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Common Deposit Insurance, Cross-Border Banks and Welfare*

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Abstract

We study the effects of aligning the incentives of national authorities through the common provision of deposit insurance in a model of cross-border banks with both endogenous risk-taking and within-group risk-sharing. Under national deposit insurance, local authorities inefficiently ring-fence resources flowing from healthy to impaired subsidiaries. A single authority responsible for a common deposit insurance fund does not ring-fence. This encourages cross-border integration, but has an ambiguous impact on banks' risk-taking. Overall, common deposit insurance increases welfare when the fundamental risk in the economy is high but otherwise can lead to excessive cross-border integration and lower welfare.

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

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1 Introduction

"An incomplete banking union is the reason why cross-border banking groups are ring-fenced along national lines and cross-border integration does not happen. "

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

The euro area Banking Union established in 2014 constitutes a landmark for cooperation among national banking authorities.[1] While one of its objectives was to foster the establishment of cross-border bank groups (European Commission, 2012), these have barely increased over the past decade (ECB, 2024; Beck et al., 2024).[2] Banks point to the excessive regulatory obstacles to the free movement of liquidity and capital across countries as the main obstacle for cross-border expansion (Reuters, 2024). Regulators, on the other hand, resort to ring-fencing as countries are obliged to cover depositor losses with their own resources in the absence of a common deposit insurance fund. Indeed, it has been argued that completing the Banking union with common deposit insurance is necessary both for the removal of ring-fencing and for more cross-border bank integration (Enria, 2023).

These developments stand in stark contrast to those in the United States following the removal of barriers for interstate bank branching in the early 1990s.[3] Ten years after such legislative initiative, the number of banks with offices in more than one state more than doubled (Kroszner, 2006). Notably, and unlike in the Banking Union, federal deposit insurance in the United States has been in place since the end of the Great Depression.

This paper provides a theoretical contribution to the debate on common deposit insurance in a

[1]The Single Supervisory Mechanism (SSM) responsible for the supervision of largest banks was put in place in 2014. The supranational authority responsible for the resolution of the largest banks in the euro area, the Single Resolution Board (SRB), was established in 2016.

[2]The current merger discussion between Italy's UniCredit and Germany's Commerzbank, which would constitute the first important cross-border merger over the last decade in the euro area, has led several voices to emphasize the importance of these operations to enhance risk-sharing opportunities in the banking union (Lagarde, 2024; Villeroy de Galhau, 2024).

[3]The 1994 Riegle-Neal Interstate Banking and Branching Efficiency Act removed several obstacles to banks opening branches across state lines, which were largely the result of the McFadden Act in 1927.

banking union, ring-fencing due to conflicts among national authorities, and cross-border banking integration.

We develop a model of cross-border banks with an internal capital market, in which intragroup support can mitigate costly recapitalization needs upon distress but is subject to approval by the deposit insurance authority(ies). We use the model to study how the architecture of deposit insurance shapes (i) ring-fencing incentives by the authority(ies), (ii) cross-border bank integration, and (iii) banks' ex-ante risk-taking, and to evaluate the welfare implications of moving from national to common deposit insurance.

We find that the deposit insurance architecture shapes the flow of resources within cross-border banking groups. Under national deposit insurance, authorities have incentives to ring-fence subsidiary resources in order to protect their own deposit insurance funds. Such ring-fencing limits the risk-sharing benefits of internal capital markets, forces banks to issue costly external equity to recapitalize impaired subsidiaries and discourages cross-border bank integration.

When a common fund provides insurance to all depositors, by contrast, the authority responsible for deposit insurance internalizes the impact of intragroup transfers on overall insurance costs and therefore does not restrict intragroup capital reallocation. As a result, common deposit insurance improves risk-sharing within the group and fosters cross-border bank integration.

However, eliminating ring-fencing through a common deposit insurance fund has ambiguous effects on banks' ex-ante risk-taking incentives and, hence, on deposit insurance costs. When the economy has riskier fundamentals, enhanced intragroup support increases the banking group's franchise value and strengthens effort incentives, thereby reducing risk-taking. When the economy is safer, intragroup support weakens the disciplining role of the recapitalization threat, and banks increase their risk-taking. As a result, the introduction of common deposit insurance may reduce welfare despite enabling better risk-sharing and increasing cross-border integration. Our results shed new light on the interplay between the completion of the euro area Banking Union and the cross-border integration of the banking sector, and on its welfare implications.

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

At an initial date, each bank in one country is matched with a bank in the other country, and their bankers decide whether to merge into a cross-border bank (CBB). The merger costs differ between pairs of banks.

Both standalone banks and subsidiaries of CBBs may become impaired at the interim date following an adverse aggregate shock, in which case the responsible DIF requires recapitalization to limit its expected costs. Integrating standalone banks into a CBB allows bankers to benefit from risk-sharing within the group: resources in a healthier unit can be used to recapitalize an impaired unit through an intragroup loan, enabling the bank to avoid raising costly external equity.[4] Yet, the DIF responsible for the healthy unit's deposits may *ring-fence* resources in order to limit its own expected costs. We first examine the impact of the DIF architecture on the occurrence of ring-fencing and on cross-border integration.

Under national DIFs, each authority evaluates recapitalization decisions solely from the perspective of the costs to its own fund. Authorizing an intragroup loan from a healthy to an impaired subsidiary reduces costs for the impaired unit's DIF and may also benefit the healthy unit's DIF if the impaired subsidiary ultimately succeeds and repays the loan. However, it increases the costs borne by the healthy unit's DIF if both units fail simultaneously. From the overall CBB's perspective, reallocating resources toward the riskier unit, which is more likely to fail, amounts to foregoing some limited liability protection and reducing total expected deposit insurance costs. Nevertheless,

[4]For simplicity, the baseline model focuses on recapitalization plans in which within-group support takes the form of intragroup loans. As shown in Section 5.1, our results extend to more general forms of both one-sided and two-sided support across CBB units.

such resource reallocation also leads to a redistribution of deposit insurance costs to the healthy unit. Since national DIFs do not internalize the group-level effects, they ring-fence, while a common DIF does not: the cross-unit transfer under national DIFs is lower than under a common DIF, and the need for the CBB to issue external equity consequently higher.

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

Next, we analyze how the anticipation of ring-fencing (or lack thereof) affects bank risk-taking. At the initial date, each banker (or pair of bankers) exerts unobservable effort in its standalone bank (or in the subsidiaries of a CBB) that reduces the probability of the bank (or the subsidiaries) becoming impaired. The elimination of ring-fencing with a common DIF has two opposing effects on the effort incentives in a CBB. On the one hand, there is a negative *recapitalization effect* that increases risk-taking: The elimination of ring-fencing allows an impaired subsidiary to save on costly equity issuance when the other subsidiary is healthy. This erodes the effort incentives provided by the costly recapitalization needs of an impaired bank. The effect is stronger when the fundamental risk in the economy is low, that is, when there is a high probability that the other subsidiary is healthy and hence capable of *providing* intragroup support.

On the other hand, there is a positive *franchise value effect*: effort in one subsidiary creates value not only for that subsidiary but also for the other, if the former can provide intragroup support and preserve the latter's continuation value when it becomes impaired. Importantly, this effect arises because the risk-taking choice is centralized at the CBB level, thereby internalizing the positive effect of lower risk in one subsidiary on the equity value of the other subsidiary. The effect is stronger when the fundamental risk in the economy is high, that is, when there is a higher probability that the other subsidiary becomes impaired and can benefit from *receiving* intragroup support.

As a result, the overall impact of a common DIF on risk-taking by a CBB depends on the fundamental risk. When this risk is low, subsidiaries of a CBB are more likely to be healthy for exogenous reasons, which strengthens the negative recapitalization effect and weakens the positive franchise value effect. As a consequence, a common DIF reduces the bankers' effort in CBBs. The opposite occurs when this risk is high: establishing a common DIF increases bankers' effort in CBBs.

Finally, we focus on normative aspects and analyze the impact of introducing 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. The introduction of a common DIF has two welfare effects. First, by removing ring-fencing, it enhances ex-post intragroup risk-sharing, increasing the value that bankers obtain from operating a CBB and incentivizing more bankers ex ante to set up one. Second, the resulting increase in cross-border bank integration, along with the associated changes in bankers' efforts in CBBs, affects deposit insurance costs. This effect is ambiguous due to the opposing forces mentioned earlier and, importantly, is not internalized by bankers.

When the fundamental risk is low, the establishment of a common DIF leads to lower effort in CBBs, thereby increasing deposit insurance costs. There is therefore a welfare trade-off between ex post risk-sharing gains and ex ante risk-taking costs. We show that the negative ex ante risk-taking effect can be strong enough to dominate the ex post risk-sharing gains, so that a common DIF may reduce welfare in the economy. Notably, the cross-border expansion induced by a common DIF can also contribute to this welfare reduction. This is because bankers do not internalize that by creating a CBB they may increase deposit insurance costs. As a result, cross-border bank integration in the economy could become excessive. When the fundamental risk is high, by contrast, no such trade-off arises, as both the ex ante reduction in risk-taking and the expansion of ex post risk-sharing contribute to higher welfare.

Our baseline model assumes that bankers' effort affects the distribution of bank types at the interim date, whereas the loan return distributions of each bank type at the final date are given. In reality, effort could also increase loan returns for each bank type, and we consider this alternative modeling of effort in an extension. We find that in this setting, the effect of introducing a common DIF on effort is unambiguous. Higher effort reduces the recapitalization needs of an impaired bank. This recapitalization channel, which provides incentives for effort, is weakened in a CBB due to intragroup support. The effect of this recapitalization channel is further attenuated under a common DIF, where ring-fencing—and thus its alleviation through effort—is muted. Hence, a common DIF unambiguously leads to more risk-taking. This suggests that the welfare trade-off associated with the introduction of a common DIF between ex-ante risk-taking costs and ex-post risk-sharing gains, which in the baseline model arises only for low fundamental risk, could be a more prevalent phenomenon.

The results in our paper have important policy implications. Our analysis shows that ring-fencing is rooted in fragmented fiscal responsibility for the costs of banking crises. This points to common deposit insurance as a mechanism to remove barriers to intragroup support and to foster cross-border banking. We highlight, though, that expanding intragroup risk-sharing also affects risk-taking—an aspect largely overlooked in the current policy debate. Without incorporating this channel, the welfare implications of initiatives to relax ring-fencing of cross-border banks cannot be fully assessed.

Indeed, our model offers a more balanced view of the trade-off implied by increased cross-border banking, drawing on insights from a large body of corporate finance literature on internal capital markets. In particular, we incorporate both its benefit in terms of risk-sharing at times of distress (see, e.g., Gopalan and Xie, 2011; Matvos and Seru, 2014; Santioni et al., 2020), but also its cost in terms of adverse effects on ex ante investment decisions (see, e.g., Scharfstein and Stein, 2000; Rajan et al., 2000). For banks, part of the cost of those unintended effects would be borne by the public through banks' access to the safety net, which warrants close attention from a policy perspective.

From a practical perspective, our model suggests that ensuring welfare gains from the establishment of a common DIF may require greater supervisory scrutiny to deter the additional risk-taking incentives we identify.

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

Our paper also relates to the literature on the resolution of multinational banks. Bolton and Oehmke (2019) analyze the optimality of different resolution regimes when national authorities have ring-fencing prerogatives. Instead, we focus on how removing ring-fencing through a supranational authority responsible for a common DIF affects banks' cross-border integration, risk-taking, and welfare. Banal-Estanol et al. (2026) analyzes how different resolution approaches affect a trade-off between ex-post recapitalization of subsidiaries through debt bail-in and ex-ante financing capabilities. The paper abstracts from cross-border conflicts between national authorities.

Our analysis of the implications of common deposit insurance in a banking union is related to

Segura and Vicente (2026), who focus on the optimal fiscal risk-sharing architecture across countries in the presence of fiscal and bank moral hazard problems. The paper characterizes the conditions under which mutualization of deposit insurance in a banking union implements an optimal risk-sharing agreement. While we abstract from fiscal moral hazard issues resulting from risk-sharing across governments, we supplement their work by focusing on how risk-sharing within a banking group affects bankers' effort incentives.

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

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

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

2 The model

There are three dates $t = 0, 1, 2$ and two countries, A and B. There is no time discounting. In each country, there is a continuum of bankers, each of whom owns a standalone bank. Each bank is endowed with loans and funded with one unit of deposits that are fully insured by a deposit insurance fund (DIF). The DIF supervises the bank and can take actions to protect its financial interests, as we will describe below. Bankers are penniless at $t = 0$ and have large endowments at $t = 1, 2$. The bankers derive linear utility from consumption c_t at $t \in \{1, 2\}$, given by:

$$U(c_1, c_2) = (1 + \Delta)c_1 + c_2, \tag{1}$$

where $\Delta > 0$ captures the opportunity cost of bankers' funds at $t = 1$.

At $t = 0$, pairs of bankers—one from each country—are formed, and each pair decides whether to merge their banks. A merger entails a disutility cost $\kappa \geq 0$, which differs between pairs and is drawn independently from a distribution $F(\cdot)$ with support on $[0, \infty)$. The cost is shared equally between the two bankers. Merger creates a CBB with a bank holding company structure and two wholly owned subsidiaries, each subject to limited liability, and centralized decision-making. Establishing a CBB allows the bankers to benefit from risk-sharing possibilities as described later. We henceforth refer as bank $i \in \{A, B\}$ both to a standalone bank and to a subsidiary of a CBB located in country i.

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

For simplicity, we assume that in a CBB, depositors in both countries can be paid in full from the loan payoffs only if the two bank subsidiaries succeed:[5]

Assumption 1. $R + 3r < 2 < 2R + 2r$.

The success probability of bank loans at $t = 2$ depends on the state of the economy and the bank's type, both of which are revealed at $t = 1$. The aggregate state is *good* with probability q and *bad* with probability $1 - q$. In the good state, all banks are safe: their loans yield R with probability one. In the bad state, however, banks are risky and can be of two types: a *healthy* bank succeeds with high probability $p_h \in (0, 1)$, while an *impaired* bank succeeds with a lower probability p_ℓ, where $p_\ell < p_h$.

The bank type distribution in the bad state depends on an exogenous risk parameter γ and the unobservable effort of the banker at $t = 0$ as we describe next.

