the constraint (5), there exists no $S$ that satisfies both the constraint (5) and the additional constraint (24) for $\rho > \underline{\rho}$.
- Suppose $\mu^A, \mu^B > 1$. This implies that the approval constraints (5) and (22) bind by complementary slackness. It is easy to verify that $s = \frac{(1-\rho)p_\ell}{1-(1-\rho)p_\ell}(1-r)$, $x = \bar{s} - s$ and $S = 1 - r + s$ satisfy (28)–(29) 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

(7), the approval constraints (3)–(4), the non-negativity constraint $x \geq 0$ is

$$
\begin{aligned}
s^*(\rho) &= \begin{cases} \bar{s} \equiv \frac{L - p_\ell(1-r)}{1-p_\ell}, & \text{if } \rho \leq \underline{\rho}, \\ \frac{(1-\rho)p_\ell}{1-(1-\rho)p_\ell}(1-r), & \text{if } \rho > \underline{\rho}, \end{cases} \\
S^*(\rho) &= \begin{cases} \frac{\bar{s}}{(1-\rho)p_\ell}, & \text{if } \rho \leq \underline{\rho}, \\ 1 - r + s^*(\rho), & \text{if } \rho > \underline{\rho}, \end{cases} \\
x^*(\rho) &= \bar{s} - s^*(\rho).
\end{aligned} \tag{30}
$$

Finally, recall that, as stated in Footnote 9, we have omitted the budget constraints $s \leq r$ and $S \leq R + (r + x + s) - 1$. We now verify that these constraints are indeed satisfied at the above solution. First, we have $s^*(\rho) \leq \bar{s} = \frac{L-p_\ell(1-r)}{1-p_\ell} < r$ by Part $(i)$ of Assumption 4. Second, we have $S \leq 1 - r + s^*(\rho) < R + r + s^*(\rho) + x^*(\rho) - 1$, where the first inequality follows from the additional constraint (24), and the second inequality follows from $x^*(\rho) \geq 0$ and Assumption 1.

Therefore the solution given by (30) characterizes the banker's optimal recapitalization plan that ensures the continuation of both units.

**The banker's decision to recapitalize.** The banker prefers not to recapitalize the bank if and only if the expected payoff difference given by (8) is negative, when evaluated at the banker's optimal recapitalization plan that ensures the continuation of both units given by (30). Using the fact that, this recapitalization plan binds the constraints (5) and (22), (8) evaluated at the solution given by (30) is equal to

$$\Pi_1(x^*(\rho), 0, s^*(\rho), S^*(\rho)) - \underline{\Pi}_1 = (p_\ell R - L) - x^*(\rho)c. \tag{31}$$

Recall that $x^*(\rho) > 0$ if and only if $\rho > \underline{\rho}$ as shown previously, and that $x^*(\rho)$ is strictly increasing in $\rho$ 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

$$(p_\ell R - L) - \left[\frac{L - p_\ell(1-r)}{1-p_\ell} - \frac{(1-\rho)p_\ell}{1-(1-\rho)p_\ell}(1-r)\right]c = 0. \tag{32}$$

Notice that $\overline{\rho} \in (\underline{\rho}, 1)$, because the left-hand side of the above expression (i) is strictly decreasing in $\rho$, (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 9, we hav 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. □

*Proof of Proposition 2.* Let us consider the banker's optimal recapitalization plan that ensures the continuation of both subsidiaries. The banker's optimization problem maximizes the banker's expected payoff given in (7), subject to the common DIF's approval condition (10), the non-negativity constraint $x \geq 0$, and the budget constraints given in Footnote 9.

Notice that the recapitalization plan given in Proposition 2 satisfies all constraint, and, in particular, satisfies the constraint (10) with equality, and has $x = 0$. The existence of such a recapitalization plan implies that, first, since any optimal recapitalization plan that ensures the continuation of both units leaves a weakly higher expected payoff for the banker, any such recapitalization binds (10) and has $x = 0$. Second, it implies that the banker always finds it optimal to recapitalize the bank.