The parameter $\gamma \in [\underline{\gamma}, \overline{\gamma}]$, where $0 < \underline{\gamma} < \frac{1}{2} < \overline{\gamma} < 1$, is assumed to be the same in both countries and proxies for the level of risks in the economy. That is, a larger (smaller) γ corresponds to a lower (higher) risk of bank loan default. We refer to this exogenous source of risk as the fundamental risk.[6]

If a banker exerts effort $e \in [0, 1 - \overline{\gamma}]$, the probability that its bank is healthy conditional on the bad state at $t = 1$ is $\gamma + e$, and the probability that it is impaired is $1 - (\gamma + e)$. The banker incurs a disutility cost from exerting effort e at $t = 0$, which, after scaling by the probability of the bad state, amounts to $(1 - q)k(e)$.

We make the following assumption on the cost function $k(\cdot)$ to ensure interior solutions:

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

[5]The first inequality takes into account any potential recapitalization by the bank, detailed below.

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

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

Table 1: Joint probability distribution of bank types in a CBB conditional on the bad state at $t = 1$ given effort e by the bankers at $t = 0$.

The loan payoffs of the two matched banks can be correlated. 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 conditional on the bad state at $t = 1$ and the joint distribution of their loan payoffs at $t = 2$ (conditional on their $t = 1$ types).[7]

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

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

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

		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 in a CBB at $t = 2$ conditional on the banks' success probabilities p^A, p^B in the bad state at $t = 1$, for $p^A \geq p^B$.

Deposit insurance architecture We consider two arrangements. With *national DIFs*, two national funds, DIF A and DIF B, provide deposit insurance for the banks (both standalone and subsidiaries) in their respective jurisdictions. At $t = 1$, each DIF takes decisions non-cooperatively to minimize its own expected insurance costs.[8] With a *common DIF*, there is a single DIF responsible for the deposit insurance payments of all banks. The single fund takes decisions at $t = 1$ in order to minimize its overall expected insurance costs.[9]

Bank recapitalization at $t = 1$ In the good state at $t = 1$, banks are safe and able to fully repay deposits at $t = 2$ out of their loan payoffs. Due to the bankers' opportunity cost of funds $\Delta > 0$ at $t = 1$ (see (1)), they find it optimal to distribute all of the interim payoff r of their banks as dividends. The dividend distribution has no effect on deposit insurance costs and hence is authorized by the responsible DIF, whose costs remain zero.

In the bad state at $t = 1$, however, banks are risky, and their responsible DIFs may wish to intervene in order to minimize their deposit insurance costs. We assume that DIFs have the option

[8] In practice, banks are subject to a capital regulation framework aimed, among other things, at protecting the deposit insurance scheme. In Section 5.4.1, we discuss the relationship between our framework and capital regulation, and how regulatory constraints can be mapped into our setting. In Section 5.4.2, we discuss how our results would be robust to a more general objective function for the DIFs consisting of a weighted average of the total value of the banks and deposit insurance costs.

[9] The current incomplete euro area Banking Union, in which deposit insurance remains at the national level, would correspond to a national DIF architecture in our model.

to liquidate the loan portfolio of the banks they are responsible for.[10] Loan liquidation results in a payoff L satisfying:

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

Part (i) of the assumption implies that liquidation reduces the expected deposit insurance cost for an impaired bank, but not for a healthy bank. This establishes a setting in which, in the absence of some action by the banker/s, the responsible DIF would liquidate impaired banks but not healthy ones. Part (ii) of Assumption 3 states that liquidation reduces the expected payoff of the impaired bank's loans.

Anticipating the actions of the DIFs, bankers can propose a recapitalization plan for their impaired banks or subsidiaries. In the baseline model, we do not allow dividend distributions in the bad state for simplicity.[11] We model the strategic interaction between the bank and the authority/ies at $t = 1$ in the bad state as follows. First, the bank proposes a recapitalization plan. Next, the responsible authority/ies decide whether to approve the recapitalization plan. The plan is implemented only if approved by all relevant authorities, and no liquidation takes place. Finally, if the plan is not implemented, the responsible DIF decides whether to liquidate the bank.

An impaired standalone bank can be recapitalized only by its banker through an equity injection $x \geq 0$. An impaired subsidiary of a CBB can also benefit from the *support* of the other subsidiary in case the latter is healthy. In the baseline model, we focus exclusively on the cross-unit support from a healthy to an impaired unit, in the form of an intragroup loan whose repayment is junior to that of deposits.[12]

Formally, a recapitalization plan for an impaired subsidiary B of a CBB with a healthy subsidiary

[10] Liquidation can involve removing the banking license of 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 requirements to divest from some non-core businesses.

[11] Section 5.1 incorporates the possibility of dividend distribution and shows that the main results continue to hold.

[12] Section 5.1 shows that the results are robust when we allow the possibility of cross-unit support in other pairs of bank types in $t = 1$ in the bad state and for general cross-unit support contracts.

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.

A is a tuple (x, s, S) consisting of: *i)* a capital injection by the bankers $x \geq 0$ into the impaired subsidiary B and *ii)* an intragroup loan described by an injection of funds s from the healthy subsidiary A into the impaired subsidiary B in exchange for a promised repayment S from subsidiary B to subsidiary A at $t = 2$, which 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.

Since the intragroup loan affects deposit insurance costs in the healthy subsidiary, it may be constrained by supervisory intervention aimed at limiting expected deposit insurance losses. We refer to this phenomenon as regulatory *ring-fencing*.[13]

We make two simplifying assumptions:

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

As will become clear later, the first condition implies that a healthy subsidiary has an interim payoff large enough to entirely recapitalize an impaired subsidiary. The second condition instead implies bankers are willing to recapitalize an impaired standalone bank using their own funds to avoid liquidation.

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

[13]In practice, ring-fencing is often achieved by invoking the existing framework of capital regulation, for example, the issuance of a risky intragroup loan could be deemed as breaching the subsidiary's capital requirement.

$t = 0$

- A bank from each country is matched and the bankers decide whether to merge to form a CBB at cost κ.
- Each banker (or banker pair) chooses effort e for its bank(s).

$t = 1$

- Each unit's interim payoff r and type p^i are realized.
- The banker proposes a recapitalization plan.
- Each authority decides whether to approve the recapitalization plan. The recapitalization plan is implemented if it is approved by all relevant DIF/s.
- If the recapitalization plan is not implemented, the responsible DIF for each bank decides whether to liquidate.

$t = 2$

- Each bank's final payoffs are realized.
- The payoffs are used to pay the holders of the different liabilities of the banks according to their seniority.

Figure 2: Time line.

3 Ring-fencing and cross-border bank integration

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

3.1 DIF intervention in a standalone bank

Suppose a banker operates a standalone bank and the bad state is realized at $t = 1$. Let $p \in \{p_h, p_\ell\}$ denote the probability that the bank succeeds at $t = 2$. The intervention decision of the responsible DIF in the absence of a recapitalization 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:

$$(1 - p)(1 - r) \leq 1 - L - r, \tag{2}$$

where the interim loan payment r contributes to reducing deposit insurance costs both under continuation and liquidation. Assumption 3 implies that condition (2) is satisfied if and only if the bank is healthy.

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

$$(1 - p_\ell)\,[1 - (r + x)]^+ \leq 1 - L - r. \tag{3}$$

Since the equity injection x reduces the costs for the DIF under continuation, a sufficiently large recapitalization x avoids liquidation. Part (ii) of Assumption 4 ensures that the continuation value of the impaired unit to the banker is sufficiently large, so that the banker is willing to comply with the required recapitalization despite his opportunity cost of funds Δ at $t = 1$.

Lemma 1 (Intervention of a standalone impaired bank)**.** *For a standalone impaired bank, regardless of the DIF architecture, the banker's optimal recapitalization plan is to inject the minimum amount of equity required to ensure continuation* $\bar{x} = \frac{L - p_\ell(1-r)}{1-p_\ell}$.

3.2 DIF intervention in a CBB

We now consider a CBB and characterize the equilibrium of the DIF intervention and recapitalization game at $t = 1$ conditional on the bad state 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, which is the only case in which we allow for cross-unit support through an intragroup loan in the baseline model. In all other scenarios, the outcomes are trivially as in the standalone case described in Section 3.1.

3.2.1 National DIFs: 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 $p^A = p_h$ and $p^B = p_\ell$. We have established in Section 3.1 that, in the absence of a recapitalization, DIF B would liquidate subsidiary B.

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

$$s \leq r. \tag{4}$$

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

$$S \leq R + r + x + s - 1. \tag{5}$$

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

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

$$C_1^B(x, s) \equiv (1 - p_\ell)\,[1 - (r + x + s)]^+ \leq 1 - L - r. \tag{6}$$

The expression, analogous to the one for the standalone case in (3), accounts for the reduction in costs for DIF B due to the equity injection *and* the cross-unit support to the subsidiary. This implies that from DIF B's perspective, recapitalization through an equity injection and an intragroup loan are perfect substitutes. Hence, DIF B requires a strictly positive minimum overall recapitalization $x + s$ in order not to liquidate subsidiary B.

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

$$C_1^A(s, S) \equiv [1 - p_h - (1 - \rho)p_\ell(1 - p_h)]\,[1 - (r - s)]^+ + (1 - \rho)p_\ell(1 - p_h)\,[1 - (r - s + S)]^+ . \tag{7}$$

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

If $r - s + S \leq 1$,[14] we can rewrite (7) in a more compact form and the following condition for DIF A to approve the recapitalization plan follows:

$$C_1^A(s,S) = (1-p_h)(1-r+s) - (1-\rho)p_\ell(1-p_h)S \leq (1-p_h)(1-r), \tag{8}$$

where the right-hand side of the inequality captures the costs for DIF A in case the recapitalization plan is rejected. The second and third terms on the left-hand side of (8) account for the costs and benefits for DIF A from the intragroup loan, respectively. Notice that the benefit is decreasing in the correlation ρ between the two subsidiaries' loan payoffs because a larger correlation makes it less likely that subsidiary B succeeds when subsidiary A fails.

The opposite signs on the intragroup loan s in the DIF B and DIF A approval conditions (6) and (8) highlight the conflict between the two DIFs that can give rise to *ring-fencing*: DIF A may not allow a recapitalization plan that involves a large intragroup loan s, forcing the bank to meet the requirement by DIF B with a costly equity injection, $x > 0$.

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

$$\underline{\Pi}_1^{CBB} = (p_h R + r - 1) + (1-p_h)(1-r), \tag{9}$$

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

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

$$\Pi_1^{CBB}(x,s,S) = (p_h R + r - 1) + (p_\ell R + r - 1) + C_1^A(s,S) + C_1^B(x,s) - x\Delta. \tag{10}$$

The first two terms in the above decomposition capture the asset values of each subsidiary net of

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

their deposit liabilities. The third and fourth terms account for the value of the deposit insurance subsidies. The final term captures the opportunity cost of the banker's equity injection $x\Delta > 0$.

Subtracting (9) from (10), we have that the payoff difference for the bankers between a recapitalization plan that is approved and no recapitalization is:

$$\begin{aligned}\Pi_1^{CBB}(x,s,S) - \underline{\Pi}_1^{CBB} =& (p_\ell R - L) - \left[(1-p_h)(1-r) - C_1^A(s,S)\right] \\ &- \left[(1-L-r) - C_1^B(x,s)\right] - x\Delta. \end{aligned} \tag{11}$$

The payoff difference is made up of four terms. The first, which is positive, captures the value gains from the continuation of subsidiary B. The second and third terms, which are weakly negative from (6) and (8), capture the portion of the value gains that is appropriated by the DIFs, which reduces the bankers' payoff. Finally, the fourth term accounts for the opportunity cost of the bankers' equity injection, which also reduces the payoff for the bankers.

The payoff decomposition in (11) highlights that bankers prefer a recapitalization plan that: *i)* leaves no gains for DIFs; and *ii)* relies as little as possible on equity injection. The next proposition characterizes the solution to the bankers' 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, the CBBs' optimal recapitalization ensures the continuation of subsidiary B and binds the two DIFs' approval conditions (6) and (8). In addition, there exists a threshold $\underline{\rho} \in (0,1)$, such that the unique equilibrium of the DIF intervention game at $t = 1$ satisfies:*

- *If $\rho \leq \underline{\rho}$: There is no ring-fencing. The CBB's recapitalization features no equity injection, $x^* = 0$ and an intragroup loan of size $s^* = \bar{x}$, where $\bar{x}$ is defined in Lemma 1.*

- *If $\rho > \underline{\rho}$: There is ring-fencing. The CBB's recapitalization features an intragroup loan with size $s^* < \bar{x}$ and equity injection $x^* = \bar{x} - s^* > 0$. Moreover, $s^* > 0$ and $x^* < \bar{x}$ if and only if $\rho < 1$.*

The proposition characterizes when ring-fencing arises under a national DIF architecture. For negative or small (positive) 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, ($s^* = \bar{x}$ and $x^* = 0$), and the bankers avoid costly equity injection. As correlation increases, the likelihood that repayment of the intragroup loan reduces the expected costs borne by DIF A declines (see the second term of $C_1^A(\cdot)$ given in (8)).

The above intuition underpins the result that, for high enough correlation ($\rho > \underline{\rho}$), there is *ring-fencing*. In this case, DIF A does not approve the intragroup loan of size $\bar{x}$ even when the promised repayment exhausts the residual payoff of subsidiary B (that is, when S reaches the upper bound given in (5) for $s = \bar{x}$ and $x = 0$). As a result, DIF A approves only an intragroup loan up to size $s^* < \bar{x}$. Ring-fencing therefore forces the bankers to rely (partially) on costly equity injection to avoid the liquidation of subsidiary B.

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

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

As in the standalone case in Section 3.1, in the absence of a recapitalization, the common DIF liquidates subsidiary B. A recapitalization plan (x, s, S) from the bankers must satisfy the following condition to be approved by a common DIF:

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

Notice that the single approval condition for a common DIF is implied by the two national approval conditions (6) and (8). Hence, if a recapitalization plan is approved under national DIFs, it is also approved under 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.