Thus, We can focus on characterizing the bank's optimal recapitalization plan, which must satisfy $x = 0$ and bind (10). Following similar arguments as those in the proof of Proposition 1, we replace the expressions for $C_1^B(x^B, s)$ and $C_1^A(x^A, s, S \mid \rho)$ in (10) given by (3) and (4) with (22) and (5), respectively, and add the additional constraints given by (23) and (24). After imposing $x = 0$, a binding constraint (10) can be expressed as follows:

$$(1 - p_\ell)(1 - r - s) + (1 - p_h)(1 - r + s) - (1 - \rho)p_\ell(1 - p_h)S$$
$$= (1 - L - r) + (1 - p_h)(1 - r). \qquad (33)$$

Since there exists a continuum of $(s, S)$ that satisfy (33), we now solve for the pair $(s, S)$ that minimizes the redistribution between the two countries' deposit insurance funds. 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. (3) and (4) are both satisfied with equality, this is also the recapitalization plan that minimizes redistribution between the two countries' deposit insurance funds.

- $\rho > \underline{\rho}$. In this case, the constraint (24), $x^B = 0$ and (33) imply that $s$ must satisfy

$$(1-p_\ell)(1-r-s) + [1-(1-\rho)p_\ell](1-p_h)(1-r+s) \leq (1-L-r) + (1-p_h)(1-r). \tag{34}$$

  Since the left-hand side of (34) is strictly decreasing in $s$, (34) is equivalent to $s \geq s^{**}(\rho)$, where $s^{**}(\rho)$ is defined as the solution to (34) with equality. As the expected cost to the deposit insurance fund of country B is strictly decreasing in s and that of country A is strictly increasing in s, the recapitalization plan that minimizes redistribution between the two countries' deposit insurance funds has $s = s^{**}(\rho)$ and $S = S^{**}(\rho) = 1 - r + s^{**}(\rho)$.

  Moreover, since the left-hand side of (34) is strictly increasing in $\rho$, we have that $s^{**}(\rho)$ is strictly increasing in $\rho$ for all $\rho > \underline{\rho}$. In addition, since (34) holds with equality as $\rho \to \underline{\rho}$, where $\underline{\rho}$ is defined in (21), it follows that $s^{**}(\rho) > s^*(\rho)$ for all $\rho > \underline{\rho}$.

  Finally, we verify that the budget constraints stated in Footnote (9) are indeed satisfied. First, we have $s^{**}(\rho) \leq s^{**}(1) = \frac{L-p_\ell(1-r)}{p_h-p_\ell} < r$, where the equality follows from (34) and the last inequality follows from Part ($i$) of Assumption 4. Second, we have $S^{**}(\rho) = 1-r+s^{**}(\rho) < R+r+s^{**}(\rho)+x^{**}(\rho)-1$, where the inequality follows from $x^{**}(\rho) = 0$ and Assumption 1.

□

*Proof of Proposition 3.* Recall that $\kappa^*(\rho,\gamma)$ and $\kappa^{**}(\rho,\gamma)$ are defined through (13) for $x = x^*(\rho)$ and $x = 0$, respectively. The properties of $\kappa^*(\rho,\gamma)$ and $\kappa^{**}(\rho,\gamma)$ characterized in this proposition then follow from the properties of $x^*(\rho)$ defined in Proposition 1 and the Envelope Theorem. □

*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 (14). 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 (14) 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 (15). 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 (14) and (15).

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

$$\frac{\partial e^*(\rho,\gamma)}{\partial \gamma} = \begin{cases} \frac{-2(1-\rho)(p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^*(\rho,\gamma))} \in (-1,0), & \text{if } \rho < \underline{\rho}, \\ \frac{-2(1-\rho)\left[(p_\ell R-L)-x^*_h(\rho)c\right]}{2(1-\rho)[(p_\ell R-L)-x^*(\rho)c]+k''(e^*(\rho,\gamma))} \in (-1,0), & \text{if } \rho \in (\underline{\rho},\overline{\rho}), \\ 0, & \text{otherwise.} \end{cases} \tag{35}$$

$$\frac{\partial e^{**}(\rho,\gamma)}{\partial \gamma} = \frac{-(1-\rho)(p_\ell R-L)}{(1-\rho)(p_\ell R-L)+k''(e^{**}(\rho,\gamma))} \in (-1,0), \tag{36}$$

where we have used the result of Proposition 1 that $x^*(\rho) = 0$ for $\rho \le \underline{\rho}$ 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 increasing in $\rho$ if and only if $\gamma \le \hat{\gamma}$, where $\hat{\gamma}$ is defined such that $\hat{\gamma} + e^*(\rho,\hat{\gamma}) = \frac{1}{2}$, i.e.,

$$k'(\frac{1}{2} - \hat{\gamma}) = p_h(R + r - 1). \tag{37}$$

Notice that (37) implies that $\hat{\gamma} + e^{SA} = \hat{\gamma} + e^*(\rho,\hat{\gamma}) = \hat{\gamma} + e^{**}(\rho,\hat{\gamma}) = \frac{1}{2}$. To see this we have

$$\frac{\partial e^*(\rho,\gamma)}{\partial \rho} = \begin{cases} \frac{-[1-2(\gamma+e^*(\rho,\gamma))](p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^*(\rho,\gamma))}, & \text{if } \rho \le \underline{\rho}, \\ \frac{-[1-2(\gamma+e^*(\rho,\gamma)]\left(\left[(p_\ell R-L)-x^*_h(\rho)c\right]+\frac{\partial x^*(\rho)}{\partial \rho}c\right)}{2(1-\rho)\left[(p_\ell R-L)-x^*_h(\rho)c\right]+k''(e^*(\rho,\gamma))}, & \text{if } \rho \in (\underline{\rho},\overline{\rho}), \\ 0, & \text{otherwise,} \end{cases} \tag{38}$$

$$\frac{\partial e^{**}(\rho,\gamma)}{\partial \rho} = \frac{-\left[1-2(\gamma+e^{**}(\rho,\gamma)\right]\left(p_\ell R-L\right)}{2(1-\rho)(p_\ell R-L)+k''(e^{**}(\rho,\gamma))}. \tag{39}$$

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 (38) and (38) imply that $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are increasing in $\rho$ if and only if $\gamma + e^*(\rho,\gamma) \ge \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \ge \frac{1}{2}$, respectively. Therefore by the definition of $\hat{\gamma}$ given in (37), if $\gamma \le \hat{\gamma}$, we have $e^*(\rho,\gamma) \ge e^*(0,\gamma) \ge \frac{1}{2}$ and $e^{**}(\rho,\gamma) \ge e^{**}(0,\gamma) \ge \frac{1}{2}$ for all $\rho$; if $\gamma \ge \hat{\gamma}$, we have $e^*(\rho,\gamma) \le e^*(0,\gamma) \le \frac{1}{2}$ and $e^{**}(\rho,\gamma) \le e^{**}(0,\gamma) \le \frac{1}{2}$ for all $\rho$. That is, $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are increasing in $\rho$ if and only if $\gamma \le \hat{\gamma}$.

(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 (14) and (15), 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 $\gamma$. This follows immediately from (35) and (36).

□

*Proof of Proposition 5.* Let us denote by $W^{CBB}(e,x|\kappa)$ and $W^{SA}(e)$ the welfare of a bank as a subsidiary of a CBB and as a stand-alone bank, respectively, where

$$W^{CBB}(e,x|\kappa) = \Pi_0^{CBB}(e,x|\kappa) - C_0(e), \tag{40}$$

$$W^{SA} = \Pi_0^{SA}(e^{SA}) - C_0(e^{SA}). \tag{41}$$

For $\rho \leq \underline{\rho}$, welfare is identical under both deposit insurance architectures for all $\kappa$. To see this, notice first that $\kappa^*(\rho,\gamma) = \kappa^{**}(\rho,\gamma)$ in this case by Proposition 3. Therefore, if $\kappa > \kappa^*(\rho,\gamma)$, then welfare is identical under both deposit insurance architectures as the banks remain stand-alone. If $\kappa \leq \kappa^*(\rho,\gamma)$, a CBB forms 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 (15).