If a recapitalization (x, s, S) is approved, bankers' expected payoff at $t = 1$ is given by (10); otherwise, it is given by (9). The bankers' optimal recapitalization problem therefore mirrors that under national DIFs (Section 3.2.1), except that the two national approval constraints (6) and (8) are replaced by the single condition (12).

The bankers' optimal recapitalization plan may not be unique: multiple pay-off equivalent plans can differ in how deposit insurance costs are distributed across subsidiaries.[15] When such multiplicity arises, we focus, without loss of generality, on the plan that minimizes redistribution of 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. Under a common DIF, the CBBs' optimal recapitalization ensures the continuation of subsidiary B, binds the common DIF's approval condition (12), and involves no equity injection, $x^{**} = 0$.*

Given the correlation threshold $\underline{\rho}$ defined in Proposition 1, we have that the optimal size s^{**} of the intragroup loan satisfies:

- *For $\rho \leq \underline{\rho} : s^{**} = \bar{x} = s^*$.*
- *For $\rho > \underline{\rho} : s^{**} > \bar{x} > s^*$.*

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

For low correlation across subsidiaries ($\rho \leq \underline{\rho}$), ring-fencing does not arise with national DIFs and the optimal recapitalization with national DIFs remains optimal with common DIF. This is due to two reasons. First, such a plan ensures that the cost of the insurance of *each* subsidiary's deposits is the same with and without recapitalization. A fortiori, the overall cost of deposit insurance is

[15]Two recapitalization plans are payoff equivalent if, conditional on their implementation, they generate the same bankers' payoff and total costs for the common deposit insurance fund.

the same with and without recapitalization, and the recapitalization is approved by the common DIF. Second, the recapitalization plan does not feature a costly equity injection. We therefore have from the value difference decomposition in (11) that the recapitalization maximizes the bankers' expected payoff.

For higher correlation between the two subsidiaries ($\rho > \underline{\rho}$), ring-fencing arises with national DIFs and the recapitalization of subsidiary B involves an intragroup loan of larger size with a common DIF relative to that with national DIFs, $s^{**} > \bar{x} > s^*$. To understand this result, consider the equity injection x^* and intragroup loan size s^* under a national DIF architecture. If the CBB increases the size of the intragroup loan above s^*, there are larger deposit insurance costs if subsidiary A fails at $t = 2$, which happens with a probability $1 - p_h$. However, this comes at the benefit of reducing the deposit insurance costs by the same amount if subsidiary B fails at $t = 2$, which happens with a higher probability $1 - p_\ell$. 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 resulting reduction in the common DIF costs allows the CBB to recapitalize the impaired subsidiary entirely through an intragroup loan, setting bankers' equity injection to zero.[16]

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

[16]The fact that the entire recapitalization of the subsidiary can be done with an intragroup loan and there is no external equity injection, $x^{**} = 0$, hinges on Assumption 4 Part (i), which ensures that the healthy bank has a sufficiently large interim payoff. Should that condition not be satisfied, a positive equity injection under a common DIF could arise when the intragroup loan size exhausts the interim payoff, $s^{**} = r$, but in that case we would still have $x^{**} < x^*$, thus reflecting ring-fencing under national DIFs (see the formal details of the extension in Section 5.1 in Appendix B.1 in which this is proven in a slightly more general context).

3.3 Cross-border bank integration

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

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

$$\Pi_0^{SA}(e) = q\left[R + r(1+\Delta) - 1\right] + \\ + (1-q)\big[(\gamma + e)p_h(R + r - 1) + (1 - \gamma - e)\left[(p_\ell R - L) - \bar{x}\Delta\right]\big] - (1-q)k(e). \tag{13}$$

The first term of this expression reflects the value for the banker in the good state at $t = 1$ (with probability q): the entire interim payoff r is paid out as dividends, yielding extra utility Δ per unit of funds to the banker. Notice that this term is independent from the banker's effort. The second term accounts for the value for the banker in the bad state at $t = 1$ (with probability q). The first term in the square brackets reflects the value of the standalone bank if it is healthy (with probability $\gamma + e$), in which case it continues without recapitalization. The second term in the square brackets reflects the value obtained from the standalone bank if it is impaired (with probability $1 - \gamma - e$), in which case the banker makes an equity injection $\bar{x}$ to avoid liquidation. This allows the banker to capture the value gains from the continuation of the unit (since the equilibrium recapitalization equalizes the bank's deposit insurance costs under continuation and liquidation), less the opportunity cost of the equity injection. The last term in (13) is the banker's effort cost (where recall that the cost function $k(e)$ was scaled by the probability that the bad state is realized at $t = 1$).

Suppose that the bankers choose to set up a CBB. Compared to standalone banks, the bankers derive additional value in a CBB from intragroup support at $t = 1$, which can reduce the equity injection needed to avoid liquidation of an impaired unit. The equilibrium equity injection x depends on the DIF architecture as described by Propositions 1 and 2 and captures the level of ring-fencing: with national DIFs we have $x = x^*$, which is strictly positive if and only if $\rho > \underline{\rho}$

due to ring-fencing; with a common DIF we have $x = x^{**} = 0$ for all ρ. As a result, the bankers' expected payoff from the CBB as a function of their effort e in each subsidiary for a ring-fencing level x is given by:

$$\Pi_0^{CBB}(e, x|\kappa) \equiv 2\Pi_0^{SA}(e) - \kappa + \underbrace{2(1-q)(1-\rho)(\gamma+e)(1-\gamma-e)}_{\text{Probability of intragroup support}} \underbrace{(\bar{x} - x)\Delta}_{\text{Support gains}}, \tag{14}$$

The first two terms of this expression represent the expected payoff the bankers would obtain from the standalone banks given by (13), and the setup cost, respectively. The last term represents the increase in the bankers' expected payoff due to intragroup support, which is equal to the product of the probability of support and the value gains for the bankers conditional on support. The latter are proportional to the reduction in the equity injection required to avoid liquidation of the impaired unit, from $\bar{x}$ in the standalone case to x in a CBB.

Notice from (14) that the bankers' value from a CBB is decreasing both in the ring-fencing level x and in the CBB setup cost κ. We thus have that the bankers find it optimal to set up a CBB when their cost κ is below a threshold κ' defined by:

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

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

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

This result shows that a common DIF promotes cross-border bank integration precisely when, under national DIFs, cross-unit support would be constrained by ring-fencing. By allowing the CBB to rely on intragroup resources to recapitalize an impaired unit, a common DIF reduces the need for costly equity injections by bankers. This makes cross-border banking more profitable and thus fosters integration. Our findings support the view articulated in Enria (2023) that common deposit insurance, by helping to remove ring-fencing, would also promote cross-border bank integration.

4 Risk-taking and welfare

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

4.1 Risk-taking at $t = 0$

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

$$k'(e) = p_h(R + r - 1) - [(p_\ell R - L) - \bar{x}\Delta]\,. \tag{16}$$

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

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

Notice that the bankers' cost κ of setting up a CBB does not appear in the expression, which implies that the bankers' effort in a CBB does not depend on the setup cost.

The first line on the right-hand side of (17) represents the marginal benefit of effort in the absence of cross-unit support and coincides with the right-hand side of (16). The second line captures the additional effect on effort stemming from the possibility of cross-unit support: this is the product of the change in the probability of support caused by a marginal change in effort and the value the bankers obtain from reduced equity injection.

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

On the other hand, the possibility of *receiving* support *reduces* the marginal benefit of effort in a given subsidiary. This is because an impaired subsidiary may (partially or fully) avoid costly equity injection through cross-unit support from the other subsidiary if the latter is healthy, which occurs with probability $\gamma + e$. We refer to this as the *recapitalization effect* as cross-unit support erodes the effort incentives provided by the costly recapitalization needs of an impaired bank, which reduces bankers' value. Notice that this effect is stronger when the economy is fundamentally less risky (that is, if γ is higher): the marginal benefit of effort in one subsidiary decreases when there is a higher probability that the other subsidiary is healthy and hence capable of giving support.

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

The following proposition summarizes how the bankers' risk-taking behavior depends on their banks' organizational structure and the DIF architecture. Let e^{SA} denote the bankers' optimal effort in a standalone bank, and e^* and e^{**} the bankers' optimal effort in the subsidiaries of a CBB with national DIFs and a common DIF, respectively.

Proposition 4 (Bankers' risk-taking decision given organizational structure and DIF architecture)**.** *Given the correlation threshold $\underline{\rho}$ defined in Proposition 1, there exists a risk threshold $\hat{\gamma} \in (\underline{\gamma}, \bar{\gamma})$ independent of ρ, such that:*

- *If $\gamma < \hat{\gamma}$, then $e^{SA} < e^* \leq e^{**}$, and $e^* < e^{**}$ if and only if $\rho \in (\underline{\rho}, 1)$.*
- *If $\gamma = \hat{\gamma}$, then $e^{SA} = e^* = e^{**}$.*
- *If $\gamma > \hat{\gamma}$, then $e^{SA} > e^* \geq e^{**}$, and $e^* > e^{**}$ if and only if $\rho \in (\underline{\rho}, 1)$.*

The proposition shows that cross-unit support in a CBB can enhance or undermine the bankers' effort depending on the fundamental risk, γ, and that the effects are (in both directions) stronger with a common DIF. When the fundamental risk is high ($\gamma \leq \hat{\gamma}$), the positive franchise value effect dominates. Effort is higher in a CBB than in standalone banks, and more so with a common DIF than with national DIFs. When the fundamental risk is low ($\gamma \geq \hat{\gamma}$), the recapitalization effect dominates. As a result, all effects are reversed: bankers choose higher risk in CBBs than in standalone banks, and more so under a common DIF than under national DIFs.

4.2 Welfare implications of the introduction of a common DIF

In this section, we assess the welfare implications of a shift from national DIFs to a common DIF. Welfare in our economy amounts to the overall value the bankers obtain net of the costs incurred by the DIF/s.[17] Bankers do not internalize the effect of their $t = 0$ decisions on the cost to the DIF/s, which opens up room for misalignment between private and socially optimal decisions.

[17]Since bank depositors are always repaid in full their utility does not need to be included in the overall welfare in the economy.

If a banker operates a standalone bank, the $t = 0$ costs of the deposit insurance for effort e is given by

$$C_0(e) = (1-q)\left[(\gamma+e)(1-p_h)(1-r) + (1-\gamma-e)(1-L-r)\right]. \tag{18}$$

The expression captures the insurance costs in case the state of the economy is bad and the bank is healthy and impaired at $t = 1$ weighted by the probability of each state. Recall that if the bank becomes impaired the banker injects the equity amount $\bar{x}$ that makes the DIF continuation condition in (3) just binding.

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

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

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

Using the characterization of the tuple (x, κ', e) for the two DIF architectures in Propositions 1, 2, 3 and 4, we can prove the following proposition, which constitutes the main contribution of the paper.

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

- *If $\rho \leq \underline{\rho}$ or $\rho = 1$, where $\underline{\rho}$ is the correlation threshold defined in Proposition 1, there is no welfare change.*

- *If $\rho \in (\underline{\rho}, 1)$, let $\hat{\gamma} \in (\underline{\gamma}, \overline{\gamma})$ be the fundamental risk threshold defined in Proposition 4. We have that:*
  - *if $\gamma \leq \hat{\gamma}$, welfare increases.*
  - *if $\gamma > \hat{\gamma}$, there exists $\tilde{\kappa} \in (\kappa^*, \kappa^{**}]$, such that welfare strictly decreases if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $(\tilde{\kappa}, \kappa^{**}]$.*

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

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

When the correlation between banks in the two countries is large enough yet imperfect ($\rho \in (\underline{\rho}, 1)$), CBBs face a ring-fencing problem with national DIFs during crises. A common DIF solves this problem and affects welfare through a number of channels, resulting in mixed welfare implications summarized in the second part of Proposition 5. To gain intuitions, we can use (19) to decompose the welfare effect from the establishment of a common DIF as follows:

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

The first term in the welfare decomposition captures the *intensive margin* effect, which applies to banker pairs with low setup cost (with $\kappa \leq \kappa^*$), who merge their banks irrespective of the

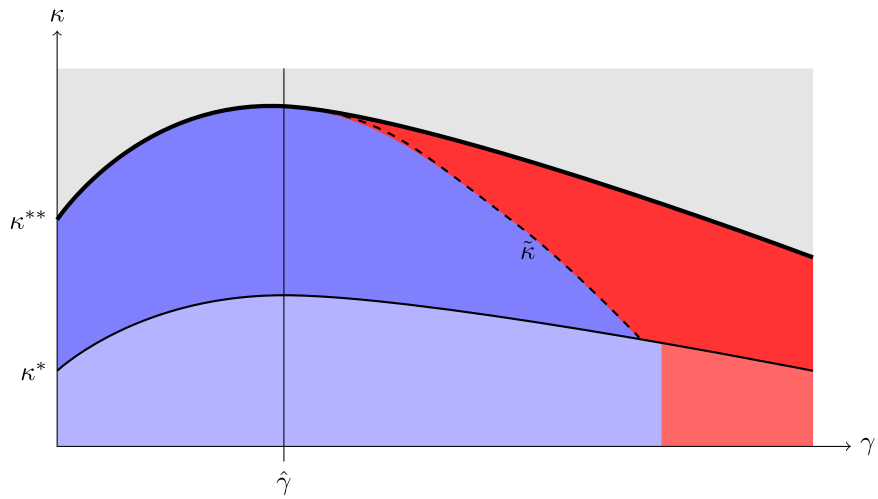

Figure 3: Welfare associated with banker pairs under common DIF versus national DIFs for $\rho \in (\underline{\rho}, 1)$. The figure considers different values of the fundamental risk in the economy (γ, horizontal axis) and banker pairs' CBB setup costs (κ, vertical axis). In the grey shaded area, welfare is identical under both DIF architectures (because banks remain standalone). In the (dark or light) blue shaded areas, welfare is higher with common DIF, whereas in the (dark or light) red shaded areas, welfare is lower with common DIF. In the light blue and light red shaded areas, cross-border integration always occurs, whereas in the dark blue and dark red shaded areas, cross-border integration occurs only with common DIF.