For $\rho = 1$, welfare is again identical under both deposit insurance architectures for all $\kappa$. This is because we again have $\kappa^*(\rho,\gamma) = \kappa^{**}(\rho,\gamma)$ 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 (12) does not depend on $x$, and $e^{**}(\rho,\gamma) = e^*(\rho,\gamma)$ by (15).

It remains to compare welfare under national and common DIF architectures for $\rho \in (\underline{\rho},1)$. Before we proceed, let us first define the threshold $\tilde{\gamma}(\rho)$, such that $W^{CBB}(e^{**}(\rho,\gamma),0|\kappa) \geq W^{CBB}(e^*(\rho,\gamma),x^*(\rho)|\kappa)$ if and only if $\gamma \leq \tilde{\gamma}(\rho)$. Notice that this threshold is independent of $\kappa$. We now show that $\tilde{\gamma}(\rho) > \hat{\gamma}$ exists and is unique by showing that the welfare difference $W^{CBB}(e^{**}(\rho,\gamma),0|\kappa) - W^{CBB}(e^*(\rho,\gamma),x^*(\rho)|\kappa)$ is strictly positive for all $\gamma \leq \hat{\gamma}$ and is strictly decreasing in $\gamma$ for all $\gamma > \hat{\gamma}$.

First, we have $W^{CBB}(e^{**}(\rho,\gamma),0|\kappa) - W^{CBB}(e^{*}(\rho,\gamma),x^{*}(\rho)|\kappa) > 0$ 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 (12) 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.

Second, we show that $W^{CBB}(e^{**}(\rho,\gamma),0|\kappa) - W^{CBB}(e^{*}(\rho,\gamma),x^{*}(\rho)|\kappa) > 0$ is strictly decreasing in $\gamma$ for all $\rho \in (\underline{\rho},1)$ and $\gamma > \hat{\gamma}$. To see this, consider first the difference in the expected deposit insurance cost. Using (16), we have

$$C(e^{**}(\rho,\gamma)) - C(e^{*}(\rho,\gamma)) = [e^{**}(\rho,\gamma) - e^{*}(\rho,\gamma)]\,[L - p_h(1-r)]\,, \tag{42}$$

$$\frac{\partial C(e^{**}(\rho,\gamma)) - C(e^{*}(\rho,\gamma))}{\partial\gamma} = \left[\frac{\partial e^{**}(\rho,\gamma)}{\partial\gamma} - \frac{\partial e^{*}(\rho,\gamma)}{\partial\gamma}\right][L - p_h(1-r)] > 0. \tag{43}$$

Recall that $\frac{\partial e^{*}(\rho,\gamma)}{\partial\gamma}$ and $\frac{\partial e^{**}(\rho,\gamma)}{\partial\gamma}$ are given by (35) and (36), respectively. Since we have $e^{**}(\rho,\gamma) < e^{*}(\rho,\gamma)$ and $x_h^{*}(\rho) > 0$ for all $\rho \in (\underline{\rho},1)$ and $\gamma > \hat{\gamma}$, we have that $k''(e^{**}(\rho,\gamma)) < k''(e^{**}(\rho,\gamma))$ by Assumption 2 and thus $\frac{\partial e^{**}(\rho,\gamma)}{\partial\gamma} < \frac{\partial e^{*}(\rho,\gamma)}{\partial\gamma}$ by comparing (35) and (36). It then follows that the $\frac{\partial C(e^{**}(\rho,\gamma)) - C(e^{*}(\rho,\gamma))}{\partial\gamma} > 0$, because $L - p_h(1-r) < 0$ by Assumption 3. Consider next the difference in the banker's expected profit. Using (12), we have