DIF architecture. The elimination of ring-fencing under a common DIF affects welfare along this margin through two channels. First, enhanced ex-post intragroup risk-sharing possibilities increase bankers' payoffs from operating a CBB and induce a new optimally chosen effort level, further increasing their payoffs (first term in intensive margin). Second, the induced change in bankers' effort affects deposit insurance costs (second term in intensive margin). These costs are reduced (contributing to a welfare increase) if bankers exert higher effort with a common DIF, which from Proposition 4 is the case only when risk in the economy is higher, that is, for $\gamma \leq \hat{\gamma}$.

The second term in (20) captures the *extensive margin* effect of introducing a common DIF. It applies to banker pairs with intermediate CBB setup cost (with $\kappa \in (\kappa^*, \kappa^{**}]$), who keep their banks as standalone under national DIFs but set up a CBB under a common DIF. Along this margin, welfare is affected through two channels analogous to those operating on the intensive margin.

Figure 3 illustrates the intensive and extensive margins of the welfare effects in (20) for different values of the fundamental risk. Recall that banker pairs' payoffs increase with a common DIF in both the intensive and the extension margins. When the economy is riskier ($\gamma < \hat{\gamma}$), a common DIF induces higher bankers' effort along both margins, thereby reducing deposit insurance costs. This is because, in this case, the positive franchise value effect on effort incentives associated with the removal of ring-fencing dominates the recapitalization effect. As a result, ex-post risk-sharing gains and ex-ante risk-taking incentives are aligned, and aggregate welfare increases under a common DIF regardless of the distribution $F(\kappa)$ of CBB setup costs.

In contrast, when the economy is safer ($\gamma > \hat{\gamma}$), a common DIF lowers bankers' effort along the two relevant margins, raising deposit insurance costs. This is because, in this case, the negative recapitalization effect dominates. Ex-post risk-sharing gains and ex-ante risk-taking incentives are no longer aligned, which opens up room for welfare reductions.

In particular, consider banker pairs with a relatively high setup cost $\kappa \in (\tilde{\kappa}, \kappa^{**}]$. These banker pairs form CBBs only under a common DIF, as they benefit more from improved ex-post risk-sharing. However, because the removal of ring-fencing weakens ex-ante effort incentives, the resulting CBB formation also imposes larger negative externalities on the common DIF. For bank pairs with setup costs close to the upper CBB setup threshold under a common DIF, their payoffs gains from setting up a CBB is small and thus outweighed by the negative impact on deposit insurance costs. As a result, if a sufficiently large mass of bankers is concentrated in this range of setup costs, the introduction of a common DIF reduces aggregate welfare, as stated in Proposition 5.

When the fundamental risk is low, the cross-border banking expansions that policymakers expect from the establishment of a common DIF in the Euro area (Enria, 2023) might be accompanied by welfare reductions. This is an important implication of our model that adds a new dimension to the policy debate. More strikingly, when risk is low, cross-border expansion not only coincides with but actively contributes to welfare reductions: Some banker pairs along the extensive margin region reduce welfare when a common DIF is introduced.

The same mechanisms that generate excessive cross-border bank integration when the economy is safer ($\gamma > \hat{\gamma}$), also result in insufficient integration when the economy is riskier ($\gamma < \hat{\gamma}$). Although the establishment of a common DIF leads to more cross-border bank mergers, some banker pairs still find it optimal to keep their banks as standalone even when forming a CBB would be socially efficient (the banker pairs with CBB setup cost just above the threshold κ^{**}). This is because bankers fail to internalize that CBB formation, by leading to more effort, would lower deposit insurance costs.

5 Robustness and extensions

5.1 Dividend payout and general cross-unit support

In the baseline model, we have restricted the contracting space to highlight voluntary support and ring-fencing in a CBB. Specifically, we have assumed that, in the bad state, banks are not allowed to pay dividends and that support between subsidiaries of a CBB must be in the form of an intragroup loan from a healthy to an impaired subsidiary. In this extension, we relax these restrictions and demonstrate that our main results and the underlying mechanisms remain valid. We provide intuition for the results in this section, and relegate details of the analysis to Appendix B.1.

We extend the contracting space at $t = 1$ in three ways. First, we allow bankers to choose to distribute dividends from either standalone banks or subsidiaries of a CBB, also in the bad state. Formally, we denote by x_i the equity injection into a bank in country i, where $x_i > 0$ corresponds to an equity injection by the banker(s) as in the baseline model, and $x_i < 0$ corresponds to a dividend payout to the banker(s). As in the baseline model, bankers' actions, including any dividend payout, must be approved by the relevant authorities. Since dividend payouts increase deposit insurance costs, the authority's intervention prerogative endogenously implies a dividend ban unless it is accompanied by some other actions that offset this effect.

Second, we allow for general cross-unit support within a CBB, whereas in the baseline model the contracting space for support was restricted to intragroup loans. A general intragroup support contract between unit A and unit B is a triple (s, S_A, S_B), consisting of: *i)* a $t = 1$ oriented transfer $s \in \mathbf{R}$ from unit A to unit B (where $s < 0$ has to be interpreted as a transfer from unit B to unit A of magnitude $-s$); and *ii)* $t = 2$ transfers $S_A \geq 0$ from unit A to unit B, and $S_B \geq 0$ from unit B to unit A. The two $t = 2$ transfers are conditional on the respective units being successful and are junior to the repayment of their deposits. These transfers do not net out because the subsidiaries do not always succeed simultaneously. The junior transfers S_A, S_B can be interpreted as a cross-unit pledging of the $t = 2$ residual claims of the subsidiaries and would be equivalent to intragroup guarantees on the subsidiary deposits.

Third, we allow for cross-unit support in all contingencies in the bad state, whereas in the baseline model, only support from a healthy unit to an impaired unit was considered.

To summarize, a general capital plan in each of the contingencies in the bad state can be described by a tuple (x_A, x_B, s, S_A, S_B).

Importantly, we also assume that there are commitment problems when promising at $t = 1$ future residual payoffs for cross-unit support. Those frictions were also implicitly assumed in the baseline model when we focused only on intragroup loans for the provision of support. Formally, each unit can pledge up to a fraction $\phi \in (0, 1)$ of its residual claim at $t = 2$ for transfers to the other unit.[18] These limited pledgeability problems could be microfounded by assuming that the banker operating a solvent unit at $t = 2$ can unobservably divert a fraction of the unit's profits for private consumption.

Specifically, the limited pledgeability of residual claims imposes the following bounds on the

[18] While we adopt a single pledgeability parameter ϕ that applies uniformly across units and contingencies in this extension, the main results and intuition apply if the pledgeability parameter is type- and/or state-contingent. The contractual restriction in the baseline model, where cross-unit support is limited to an intragroup loan from a healthy to an impaired unit, could also be interpreted as a particular (and ad hoc) case of limited pledgeability of residual claims. In particular, it corresponds to a configuration in which the healthy unit cannot pledge any of its $t = 2$ residual payoff ($\phi_h = 0$), while repayment by the impaired unit is fully enforceable ($\phi_\ell = 1$). In the remaining contingencies in the bad aggregate state, the absence of cross-unit support in the baseline model can be represented by a single pledgeability constraint $\phi = 0$, implying that no residual claims can be pledged across units.

$t = 2$ transfers of a CBB's capital plan:

$$S_A \leq \phi(R + r + x_A - s - 1), \tag{21}$$

$$S_B \leq \phi(R + r + x_B + s - 1). \tag{22}$$

In addition, any capital plan must also satisfy the follow beduget constraints at $t = 1$, which state that dividend payouts at each subsidiary and the $t = 1$ transfer should not exceed the subsidiary's available funds r:

$$-x_A + s \leq r, \tag{23}$$

$$-x_B - s \leq r. \tag{24}$$

5.1.1 Ring-fencing and cross-border bank integration

We first discuss whether and how these contracting extensions affect the outcome of the intervention game in the bad state at $t = 1$.

For a standalone bank, the possibility to pay dividends ($x_i < 0$) does not affect the outcome relative to the baseline model. First, if the unit is healthy, the responsible DIF would not allow dividend payments as they would increase the deposit insurance costs should the unit fail at $t = 2$. In this case, the authority's intervention prerogative is equivalent to imposing a dividend ban, effectively "ring-fencing" standalone banks in the bad state. Second, as in the baseline model, impaired standalone banks are required to inject the amount of equity $\bar{x}$, which is defined in Lemma 1.

For a CBB, consider first the case in which one subsidiary (A) is healthy and the other subsidiary (B) is impaired. Under a national DIF architecture, a capital plan (x_A, x_B, s, S_A, S_B) is accepted by both DIFs if and only if:

$$(1 - p_\ell)(1 - r - x_B - s) - [(1 - \rho)p_\ell(1 - p_h) + (p_h - p_\ell)]\, S_A \leq 1 - L - r, \tag{25}$$

$$(1 - p_h)(1 - r - x_A + s) - (1 - \rho)p_\ell(1 - p_h)S_B \leq (1 - p_h)(1 - r). \tag{26}$$

Instead, under a common DIF, the two approval constraints in (25) and (26) are replaced by a single constraint adding up the two.

The expressions above account for the enlarged contracting space for cross-unit support. First, (25) extends the baseline model approval condition for DIF B in (6). The additional (second) term on the left-hand side accounts for the $t = 2$ transfer S_A from subsidiary A to subsidiary B when the former is successful and the latter is failing, which reduces DIF costs in country B. This decreases the total recapitalization required by DIF B compared to the baseline model. Second, (26) extends the baseline model approval condition for DIF A in (8). The first term on the left-hand side includes an additional term $-x_A$, which captures the possibility of dividend payouts by subsidiary A. DIF A may allow a positive dividend distribution ($x_A < 0$) because the $t = 2$ transfer S_B reduces unit A's DIF cost. Notice that the $t = 2$ transfers S_A and S_B relax the approval constraints of the units receiving the transfer, while not affecting those of the units making the transfer due to their juniority to deposits. As a result we can prove that, when r is large so that the budget constraint of subsidiary A at $t = 1$ (23) is slack, bankers find it optimal to cross-pledge the maximum residual claim compatible with conditions (21) and (22) in order to minimize the overall net equity injection in the CBB, which we denote by $\tilde{x} \equiv x_A + x_B$.

As in the baseline model, there is a conflict between the two DIFs regarding the $t = 1$ transfer s, leading to ring-fencing under national DIFs. To see this, we exploit the fact that, provided r is large enough so that the budget constraint of subsidiary A at $t = 1$ (23) is slack, the pledgeability constraints (21) and (22) will be binding at the optimal recapitalization plan, and rewrite the approval constraints in (25) and (26) as a function of x_A, x_B and s:

$$(1 - p_\ell)(1 - r - x_B - s) - [(1-\rho)p_\ell(1 - p_h) + (p_h - p_\ell)]\,\phi(R + r + x_A - s - 1) \leq 1 - L - r, \tag{27}$$

$$(1 - p_h)(1 - r - x_A + s) - (1-\rho)p_\ell(1 - p_h)\phi(R + r + x_B + s - 1) \leq (1 - p_h)(1 - r). \tag{28}$$

Equations (27) and (28) imply that a marginal increase in the $t = 1$ transfer s from the healthy subsidiary A to the impaired subsidiary B leads to a marginal *reduction* in the expected cost to

DIF B that can be decomposed into

$$\underbrace{\left[1-(1-\rho)p_\ell\right](1-p_h)}_{\textit{Prob. both units fail}}+\underbrace{\underbrace{\left[(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)\right]}_{\textit{Prob. unit A succeeds and unit B fails}}(1-\phi)}_{\text{Benefit of increase in early support}}, \tag{29}$$

and to a marginal *increase* in the expected cost to DIF A that can be decomposed into

$$\underbrace{\left[1-(1-\rho)p_\ell\right](1-p_h)}_{\textit{Prob. both units fail}}+\underbrace{\underbrace{(1-\rho)p_\ell(1-p_h)}_{\textit{Prob. unit B succeeds and unit A fails}}(1-\phi)}_{\text{Cost of increase in early support}}. \tag{30}$$

The first term in (29) and (30) is the same, since when both units fail simultaneously, the marginal reduction in DIF costs in unit B associated with the increase in s is exactly offset by the increase in DIF costs in unit A. The second term in (29) and (30) captures the marginal effects of early support that arise due to the limited pledgeability of the residual claims in $t = 2$.

On the one hand, the second term in (29) captures the *benefit of early support*: conditional on unit A succeeding and unit B failing at $t = 2$, a marginal increase in s reduces the expected cost to DIF B at a rate $1 - \phi$. This is because, due to limited pledgeability of the residual payoff in unit A at $t = 2$, support provided at $t = 1$ cannot be fully replicated by transfers at the final date.

On the other hand, the second term in (30) captures the *cost from early support*: conditional on unit B succeeding and unit A failing at $t = 2$, a marginal increase in s increases the expected cost to DIF A at a rate $1 - \phi$. This is because support frontloaded to unit B at $t = 1$ cannot be fully transferred back at $t = 2$ when unit A would benefit from it, due to limited pledgeability of unit B's residual payoff.

While under national DIFs, DIF A is concerned with the negative impact of the $t = 1$ transfer s on its own costs under national DIFs, a common DIF internalizes the positive impact on the costs to DIF B and considers the net effect of increasing early support. Using (29) and (30) we have that for any $\phi < 1$ the benefit from early support exceeds its cost, that is:

$$\underbrace{\underbrace{[(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)]}_{\textit{Prob. unit A succeeds and unit B fails}}(1-\phi)}_{\text{Benefit of increase in early support}} > \underbrace{\underbrace{(1-\rho)p_\ell(1-p_h)}_{\textit{Prob. unit B succeeds and unit A fails}}(1-\phi)}_{\text{Cost of increase in early support}}. \tag{31}$$

Hence, a marginal increase in the $t = 1$ support s to the impaired subsidiary leads to an overall reduction of DIF costs. The intuition is similar to that in the baseline model: given limited pledgeability of residual claims at $t = 2$, which restricts $t = 2$ redistribution across units, transferring resources at $t = 1$ toward the riskier unit effectively amounts to the CBB foregoing limited liability protection and is beneficial to depositors. Consistent with this intuition, inequality (31) holds because the probability that the impaired unit (B) fails while the healthy unit (A) succeeds at $t = 2$ exceeds the probability that the impaired unit succeeds while the healthy unit fails at $t = 2$ (which can be formally seen in the relevant terms in (31) using that $p_h > p_\ell$).

As a result, a CBB under a common DIF can take advantage of the transfer of $t = 1$ resources across subsidiaries to lower its net equity injection requirement. Those additional transfers lead to a redistribution of DIF costs across countries and would lead to ring-fencing restrictions under national DIFs.

Formally, we show that the net equity injection in a CBB under a common DIF, $\tilde{x}^{**}$, is strictly lower than that under national DIFs, $\tilde{x}^{*}$, as a result of the ring-fencing described above, that is, $\tilde{x}^{**} < \tilde{x}^{*}$. This result holds for any correlation level ρ in this generalized contracting framework, whereas a common DIF only reduces the equity injection in the baseline model for high correlation ρ across countries (see Propositions 1 and 2). This highlights that the result on the emergence of ring-fencing under national DIFs in the baseline model strengthens when the assumption of dividend prohibition and contractual restrictions on support are lifted.

Moreover, the possibility of cross-pledging of the subsidiaries' residual claims may lead to dividend distributions that would otherwise be banned (as in standalone banks). Indeed, under either of the DIF architectures, we have that a CBB is able to distribute a net dividend (that is $\tilde{x}^{*} < 0$ or $\tilde{x}^{**} < 0$) if correlation ρ is low and the pledgeability ϕ of residual claims is large. In this case, the value of cross-pledging to the deposit insurance fund becomes sufficiently large that the CBB with a healthy subsidiary can distribute dividends even though its impaired subsidiary must still be recapitalized to avoid liquidation.

A CBB also takes advantage of cross-unit support opportunities when its subsidiaries are both healthy or both impaired, something we did not allow for in the baseline model. In these scenarios, the CBB optimally cross-pledges the maximum amount of each subsidiaries' $t = 2$ residual payoff but makes no $t = 1$ transfer due to the symmetry of the units. Cross-unit support allows the CBB to make dividend distributions when both subsidiaries are healthy (while a standalone healthy unit is not allowed to distribute dividends) and to reduce the equity injections in each unit when both subsidiaries are impaired compared to standalone impaired banks. Since these scenarios are symmetric, the cross-unit support within a CBB does not lead to redistribution of DIF costs across the two countries. Therefore, the outcome of the intervention game in these scenarios does not depend on the DIF architecture. Ring-fencing thus only emerges when there is asymmetry in the state of the subsidiaries of the CBB.

Finally, the outcome of the intervention game at $t = 1$ influences the bankers' decision to form cross-border banks at $t = 0$. As in the baseline model (see Proposition 3), the introduction of a common DIF expands CBB integration by raising the threshold of the setup cost below which banker pairs find it optimal to form a CBB. This is because, under a common DIF, operating a CBB becomes more profitable as the overall net equity injection required for a CBB is lower when one subsidiary is impaired and the other is healthy ($\tilde{x}^{**} < \tilde{x}^{*}$). This expansion occurs for all levels of correlation ρ, again highlighting that the irrelevance of the ring-fencing under low correlation in our baseline model is solely due to contracting restrictions.

5.1.2 Risk-taking and welfare

The DIF architecture also influences the banker's effort decision in a CBB at $t = 0$. For a given amount of overall net equity injection $\tilde{x} \in \{\tilde{x}^{*}, \tilde{x}^{**}\}$, the first-order condition determining effort in this extension is analogous to (17) in the baseline model and is given by:

$$k'(e) = \mathcal{M}(e) + \underbrace{(1-\rho)\left[\overbrace{(1-(\gamma+e))}^{\text{Franchise value eff.}} - \overbrace{(\gamma+e)}^{\text{Liq. threat eff.}}\right]}_{\text{Change in support probability in the bad state}} \times \underbrace{(\bar{x}-\tilde{x})\Delta}_{\text{Support gains}}, \tag{32}$$

where $\mathcal{M}(e)$ is a function of effort that does not depend on the DIF architecture.[19] The second term is identical to the second line in (17) and captures the marginal effect of effort in the bad state at $t = 1$ when one unit is impaired, and the other is healthy, which depends on the DIF architecture. Taking into account that, as in the baseline model, the introduction of a common DIF reduces the overall equity injection ($\tilde{x}^{**} < \tilde{x}^{*}$), bankers' effort in a CBB responds analogously to Proposition 4: When the fundamental risk is high (low γ), CBB's take less risk under a common DIF, while the opposite happens when risk is low (high γ).

Our discussion above highlights that the same mechanisms associated with the introduction of a common DIF in the baseline model also operate in this more general setup. As a result, the welfare comparison characterized in Proposition 5 continues to hold. In particular, a common DIF can reduce welfare in safer economies if the ex-post gains from relaxing ring-fencing are outweighed by the ex-ante increase in risk-taking incentives.

More broadly, the generalized contracting framework clarifies that our results are not driven by the dividend prohibitions in the baseline model. Although CBBs may distribute dividends in some contingencies in the bad state, allowing for such payouts does not change the main results and mechanisms emphasized in the baseline model.

Importantly and contrary to the baseline model, the extended analysis highlights that ring-fencing arises for all levels of correlation, which suggests it could be a more pervasive phenomenon.

[19] The function $\mathcal{M}(e)$ accounts for the marginal benefit of effort in a standalone bank as captured by the first term in (17) and additional effects of effort−invariant to the DIF architecture−that arise from the cross-pledging of residual claims of a CBB in the bad aggregate states when both units are either healthy or impaired.

5.2 Alternative effort modeling

In the baseline model, effort affects the probability that a bank is healthy or impaired at $t = 1$ in the bad state, but not the loan performance at $t = 2$ conditional on the realized type. However, in practice, effort could also affect loan performance for each bank type. To examine the robustness of our results to this alternative modeling choice, we consider an extension in which effort increases the bank's success probability at the final date, but leaves the interim type distribution conditional on the bad state unchanged. We highlight the main results of this extension and their intuitions in this section, and relegate details of the analysis to Appendix B.2.

Formally, we assume that, at $t = 1$ in the bad state, a bank is healthy with exogenous probability γ, and impaired with probability $1 - \gamma$. Subsequently, at $t = 2$, a healthy bank and an impaired bank succeed with probabilities $p_h(e)$ and $p_\ell(e)$, respectively, where effort $e \in [0, 1]$ is exerted at $t = 0$ and $p_h(\cdot)$ and $p_\ell(\cdot)$ increase in e. Banks' $t = 2$ success probabilities are realized and observable at $t = 1$. We modify Assumptions 2 – 4 so that the key properties of the baseline model continue to hold for any effort choice in this alternative environment: DIFs require a recapitalization for impaired units but not for healthy units, bankers are willing to recapitalize an impaired bank using their own funds, and a healthy subsidiary has an interim payoff large enough to recapitalize an impaired subsidiary.

5.2.1 Ring-fencing and cross-border bank integration

Unlike the baseline model, the bankers' effort now influences the equity injection required by the responsible DIF of a standalone impaired bank. Indeed, the DIF allows the bank's continuation when the equity injection x satisfies:

$$(1 - p_\ell(e))\,[1 - (r + x)]^+ \leq 1 - L - r. \tag{33}$$

The expression is analogous to that in (3) for the baseline model, with the only difference being that p_ℓ is replaced by $p_\ell(e)$. In the new environment, higher effort increases the likelihood that an impaired bank's loan portfolio succeeds at the final date if continued, which in turn reduces the expected losses for the responsible DIF. Hence, the minimum equity injection that avoids liquidation $\bar{x}(e)$, which is analogously characterized as in Lemma 1 in the baseline model, is strictly decreasing in effort e.

Under national DIFs, a recapitalization plan (x, s, S) for the impaired unit B when unit A is healthy is approved by DIF B and DIF A, respectively, if and only if:

$$(1 - p_\ell(e))\,(1 - r - x - s) \leq 1 - L - r, \tag{34}$$

$$(1 - p_h(e))\,(1 - r + s) - (1 - \rho)p_\ell(e)\,(1 - p_h(e))\,S \leq (1 - p_h(e))\,(1 - r). \tag{35}$$

The approval constraints are analogous to those in (6) and (8) for the baseline model, with the only difference being that the success probabilities of each unit now depend on effort e.

For a given level of effort, the equilibrium of the intervention game at $t = 1$ under national DIFs is characterized as in Proposition 1: the bankers' equity injection $x^*(e) \geq 0$ is strictly positive when the correlation ρ between the banks' loans is above some threshold, that is, the national DIF architecture leads to ring-fencing. Moreover, since $p_\ell(e)$ is increasing in effort, the bankers' equity injection is strictly decreasing in effort when $x^*(e) > 0$. To see this, note that the approval condition for the DIF responsible for the healthy unit in (35) depends on the success probability of the impaired unit, but not on the success probability of the healthy unit itself (as the common term $1 - p_h(e)$ cancels out). Therefore, effort affects $x^*(e)$ only through its impact on the success probability of the impaired unit $p_\ell(e)$, and two channels that complement each other emerge. First, as for a standalone bank, the total recapitalization $\bar{x}(e) = x + s$ required to avoid the liquidation of the impaired unit B decreases as effort improves the success probability of the unit. Second, effort also enhances the impaired unit's ability to repay the intragroup loan. As this is used to repay the deposits of the healthy unit when the latter fails in $t = 2$, it relaxes the approval condition of DIF A, allowing a greater intragroup loan size s.[20] As a result, the equity injection needed to recapitalize the impaired unit $x^*(e)$ is decreasing in effort.

Instead, under a common DIF, the approval constraints (34) and (35) are replaced by a single constraint adding up the two, analogously to (12). Results in Proposition 2 extends to this environment, and the impaired unit of the CBB is recapitalized entirely through an intragroup loan, i.e, $x^{**}(e) = 0$. Similarly to the baseline model, the reduction in the costly equity injection associated with the introduction of a common DIF for large correlation ρ, $x^{**}(e) < x^*(e)$, can be interpreted as resolving the ring-fencing problem of the national DIF architecture.

Finally, as in Proposition 3, the elimination of ring-fencing also implies that CBBs expand when a common DIF is introduced.

5.2.2 Risk-taking and welfare

We now turn to the bankers' effort decision at $t = 0$. We focus on analyzing how effort depends on the DIF architecture in the large correlation case in which ring-fencing arises under national DIFs.

Effort in a standalone bank is determined by the following first-order condition:

$$k'(e) = \left[\gamma p_h'(e)(R + r - 1) + (1 - \gamma)p_\ell' R\right] - (1 - \gamma)\frac{d\bar{x}}{de}\Delta. \tag{36}$$

Similarly to (16) in the baseline model, the right-hand side of (36) captures the marginal benefits of effort. The first term reflects that effort increases the expected bank profit in the absence of recapitalization, and second term reflects that effort reduces the recapitalization $\bar{x}(e)$ required to avoid liquidation at $t = 1$.

In a CBB, there is an additional effect of effort, since cross-unit support lowers the equity injection at $t = 1$ to an impaired unit when the other unit is healthy from $\bar{x}(e)$ to $x(e) \in \{x^*(e), x^{**}(e)\}$, depending on the deposit insurance architecture. This is captured by the last term in the first-order

[20] There is a countervailing effect that arises due to the interaction between the two aforementioned effects. That is, since the impaired unit receives a smaller total recapitalization, it also has fewer funds to repay the intragroup loan. However, this effect is of the second order and is always dominated.

condition for effort in a CBB given by, similar to (17) in the baseline model:

$$k'(e) = \left[\gamma p_h'(e)(R+r-1) + (1-\gamma)p_\ell' R\right] - (1-\gamma)\frac{d\bar{x}(e)}{de}\Delta$$
$$+ (1-\rho)\gamma(1-\gamma) \underbrace{\frac{d\left(\bar{x}(e) - x(e)\right)}{de}\Delta}_{\text{Recapitalization effect}}, \tag{37}$$

Two dimensions of effort comparison are relevant. First, bankers exert less effort in a CBB under a common DIF than in standalone banks. That is, the recapitalization effect is negative $\frac{d(\bar{x}(e)-x(e))}{de} < 0$. This is because, by eliminating the need for costly equity injection $x^{**}(e) = 0$ in the impaired unit, cross-unit support also weakens effort incentives that result from the reduction in the recapitalization needs $\bar{x}(e)$ of the impaired unit. This suggests that the introduction of a common DIF increases bank risk-taking on the extensive margin; that is, for those banker pairs with intermediate setup costs who only set up CBBs under a common DIF and would remain standalone under national DIFs.

Second, bankers exert less effort in a CBB under a common DIF than under national DIFs. That is, the recapitalization effect is strictly larger under national DIFs than under a common DIF (that is, $\frac{d\bar{x}(e)}{de} - \frac{dx^*(e)}{de} > \frac{d\bar{x}(e)}{de} - \frac{dx^{**}(e)}{de}$). This is because, under national DIFs, cross-unit support is limited due to ring-fencing, which is endogenously weakened by higher effort. Such an effect fosters effort and is absent under a common DIF, in which ring-fencing is removed for any effort level, and the gains from cross-unit support have a lower sensitivity to effort. This suggests that the introduction of a common DIF increases bank risk-taking also on the intensive margin; that is, for those banker pairs with low setup costs who operate CBBs under either deposit insurance structure.

Overall, in this alternative environment there is only a recapitalization effect that leads to more risk-taking in a CBB when ring-fencing is removed with a common DIF, while in the baseline model there was also a franchise value effect that led to lower risk-taking and whose relative importance was increasing in the fundamental risk (see Proposition 4). The introduction of a common DIF thus gives rise to a welfare trade-off between ex-post risk-sharing gains and ex-ante risk-taking losses that is qualitatively similar to that in the baseline model when the fundamental risk is small. This suggests that our main policy message in Proposition 5 that risk-sharing gains through a common DIF could lead to more risk-taking and end up being detrimental despite expanding cross-border banking is robust to alternative modeling choices.[21]

5.3 Fairly priced deposit insurance

In this section, we discuss the effect of subjecting banks to fairly priced deposit insurance. We assume bankers are required to pay an actuarially fair deposit insurance premium to the relevant DIF/s. The premium is paid out of the banks profits at $t = 2$ conditional on the good state at $t = 1$. The premium depends both on the banks' organizational structure and on the DIF architecture, and correctly anticipates how the two affect the bankers' optimal effort choice at $t = 0$.