$$\begin{aligned}&\frac{d\Pi_0(e^{**}(\rho,\gamma);0) - \Pi_0(e^{*}(\rho,\gamma);x_h^{*}(\rho))}{d\gamma}\\ &= (1-\rho)\left([1 - 2(\gamma + e^{**}(\rho,\gamma))]\,(p_\ell R - L) - [1 - 2(\gamma + e^{*}(\rho,\gamma))]\,[(p_\ell R - L) - x_h^{*}(\rho)c]^{+}\right),\end{aligned} \tag{44}$$

which, by the envelop theorem, contains only the direct effect of changes in $\gamma$, and no indirect effects through the changes in the the effort choice. For all $\rho \in (\underline{\rho},1)$ and $\gamma > \underline{\gamma}$, we have $x_h^{*}(\rho) > 0$ and $\gamma + e^{**}(\rho,\gamma) \geq \gamma + e^{*}(\rho,\gamma) > \frac{1}{2}$, resulting in

$$\begin{aligned}&\frac{d\Pi_0(e^{**}(\rho,\gamma);0) - \Pi_0(e^{*}(\rho,\gamma);x_h^{*}(\rho))}{d\gamma}\\ &< 2(1-\rho)\left([1 - 2(\gamma + e^{**}(\rho,\gamma))]\,(p_\ell R - L) - [1 - 2(\gamma + e^{*}(\rho,\gamma))]\,(p_\ell R - L)]\right)\\ &= 2(1-\rho)\,[-e^{**}(\rho,\gamma) + e^{*}(\rho,\gamma)]\,(p_\ell R - L) \leq 0.\end{aligned} \tag{45}$$

As a result, we have that the welfare difference $W^{CBB}(e^{**}(\rho,\gamma),0|\kappa) - W^{CBB}(e^{*}(\rho,\gamma),x^{*}(\rho)|\kappa) > 0$ is strictly decreasing in $\gamma$ for all $\rho \in (\underline{\rho},1)$ and $\gamma > \hat{\gamma}$, because $\Pi_0(e^{**}(\rho,\gamma);0) - \Pi_0(e^{*}(\rho,\gamma);x_h^{*}(\rho))$ is decreasing in $\gamma$ and $C(e^{**}(\rho,\gamma)) - C(e^{*}(\rho,\gamma))$ is increasing in $\gamma$ as shown above.

It then follows that there exists a unique threshold $\tilde{\gamma}(\rho) > \hat{\gamma}$, such that $W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa) - W^{CBB}(e^{*}(\rho,\gamma), x^{*}(\rho)|\kappa) \geq 0$ if and only if $\gamma \leq \tilde{\gamma}(\rho)$.

We now proceed to compare welfare for $\rho \in (\underline{\rho}, 1)$. Consider the following three regions of $\gamma$ given the thresholds $\hat{\gamma}$ defined in (37) and $\tilde{\gamma}(\rho)$ defined above.