For a given DIF architecture and banks' organizational structure, deposit insurance premia paid at $t = 2$, following the good state at $t = 1$, do not affect the recapitalization game upon the bad state at $t = 1$. Since bankers' effort at $t = 0$ does not influence the realization of the $t = 1$ state, these premia are also irrelevant to the optimal effort. The deposit insurance premium thus only impacts the bankers' decision to set up a CBB and, when it is fairly priced, aligns this decision with the social welfare maximizing one. In other words, the fairly priced premium makes the cross-border integration decision always efficient irrespective of the DIF architecture.

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

Figure 4 graphically illustrates the effects of the establishment of a common DIF in the presence of fairly priced deposit insurance (under both DIF architectures) for a large correlation of banks'

[21] Instead, the results suggest that the alignment between ex-ante risk-taking and ex-post risk sharing following the introduction of a common DIF when the fundamental risk is large in the baseline model could be, to some extent, model specific.

loans ρ that gives rise to ring-fencing under national DIFs. The solid lines represent the CBB setup cost thresholds under the two DIF architectures with fairly priced premia, while dashed lines represent the analogous thresholds without them (which correspond to the solid lines in Figure 3). Compared to the baseline model, when the economy is riskier ($\gamma < \hat{\gamma}$), the CBB setup cost thresholds shift upwards as bankers are rewarded for setting up a CBB through a reduction in the deposit insurance premium that accounts for the increase in effort; analogously, when the economy is safer ($\gamma > \hat{\gamma}$), the CBB setup cost thresholds shift downwards as deposit insurance premia for CBBs increases to account for the fact that bankers exert less effort in CBBs.

The figure also shows that, contrary to the case of no deposit insurance premia, the establishment of a common DIF may lead to a reduction in cross-border integration. This can happen for very safe economies as illustrated by the dark red shaded area in Figure 4. Notice that when such a reduction of cross-border integration happens, the establishment of a common DIF also reduces welfare.

5.4 Further robustness discussion

5.4.1 Capital regulation and intervention prerogatives

Our model assumes DIFs have intervention prerogatives in the bad state that allows to them to prohibit dividend payouts and to liquidate bank loans. We next discuss how these prerogatives relate to actual powers by supervisory authorities when banks breach their capital requirements.

Our model consider banks that at $t = 0$ are endowed with loans and whose liabilities consist of insured deposits whose notional amount is normalized to one and equity as a residual claim held by bankers. We can interpret such a capital structure as determined by some exogenous bank capital regulation that banks are compliant with at $t = 0$.[22]

Following the bad state, the loan quality of the two bank types deteriorates, which leads them

[22] Equivalently, if the notional amount of banks' deposits was not normalized to one but were instead some value D, all the results in the model would still be valid provided Assumptions 3 and 4 are adjusted in order for healthy and impaired banks in the bad state to face the same intervention threats as in our current environment.

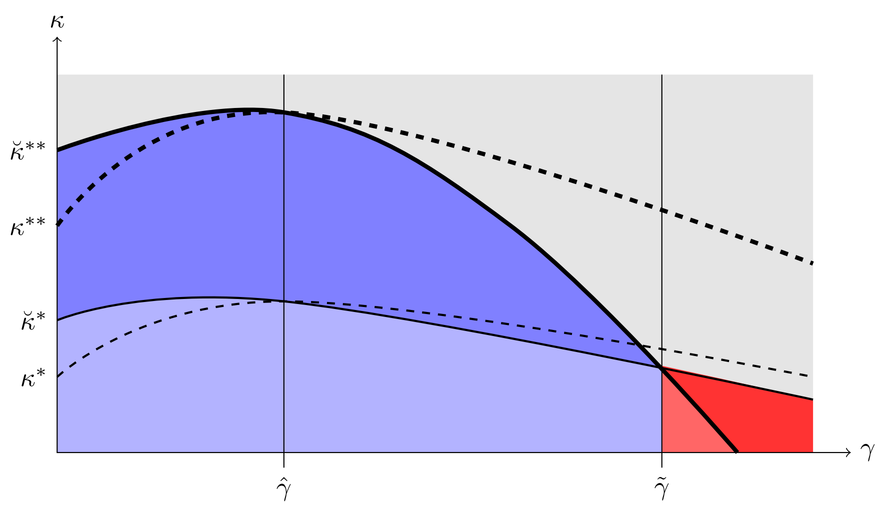

Figure 4: Welfare associated with banker pairs under a common DIF versus national DIFs for $\rho \in (\underline{\rho}, \overline{\rho})$ and fairly priced deposit insurance. The figure considers different values of the fundamental risk (γ, horizontal axis) and banker pairs' CBB setup costs (κ, vertical axis). $\breve{\kappa}^{*}$ and $\breve{\kappa}^{**}$ (solid lines) are the upper thresholds of the CBB merger costs such that banker pairs with lower costs setup a CBB under national DIFs and a common DIF, respectively, while κ^{*} and κ^{**} (dashed lines) are the analogous thresholds in the absence of deposit insurance premia given in Proposition 3. In the grey shaded area, welfare is identical under both DIF architectures. In the (dark or light) blue shaded areas, welfare is higher with a common DIF, whereas in the (dark or light) red shaded areas, welfare is lower with a common DIF. In the light blue and light red shaded areas, cross-border integration always occurs. In the dark blue shaded area, cross-border integration occurs only with a common DIF, whereas in the dark red shaded area, cross-border integration occurs only with national DIFs.

to breach the capital requirements they initially satisfied. In those conditions, authorities have at their disposal a set of intervention measures aimed at ensuring banks reestablish their capital requirements. These initially include restrictions on dividend payments when only capital conservation buffers have been depleted, which would correspond with healthy banks in our model. If the loan deterioration becomes sufficiently severe and capital ratios fall further, which would correspond with impaired banks in our model, more intrusive supervisory actions may follow, including through limits on lending, request to divest from some assets or to immediately recapitalize, under the threat of bank's closure in case of non-compliance.[23]

Our model thus captures the key features of the intervention powers of authorities when banks' capital ratios deteriorate. From this perspective, our results (especially those in Section 5.1) contribute to the literature on bank crises management by providing a microfoundation for the authorities' use of different intervention tools like recapitalization requirements, dividend limits, and intragroup exposure restrictions, and characterizing how their usage depends on the banks' structure (standalone or CBB) and the architecture of deposit insurance provision.

5.4.2 The DIFs' objective function

In the baseline model, we have assumed that the objective of the agent we refer to as DIF is to minimize costs. A prominent example of such type of agent is the Federal Deposit Insurance Corporation, which in the US is also responsible for the supervision of small- and medium-sized banks. In other jurisdictions, the supervision and resolution of banks are assigned to specific authorities that are legally different from the national deposit insurance funds. Nevertheless, 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

[23]Such an incremental approach is embedded in both the US and EU regulatory regimes through the Prompt Corrective Action of the Federal Deposit Insurance Corporation Act and the Capital Conservation Measures of the EU Capital Regulation Directive 2013/36/EU, respectively.

loans to the economy. Our model easily lends itself to such variation. In particular, we can assume that the DIF/s' objective 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.[24]

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

5.4.3 Cost of equity

Assumption 4 (ii) implies that the opportunity cost Δ of bankers' own funds−the cost of equity− is small enough to allow the recapitalization of an impaired standalone bank. Our results remain qualitatively the same if Δ is higher, so that the recapitalization of an impaired standalone bank is too costly and the banker prefers to let the bank be liquidated. In this environment, ring-fencing of a CBB by national DIFs could make the recapitalization of an impaired subsidiary so costly that it results in liquidation. Beyond that all our results under baseline assumptions hold qualitatively.

6 Conclusion

Intragroup support within a cross-border bank allows for more efficient central liquidity and capital management. Yet when deposit insurance is organized at the national level, domestic authorities have incentives to ring-fence local resources to protect their own deposit insurance funds. Such practices raise concerns about welfare losses and have long been viewed as a key obstacle to the

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

emergence of pan-European banks. Despite the establishment of the banking union, ring-fencing remains pervasive in the euro area and is widely regarded as a barrier to cross-border integration (Lautenschläger, 2019; Enria and Fernandez-Bollo, 2020; Villeroy de Galhau, 2024) It has been argued that introducing a common deposit insurance fund would solve, at the same time, the issue of ring-fencing and the lack of cross-border integration (Enria, 2023).

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

We show that national deposit insurance induces ring-fencing and thereby discourages cross-border bank integration. By contrast, a common deposit insurance fund removes these barriers and expands intragroup risk-sharing, leading to greater cross-border integration.

However, the welfare consequences of the removal of ring-fencing through common deposit insurance are non-trivial. Banks do not internalize the effect of their risk-taking and cross-border integration decisions on deposit insurance costs, which gives rise to potential misalignment between private and socially optimal choices. We find that in economies with higher fundamental risk, common deposit insurance leads to greater cross-border bank integration, less risk-taking, and higher welfare. By contrast, when this risk is low, the same expansion of cross-border banking can weaken effort incentives, raise deposit insurance costs, and reduce welfare.

Our analysis cautions against viewing the expansion of cross-border banking as an unambiguous indicator of welfare gains from common deposit insurance. The welfare effects instead depend on how such arrangements reshape intragroup risk-sharing and, through this channel, banks' risk-taking incentives.

Appendices

A Proofs

A.1 Proof of Proposition 1

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

$$\frac{L - p_\ell(1-r)}{1-p_\ell}\frac{1}{(1-\rho)p_\ell} = R + r + \frac{L - p_\ell(1-r)}{1-p_\ell} - 1. \tag{38}$$

$\underline{\rho} \in (0,1)$ exists and is unique, because the left-hand side of (38) is strictly smaller than the right-hand side for $\rho = 0$ by Part (ii) of Assumption 3, is strictly greater than the right-hand side for $\rho = 1$, and is strictly increasing in ρ.

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

The bankers' optimal recapitalization plan that ensures the continuation of both subsidiaries. The bankers' optimization problem is to maximize their expected payoff as of $t = 1$, which is given by (10), subject to the two authorities' approval requirements given by (6) and (7), the budget constraints (4) and (5), and the non-negativity constraint $x \geq 0$.

We first try to rewrite the optimization problem by showing that it is without loss of generality to restrict attention to recapitalization plans that 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 (6) is slack, and that $x + s > 0$ as $r < 1$. If $x > 0$, then it is possible to decrease x to strictly increase the bankers' expected payoff while keeping all constraints satisfied. If $x = 0$, then there exists another recapitalization plan with $s' = 1 - r - \epsilon < s$ and $S' = S - \frac{s-s'}{(1-\rho)p_\ell}$ for ϵ sufficiently small, which strictly increases the bankers' expected payoff while keeping all constraints satisfied.

Next, we have that $r-s+S \leq 1$ is implied by the budget constraint (5) and Part (i) of Assumption 1.

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

$$C_1^B(x,s) = (1-p_\ell)\left[1-(r+x+s)\right] \leq 1-L-r, \tag{39}$$

and replace the approval condition by DIF A given by (7) with (8). That is, the bankers' optimization problem is equivalently defined as maximizing the objective function given by (10), subject to the DIF approval conditions (39) and (8), the budget constraints (4) and (5) and the non-negativity constraint $x \geq 0$.

We solve this alternative problem in two steps below. (i) We first define a simplified problem that drops the budget constraints (4) and (5), and show that the solution to this simplified problem indeed satisfies the budget constraint (4), but only satisfies the budget constraint (5) if and only if $\rho \leq \underline{\rho}$. This implies that the solution to this simplified problem is also the solution to the original problem for $\rho \leq \underline{\rho}$. (ii) As the previous step implies that the budget constraint (5) binds for $\rho > \underline{\rho}$, we define a second simplified problem that drops the budget constraint (4) and binds the budget constraint (5). We can show that the solution to this simplified problem indeed satisfies the budget constraint (4) for $\rho > \underline{\rho}$ and thus is also the solution to the original problem.

(i) Consider the simplified problem given by the objective function (10), the approval constraints (8) and (39), and the non-negativity constraint $x \geq 0$. Let us denote the Lagrangian multipliers on the approval requirements of DIF A and B in (8) and (39), respectively, by μ^i for $i \in \{A, B\}$, and that on the non-negativity constraint on x by ξ . We derive the following first-order conditions with respect to x, s, and S, respectively:

$$-(1-p_\ell)(1-\mu^B) - \Delta + \xi = 0, \tag{40}$$

$$(1-p_h)(1-\mu^A) - (1-p_\ell)(1-\mu^B) = 0, \tag{41}$$

$$-(1-\rho)p_\ell(1-p_h)(1-\mu^A) = 0, \tag{42}$$

and their respective complementary slackness conditions. We can now characterize the solution to this simplified optimization problem. (42) implies that $\mu^A = 1$ and therefore the constraint (8) binds by complementary slackness. $\mu^A = 1$ and (41) then imply that $\mu^B = 1$ and therefore (6) binds by complementary slackness. $\mu^B = 1$ and (40) imply that $\xi = \Delta > 0$ and therefore $x = 0$ by complementary slackness. Imposing $x = 0$, a binding constraint (39) implies that $s = \bar{x} \equiv \frac{L-p_\ell(1-r)}{1-p_\ell}$, and a binding constraint (8) in turn implies that $S = \frac{s}{(1-\rho)p_\ell} = \frac{1}{(1-\rho)p_\ell}\frac{L-p_\ell(1-r)}{1-p_\ell}$.

Notice that this solution satisfies the budget constraint (4), as $\bar{x} = \frac{L-p_\ell(1-r)}{1-p_\ell} < r$ by Part (i) of Assumption 4. This solution also satisfies the budget constraint (5) if and only if $\rho \leq \underline{\rho}$, where $\underline{\rho}$ is defined as the solution to (38). 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 (10), the approval constraints (8) and (39), the non-negativity constraint $x \geq 0$, and a binding budget constraint (5) for $\rho > \underline{\rho}$. After substituting the binding constraint (5) 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:

$$-(1-\rho)p_\ell(1-p_h)(1-\mu^A) - (1-p_\ell)(1-\mu^B) - \Delta + \xi = 0, \tag{43}$$

$$[1-(1-\rho)p_\ell]\,(1-p_h)(1-\mu^A) - (1-p_\ell)(1-\mu^B) = 0, \tag{44}$$

and their respective complementary slackness conditions, where the Lagrangian multipliers are similarly as defined above. (44) implies that either $\mu^A, \mu^B \leq 1$, or $\mu^A, \mu^B > 1$. We consider these two cases separately.

- Suppose $\mu^A, \mu^B \leq 1$. Then (43) implies $\xi > 0$ and therefore $x = 0$ by complementary slackness. Moreover, recall that the term multiplying $(1-\mu^A)$ in (44) is the joint probability that both units fail simultaneously. This term is thus strictly smaller than

$(1-p_\ell)$, the unconditional probability that unit B fails. Therefore, (44) 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 (39) binds by complementary slackness. $x = 0$ and a binding constraint (39) then imply $s = \frac{L - p_\ell(1-r)}{1-p_\ell}$, the same as in Case (i). However, the analysis in Case (i) shows that the value of S that binds the approval constraint (8) violates the budget constraint (5) for $\rho > \underline{\rho}$. However, since lowering S tightens the constraint (8), there exists no S that satisfies both the constraint (8) and the budget constraint (5) for $\rho > \underline{\rho}$.

- Suppose $\mu^A, \mu^B > 1$. This implies that the approval constraints (8) and (39) bind by complementary slackness. It is easy to verify that $s = \frac{(1-\rho)p_\ell(R+r-1+L-p_\ell R)}{1-p_\ell}$, $x = \bar{x} - s$ and $S = R + r + \bar{x} - 1$ satisfy (43)–(44) 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 (10), the budget constraints (4) and (5), the approval constraints (6) and (7), and the non-negativity constraint $x \geq 0$ is

$$
\begin{aligned}
s^*(\rho) &= \begin{cases} \bar{x} \equiv \frac{L-p_\ell(1-r)}{1-p_\ell}, & \text{if } \rho \leq \underline{\rho}, \\ \frac{(1-\rho)p_\ell(R+r-1+L-p_\ell R)}{1-p_\ell}, & \text{if } \rho > \underline{\rho}, \end{cases} \\
S^*(\rho) &= \begin{cases} \frac{\bar{x}}{(1-\rho)p_\ell}, & \text{if } \rho \leq \underline{\rho}, \\ R + r + \bar{x} - 1, & \text{if } \rho > \underline{\rho}, \end{cases} \\
x^*(\rho) &= \bar{x} - s^*(\rho).
\end{aligned} \tag{45}
$$

The bankers' decision to recapitalize. The bankers prefer to recapitalize the impaired subsidiary whwnever the expected payoff difference given by (11) is positive when evaluated at the optimal recapitalization plan that ensures the continuation of both units given by (45). Using the fact that this recapitalization plan binds the constraints (8) and (39), (11) evaluated at the solution given by (45) is equal to

$$\Pi_1^{CBB}(x^*(\rho), 0, s^*(\rho), S^*(\rho)) - \underline{\Pi}_1^{CBB} = (p_\ell R - L) - x^*(\rho)\Delta. \tag{46}$$

Since $x^*(\rho) < \bar{x} = \frac{L-p_\ell(1-r)}{1-p_\ell}$, Part (ii) of Assumption 4 implies that the bank always recapitalizes the impaired subsidiary with the recapitalization plan characterized above.

A.2 Proof of Proposition 2

Let us consider the bankers' optimal recapitalization plan that ensures the continuation of both subsidiaries. It maximizes the banker's expected payoff given in (10), subject to the common DIF's approval condition (12), the budget constraints (4) and (5), and the non-negativity constraint $x \geq 0$.

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

Thus, we can focus on characterizing the bankers' optimal recapitalization plan, which must satisfy $x = 0$ and bind (12). Following similar arguments as those in the proof of Proposition 1, we replace the expression for $C_1^B(x^B, s)$ in (12) given by (6) with that in (39), and replace the expression for $C_1^A(x^A, s, S \mid \rho)$ in (7) with that in (39). After imposing $x = 0$, a binding constraint (12) can be expressed as follows:

$$\begin{aligned}(1-p_\ell)(1-r-s) + (1-p_h)(1-r+s) - (1-\rho)p_\ell(1-p_h)S \\ = (1-L-r) + (1-p_h)(1-r). \qquad (47)\end{aligned}$$

Since there exists a continuum of (s, S) that satisfy (47), we now solve for the pair (s, S) that minimizes the redistribution between the two deposit insurance costs incurred in the two countries. Consider the following two cases.

- $\rho \leq \underline{\rho}$. In this case, it is easy to verify that $s^* = \bar{x}$ and $S^*(\rho) = \frac{\bar{x}}{(1-\rho)p_\ell}$ satisfy all constraints.

Moreover, since it does not lead to any redistribution, i.e. (6) and (7) are both satisfied with equality, this is also the recapitalization plan that minimizes redistribution between the deposit insurance costs incurred in the two countries.

- $\rho > \underline{\rho}$. In this case, the budget constraint (5), $x^B = 0$ and (47) imply that s must satisfy

$$(1 - p_\ell)(1 - r - s) + (1 - p_h)s - (1 - \rho)p_\ell(1 - p_h)(R + r + s - 1) \leq 1 - L - r. \tag{48}$$

Since the left-hand side of (48) is strictly decreasing in s, (48) is equivalent to $s \geq s^{**}(\rho)$, where $s^{**}(\rho)$ is defined as the solution to (48) with equality. As the expected deposit insurance cost for subsidiary B is strictly decreasing in s and that of subsidiary A is strictly increasing in s, the recapitalization plan that minimizes redistribution between the costs incurred in the two countries has $s = s^{**}(\rho)$. Since $s = s^{**}(\rho)$ binds (48), the budget constraint (5) implies that $S = S^{**}(\rho) = R + r + s^{**}(\rho) - 1$.

Moreover, since the left-hand side of (48) is strictly increasing in ρ, we have that $s^{**}(\rho)$ is strictly increasing in ρ for all $\rho > \underline{\rho}$. In addition, since (48) holds with equality as $\rho \to \underline{\rho}$, where $\underline{\rho}$ is defined in (38), it follows that $s^{**}(\rho) > s^*(\rho)$ for all $\rho > \underline{\rho}$.

Finally, we verify that the budget constraint (4) is satisfied. We have (4) as $s^{**}(\rho) \leq s^{**}(1) = \frac{L - p_\ell(1-r)}{p_h - p_\ell} < r$, where the equality follows from (48) and the last inequality follows from Part (i) of Assumption 4.

A.3 Proof of Proposition 3

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

A.4 Proof of Proposition 4

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

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

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

$$\frac{\partial e^*(\rho,\gamma)}{\partial \gamma} = \begin{cases} \frac{-2(1-\rho)(p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^*(\rho,\gamma))} \in (-1,0), & \text{if } \rho < \underline{\rho}, \\ \frac{-2(1-\rho)\left[(p_\ell R-L)-x_h^*(\rho)\Delta\right]}{2(1-\rho)[(p_\ell R-L)-x^*(\rho)\Delta]+k''(e^*(\rho,\gamma))} \in (-1,0), & \text{if } \rho \in (\underline{\rho},\overline{\rho}), \\ 0, & \text{if } \rho > \overline{\rho}. \end{cases} \tag{49}$$

$$\frac{\partial e^{**}(\rho,\gamma)}{\partial \gamma} = \frac{-2(1-\rho)(p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^{**}(\rho,\gamma))} \in (-1,0), \tag{50}$$

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

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

$$k'(\frac{1}{2}-\hat{\gamma}) = p_h(R+r-1). \tag{51}$$

Notice that $\overline{\gamma} > \frac{1}{2}$ and Assumption 2 imply that $\hat{\gamma} \in (\underline{\gamma},\overline{\gamma})$. Moreover, (51) implies that $\hat{\gamma} + e^{SA} = \hat{\gamma} + e^*(\rho,\hat{\gamma}) = \hat{\gamma} + e^{**}(\rho,\hat{\gamma}) = \frac{1}{2}$.

To prove this property, we first derive the following:

$$\frac{\partial e^*(\rho,\gamma)}{\partial \rho} = \begin{cases} \frac{-[1-2(\gamma+e^*(\rho,\gamma))](p_\ell R-L)}{2(1-\rho)(p_\ell R-L)+k''(e^*(\rho,\gamma))}, & \text{if } \rho \leq \underline{\rho}, \\ \frac{-[1-2(\gamma+e^*(\rho,\gamma)]\left(\left[(p_\ell R-L)-x_h^*(\rho)\Delta\right]+(1-\rho)\frac{\partial x^*(\rho)}{\partial \rho}\Delta\right)}{2(1-\rho)\left[(p_\ell R-L)-x_h^*(\rho)\Delta\right]+k''(e^*(\rho,\gamma))}, & \text{if } \rho \in (\underline{\rho},\overline{\rho}), \\ 0, & \text{if } \rho > \overline{\rho}, \end{cases} \tag{52}$$

$$\frac{\partial e^{**}(\rho,\gamma)}{\partial \rho} = \frac{-\left[1-2(\gamma+e^{**}(\rho,\gamma)\right]\left(p_\ell R-L\right)}{2(1-\rho)(p_\ell R-L)+k''(e^{**}(\rho,\gamma))}. \tag{53}$$

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 (52) and (53) imply that $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are increasing in ρ if and only if $\gamma + e^*(\rho,\gamma) \geq \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \geq \frac{1}{2}$, respectively. By the definition of $\hat{\gamma}$ given in (51), if $\gamma \leq \hat{\gamma}$, we have $\gamma + e^*(\rho,\gamma) \geq \gamma + e^*(0,\gamma) \leq \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \leq \gamma + e^{**}(0,\gamma) \geq \frac{1}{2}$ for all ρ; if $\gamma \geq \hat{\gamma}$, we have $\gamma + e^*(\rho,\gamma) \leq \gamma + e^*(0,\gamma) \geq \frac{1}{2}$ and $\gamma + e^{**}(\rho,\gamma) \geq \gamma + e^{**}(0,\gamma) \leq \frac{1}{2}$ for all ρ. This and (52)–(53) then imply that $e^*(\rho,\gamma)$ and $e^{**}(\rho,\gamma)$ are decreasing in ρ if and only if $\gamma \geq \hat{\gamma}$.

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

(iv) $\gamma + e^{SA}$, $\gamma + e^*(\rho,\gamma)$, $\gamma + e^{**}(\rho,\gamma)$ are increasing in γ. This follows immediately from (49) and (50).

A.5 Proof of Proposition 5

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

$$W^{CBB}(e,x|\kappa) = \Pi_0^{CBB}(e,x|\kappa) - 2C_0(e), \tag{54}$$

$$W^{SA} = 2\Pi_0^{SA}(e^{SA}) - 2C_0(e^{SA}), \tag{55}$$

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

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

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

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

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

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

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

$\Pi_0^{CBB}(e^*(\rho,\gamma), x^*(\rho))$, where $\Pi_0^{CBB}(e,x)$ is defined in (14) and the inequality follows because $x^*(\rho) > 0$ for all $\rho \in (\underline{\rho}, 1)$ by Proposition 1, and (ii) $C_0(e^{**}(\rho,\gamma)) \leq C_0(e^*(\rho,\gamma))$, which follows because $C_0(e)$ is strictly decreasing in e and $e^{**}(\rho,\gamma) \geq e^*(\rho,\gamma)$ for all $\gamma \leq \hat{\gamma}$ by Proposition 4.

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

B Extensions

B.1 Dividend payout and general cross-unit support

This appendix provides a detailed analysis of the extension outlined in Section 5.1. The proofs of the formal results in this extension are in Appendix B.1.3.

In this extension, we modify the assumptions in the baseline model to incorporate the possibility of providing support with $t = 2$ transfers. First, we modify the first inequality in Assumption 1 to ensure that a subsidiary of a CBB can only repay its deposits in full at $t = 2$ if it succeeds, taking into account cross-unit support using the $t = 2$ residual payoff and dividend distribution at $t = 1$:

Assumption 1D. $R + 2r + 2\frac{L - p_\ell(1-r)}{1-p_\ell} < 2 < 2R.$

Second, we modify the last part of Assumption 2 to ensure that the effort cost function $k(\cdot)$ is sufficiently convex and leads to a unique effort choice in equilibrium:

Assumption 2D. *(iv)* $k''(e) \geq 2(1-\rho_0)(R+2r-1)\Delta$.

Third, we modify the second inequality in Part (i) of Assumption 3 to ensure that, in the absence of an equity injection, liquidation of an impaired subsidiary of a CBB lowers the expected deposit insurance cost, even with maximal cross-unit support using the $t=2$ residual payoff:

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

Finally, we drop parameter restriction in Part (i) of Assumption 4 and allow any $r > 0$.

Under the general capital plans considered in this extension, bankers can inject funds in any of the subsidiaries of a CBB and also distribute them out at $t=1$. Since they can also reallocate funds across the subsidiaries with the $t=1$ transfers, there exist capital plans that are payoff equivalent. Without loss of generality, we focus hence attention to capital plans for a CBB that: *i)* feature a (weak) dividend distribution ($x_i \leq 0$) if a subsidiary is healthy and a (weak) equity injection ($x_i \geq 0$) if a subsidiary is impaired; and that *ii)* do not feature a strict simultaneous dividend payout by a subsidiary and equity injection in the other subsidiary. To see why our focus is without loss of generality, notice that any capital plan whose $t=1$ transfer tuple is described by (x'_A, x'_B, s') with $x'_A < 0 < x'_B$ is payoff equivalent to the capital plan with $t=1$ transfers (x_A, x_B, s) with $s = \min\{-(x'_A - s'), x'_B + s'\} > s' > 0$, $x_A = x'_A - s' + s \leq 0$ and $x_B = x'_B + s' - s \geq 0$, which satisfies either $x_A \leq 0 = x_B$ (if $-x'_A \geq x'_B$) or $x_A = 0 \leq x_B$ (if $-x'_A \leq x'_B$).

B.1.1 Intervention game

Consider the bad state at $t=1$, in which banks are risky regardless of their type. As in the baseline model, bankers propose a capital plan to recapitalize or pay dividends from the bank, anticipating the authorities' prerogative to prohibit such actions and to liquidate the bank with the objective to minimize deposit insurance costs.