- If $\gamma \leq \hat{\gamma}$, welfare is higher under a common DIF than under national DIFs for all $\kappa$, and strictly so for all $\kappa \leq \kappa^{**}(\rho,\gamma)$. Too see this, consider the following three regions of $\kappa$ given the thresholds $\kappa^{*}(\rho,\gamma)$ and $\kappa^{**}(\rho,\gamma)$ defined in Proposition 3.
  - If $\kappa > \kappa^{**}(\rho,\gamma)$, the banks remain stand-alone and welfare is identical under both deposit insurance architectures.
  - If $\kappa \in (\kappa^{*}(\rho,\gamma), \kappa^{**}(\rho,\gamma)]$, the bank remains stand-alone under national DIFs but forms a CBB under a common DIF. We thus have that welfare is strictly higher under a common DIF than under national DIFs. This is because (i) $\Pi_0^{CBB}(e^{**}(\rho,\gamma), 0) = \max_e \Pi_0^{CBB}(e, 0) > \max_e \pi^{SA}(e) = \Pi_0^{SA}(e^{SA})$, where $\Pi_0^{SA}(e)$ and $\Pi_0^{CBB}(e, x)$ are defined in (11) and (12), respectively; and (ii)$C_0(e^{**}(\rho,\gamma)) \leq C_0(e^{SA})$, where $C_0(e)$ is given by (16), 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 $\kappa \in (\kappa^{*}(\rho,\gamma), \kappa^{**}(\rho,\gamma)]$.
  - If $\kappa \leq \kappa^{*}(\rho,\gamma)$, a CBB forms under both deposit insurance architectures. We again have that welfare is strictly higher under a common DIF than under national DIFs since $\gamma \leq \hat{\gamma} < \tilde{\gamma}(\rho)$.
- If $\gamma \geq \tilde{\gamma}(\rho)$, welfare is lower under a common DIF than under national DIFs for all $\kappa$, and strictly so for all $\kappa \leq \kappa^{**}(\rho,\gamma)$. This follows analogous arguments for the three regions of $\kappa$ as for $\gamma \leq \hat{\gamma}$.
- If $\gamma \in (\hat{\gamma}, \tilde{\gamma}(\rho))$, there exists $\tilde{\kappa}(\rho,\gamma)$, such that welfare is higher under a common DIF than under national DIFs if and only if $\kappa \leq \tilde{\kappa}(\rho,\gamma)$. Consider again the following three regions of $\kappa$.
  - If $\kappa > \kappa^{**}(\rho,\gamma)$, the banks remain stand-alone and welfare is identical under both deposit insurance architectures.

– If $\kappa \in (\kappa^*(\rho,\gamma), \kappa^{**}(\rho,\gamma)]$, the bank remains stand-alone under national DIFs but forms a CBB under a common DIF. Notice that the welfare difference $W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa) - W^{SA}$ is strictly decreasing in $\kappa$ and is equal to 0 for $\kappa = \kappa^{**}(\rho,\gamma)$. Therefore there exists a threshold $\tilde{\kappa}(\rho,\gamma) \in [\kappa^*(\rho,\gamma), \kappa^{**}(\rho,\gamma))$, such that welfare is higher under a common DIF than under national DIFs, i.e., $W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa) - W^{SA} \geq 0$ if and only if $\kappa \leq \tilde{\kappa}(\rho,\gamma)$.

  Moreover, notice that $W^{CBB}(e^{**}(\rho,\gamma), 0|\kappa) - W^{SA}$ is decreasing in $\gamma$ for $\gamma > \hat{\gamma}$:

$$\frac{\partial\left[W^{CBB}(e^{**}(\rho,\gamma),0|\kappa) - W^{SA}\right]}{\partial\gamma} = 2(1-\rho)\left[1 - 2(\gamma + e^{**}(\rho,\gamma))\right](p_\ell R - L) - 2\frac{d\left[\gamma + e^{**}(\rho,\gamma)\right]}{d\gamma}\left[L - p_h(1-r)\right] < 0, \tag{46}$$

  where the first term is negative because $\gamma + e^{**}(\rho,\gamma) > \frac{1}{2}$ and the second term is negative because $\gamma + e^{**}(\rho,\gamma)$ is decreasing in $\gamma$ by Proposition 4. This then implies that the threshold $\tilde{\kappa}(\rho,\gamma)$ is strictly decreasing in $\gamma$.

– If $\kappa \leq \kappa^*(\rho,\gamma)$, a CBB forms under both deposit insurance architectures. We again have that welfare is strictly higher under a common DIF than under national DIFs since $\gamma \leq \tilde{\gamma}(\rho)$.

We now show that there exists $\gamma^* \in (\hat{\gamma}, \tilde{\gamma}(\rho))$, such that welfare given by (17) is higher under a common DIF than under national DIFs if and only if $\gamma \leq \gamma^*$. This is because $\Delta W$ given by (18) is strictly decreasing in $\gamma$. Let us express $\Delta W$ as

□

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