We first demonstrate that a standalone bank is not allowed to distribute dividends, and the outcome of the intervention game at $t = 1$ is identical to the baseline model. Consider a bank's capital plan characterized by equity injection x (which might be negative, capturing a dividend payoff). From Assumption 3D, if an authority rejects the bank's capital plan, it continues a healthy bank and liquidates an impaired bank, and its expected deposit insurance costs are hence given by $(1-p_h)(1-r)$ and $1-L-r$, respectively. The authority approves the equity injection x if and only if it does not lead to an increase in deposit insurance costs. That is, for a healthy and an impaired bank, respectively, the equity injection x is approved if and only if

$$(1 - p_h)(1 - r - x) \leq (1 - p_h)(1 - r), \tag{56}$$

$$(1 - p_\ell)(1 - r - x) \leq 1 - L - r. \tag{57}$$

It then follows that this expression is satisfied for a healthy bank if and only if $x \geq 0$, and for an impaired bank if and only if $x \geq \bar{x}$, where $\bar{x} > 0$ is defined as the minimum equity injection required for the continuation of an impaired bank defined in Lemma 1. Therefore, a standalone bank is not allowed to distribute any dividends in the bad state, and an impaired bank injects equity $\bar{x}$ as described in Lemma 1.

The outcomes of the intervention game at $t = 1$ for a CBB are different from the baseline model. We start by analyzing the scenario with a healthy subsidiary (A) and an impaired subsidiary (B), in which in the baseline model support with an intragroup loan was allowed. Under national DIFs, the approval constraints by DIF B and A are given by, respectively,

$$\begin{aligned} C_1^B(x_B, s, S_A) \equiv{}& [1 - (1-\rho)p_\ell]\,(1-p_h)\,[1 - (r + s + x_B)]^+ \\ &+ [(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)]\,[1 - (r + s + x_B + S_A)]^+ \leq 1 - L - r. \end{aligned} \tag{58}$$

$$\begin{aligned} C_1^A(x_A, s, S_B) \equiv{}& [1 - (1-\rho)p_\ell]\,(1-p_h)\,[1 - (r - s + x_A)]^+ \\ &+ (1-\rho)p_\ell(1-p_h)\,[1 - (r - s + x_A + S_B)]^+ \leq (1-p_h)(1-r), \end{aligned} \tag{59}$$

The first terms in (58) and (59) capture the DIF costs to subsidiaries B and A, respectively, when both subsidiaries fail at $t = 2$. The second terms capture those when the subsidiary fails at

$t = 2$ but the other subsidiary succeeds and makes the transfer S_i out of its residual payoff. If $r + s + x_B + S_A \leq 1$ and $r - s + x_A + S_B \leq 1$,[25] approval conditions (58) and (59) can be written more compactly as (25) and (26).

As in the baseline model, the bankers choose a capital plan that satisfies the approval constraints of the DIFs to maximize their expected payoff from the CBB as of $t = 1$, which is analogous to (10) and is given by

$$\Pi_1^{CBB}(x_A, x_B, s, S_A, S_B) = (p_h R + r - 1) + (p_\ell R + r - 1) + C_1^A(x_A, s, S_B) + C_1^B(x_B, s, S_A) - (x_A + x_B)\Delta. \qquad (60)$$

The equilibrium of the intervention game in this scenario is characterized as follows:

Proposition 1D. *Suppose at $t = 1$ a CBB has a healthy subsidiary A and an impaired subsidiary B. Under national DIFs, the optimal capital plan binds the two DIFs' approval constraints* (25) *and* (26)*, and is characterized by its overall net equity injection in the two subsidiaries $\tilde{x}^* = x_A^* + x_B^*$. Moreover, if r and ϕ are high enough, then there exists $\tilde{\rho} < 1$ such that $\tilde{x}^* = x_A^* < 0, x_B^* = 0$ for $\rho < \tilde{\rho}$ and $x_A^* = 0, \tilde{x}^* = x_B^* > 0$ for $\rho > \tilde{\rho}$, and $\tilde{\rho} > \rho_0$.*

This result shows that, first, the optimal capital plan binds the two approval constraints as this maximizes the bankers' value (see (60)). Second, as in the baseline model, since the extent to which cross-unit support relaxes the DIF approval constraints is decreasing with the correlation between the subsidiaries, ρ, the overall equity injection $\tilde{x}^*$ is positive for large ρ, that is, the impaired subsidiary receives an equity injection $\tilde{x}^* = x_B^* > 0$ while the healthy subsidiary does not pay dividends. Instead, provided both r and ϕ are large enough, when ρ is sufficiently low, the CBB makes a net dividend distribution. That is, the healthy subsidiary pays out a dividend $-\tilde{x}^* = -x_A^* > 0$ and the impaired subsidiary does not need any equity injection as it is entirely recapitalized through $t = 1$ support s and $t = 2$ support S_A.

[25] We show in the proofs of Propositions 1D and 2D that this is the case in equilibrium.

Under a common DIF, the two approval constraints (25) and (26) are replaced by a single constraint on the sum of the DIF costs analogous to (12):

$$C_1^B(x_B, s, S_A) + C_1^A(x_A, s, S_B) \leq (1 - L - r) + (1 - p_h)(1 - r). \tag{61}$$

The equilibrium in this case is characterized as follows:

Proposition 2D. *Suppose at $t = 1$ a CBB has a healthy subsidiary A and an impaired subsidiary B. Under a common DIF, the optimal capital plan binds the common DIF's approval condition and its overall net equity injection $\tilde{x}^{**}$ satisfies $\tilde{x}^{**} < \tilde{x}^{*}$, where $\tilde{x}^{*}$ is defined in Proposition 1D.*

Importantly, this result shows that, as in the baseline model, the CBB undertakes a lower overall net equity injection under a common DIF than under national DIFs. This is due to the greater flexibility in reallocating capital within the CBB at $t = 1$ allowed by a common DIF, who is only concerned with the overall deposit insurance costs and not the allocation of the costs to each country. The gap in the net equity injection between the two DIF architectures, $\tilde{x}^{*} - \tilde{x}^{**} > 0$, measures the extent of ring-fencing under national DIFs. Combining Proposition 1D and 2D implies that, when r and ϕ are high and ρ is low, the healthy subsidiary of the CBB distributes an overall dividend and its impaired subsidiary is entirely recapitalized with $t = 1$ and $t = 2$ support under both DIF architectures, and that the dividend is larger under a common DIF.

Next, we consider the scenarios in which the CBB subsidiaries are both impaired or both healthy. In the baseline model, the outcome of the intervention game at $t = 1$ in these cases for CBB subsidiaries is identical to that for standalone banks trivially because cross-unit support is not allowed. In this extension, the possibility for the CBB to provide cross-unit support with a $t = 2$ transfer relaxes the DIFs' approval constraints, lowering the amount of equity injection required.

Since the units are symmetric, it is without loss of generality to consider a symmetric capital plan $(x_A, x_B, s, S_A, S_B) = (x, x, 0, S, S)$ with no $t = 1$ capital transfer. This symmetry also implies that the approval condition is identical under both deposit insurance architectures. When the CBB subsidiaries are both impaired, the approval condition is given by

$$[1-(1-\rho)p_\ell]\,(1-p_\ell)\,[1-(r+x)]^+ + (1-\rho)p_\ell(1-p_\ell)\,[1-(r+x+S)]^+ \le 1-L-r. \tag{62}$$

When the CBB subsidiaries are both healthy, the approval condition is given by

$$[1-(1-\rho)p_h]\,(1-p_h)\,[1-(r+x)]^+ + (1-\rho)p_h(1-p_h)\,[1-(r+x+S)]^+ \le (1-p_h)(1-r). \tag{63}$$

The second terms in (62) and (63) take into account the cross-unit support S received when the subsidiary fails but the other one succeeds. The equilibrium of the recapitalization game in this case is characterized as follows:

Proposition 3D. *For any DIF architecture, the outcome of the intervention game in a CBB in the bad state at $t = 1$ when the two subsidiaries are in the same condition is as follows:*

- *Two impaired subsidiaries: The CBB's capital plan consists of an equity injection $x_{\ell\ell} > 0$ into each subsidiary and maximal cross-unit support $S_{\ell\ell} = R + r + x(\rho) - 1$, where $x_{\ell\ell} < \bar{x}$ if and only if $\rho < 1$, where $\bar{x}$ is defined in Lemma 1.*

- *Two healthy subsidiaries. The CBB's capital plan consists of a dividend distribution $-x_{hh} \ge 0$ from each subsidiary and strictly positive cross-unit support $S_{hh} > 0$, where $-x_{hh} > 0$ if and only if $\rho < 1$.*

When the subsidiaries are both impaired, the second inequality of Assumption 3D implies that equity injection is required for an impaired subsidiary even with maximal cross-unit suppport using the other subsidiary's $t = 2$ residual payoff. Therefore the CBB pledges maximal cross-unit support in order to minimize the equity injection $x_{\ell\ell}$, which is strictly below that for a standalone impaired bank $\bar{x}$ whenever the two subsidiaries are not perfectly correlated $\rho < 1$. When the subsidiaries are both healthy, cross-unit support using $t = 2$ residual payoffs enables the CBB to distribute a strictly positive dividend whenever the two subsidiaries are not perfectly correlated $\rho < 1$. In this case, the CBB pledges maximal cross-unit support to increase the dividend payments unless all interim payoff of each subsidiary r is paid out.

B.1.2 Risk-taking and welfare

The risk-taking decision for a standalone bank is identical to that in the baseline model, since the outcome of the intervention game at $t = 1$ remains identical.

The risk-taking decision for a CBB, however, changes. Given the outcome of the intervention game at $t = 1$, the expected payoff of a pair of bankers from the CBB is given by

$$\begin{aligned}\tilde{\Pi}_0^{CBB}(e, \tilde{x} \mid \kappa) \equiv 2\Pi_0^{SA} - \kappa &+ (1-q)\left[1-(1-\rho)(1-\gamma-e)\right](\gamma+e)2(-x_{hh})\Delta \\ &+ (1-q)\left[1-(1-\rho)(\gamma+e)\right](1-\gamma-e)2(\bar{x}-x_{\ell\ell})\Delta \\ &+ 2(1-q)(1-\rho)(\gamma+e)(1-\gamma-e)(\bar{x}-\tilde{x})\Delta, \end{aligned} \tag{64}$$

where $\tilde{x} \in \{\tilde{x}^*, \tilde{x}^{**}\}$ is the overall net equity injection when one unit is healthy and the other is impaired, and depends on the deposit insurance architecture and Π_0^{SA} is the welfare generated by a standalone bank given in (13). The first-order condition that determines the optimal effort choice is given by (32), where $\mathcal{M}(e)$ captures the marginal effects of effort in a standalone bank (the first line) and in the bad aggregate state at $t = 1$ when both subsidiaries are healthy and when both subsidiaries are impaired (the second line), which do not depend on the DIF architecture:

$$\begin{aligned}\mathcal{M}(e) \equiv p_h(R+r-1) &- \left[(p_\ell R - L) - \bar{x}\Delta\right] \\ &+ \left[(-x_{hh}) - (\bar{x}-x_{\ell\ell})\right]\Delta - (1-\rho)(1-2(\gamma+e))\left[(-x_{hh}) + (\bar{x}-x_{\ell\ell})\right]\Delta \end{aligned} \tag{65}$$

Since a common DIF reduces the overall equity injection for the CBB when one subsidiary is healthy and the other is impaired (that is, $\tilde{x}^{**} < \tilde{x}^*$ by Proposition 2D), the DIF architecture affects bankers' effort depending on fundamental risk γ in an analogous way to the baseline model. Specifically we have the following proposition:

Proposition 4D. *Let $\tilde{e}^*(\gamma)$ and $\tilde{e}^{**}(\gamma)$ denote the bankers' optimal effort in the subsidiaries of a CBB under national DIFs and a common DIF, respectively. If $\rho < 1$, there exists a risk threshold $\tilde{\gamma}$ such that:*

- *If $\gamma < \tilde{\gamma}$, then $\tilde{e}^* \leq \tilde{e}^{**}$, with strict inequality if and only if $\rho < 1$.*

- *If $\gamma = \tilde{\gamma}$, then $\tilde{e}^* = \tilde{e}^{**}$.*

- *If $\gamma > \tilde{\gamma}$, then $\tilde{e}^* \geq \tilde{e}^{**}$, with strict inequality if and only if $\rho < 1$.*

Following Propositions 1D–4D, the establishment of a common DIF leads to a similar trade-off as in the baseline model. That is, while a common DIF alleviates ring-fencing at $t = 1$, it enhances the efficiency of the recapitalization of an impaired subsidiary of a CBB at $t = 1$ but can lead to more risk-taking at $t = 0$. When the economy is safer (γ low), the negative effect through risk-taking can dominate and reduce overall welfare. Let $\tilde{\kappa}^*$ and $\tilde{\kappa}^{**}$ denote the cost thresholds for bankers to set up a CBB under national DIFs and a common DIF, respectively analogous to those in the baseline model defined in Proposition 3. The following proposition formally characterizes the conditions for welfare to increase and decrease when moving to a common DIF:

Proposition 5D. *Suppose $\rho < 1$. Given $\tilde{\gamma}$ defined in Proposition 4D, moving from national DIFs to a common DIF changes the overall welfare in the economy as follows:*

- *If $\gamma \leq \tilde{\gamma}$, welfare increases if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $[0, \tilde{\kappa}^*]$.*

- *If $\gamma > \tilde{\gamma}$, there exists $\breve{\kappa} \in (\kappa^*, \kappa^{**})$, such that welfare strictly decreases if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $(\breve{\kappa}, \tilde{\kappa}^{**}]$ and*

$$p_\ell R - L < \frac{p_\ell - p_h(1 - p_\ell)}{p_\ell}(R + r - 1). \tag{66}$$

B.1.3 Proofs of formal results in Appendix B.1

Proof of Proposition 1D. We first solve the CBB's optimization problem assuming that the solution satisfies $r + s + x_B + S_A \leq 1$ and $r - s + x_A + S_B \leq 1$, and then verify these conditions are indeed satisfied by the solution. Notice that these conditions imply $r + s + x_B \leq 1$ and $r - s + x_A \leq 1$.

Therefore we can drop the superscript "+" in the DIFs' approval requirements given by (58) and (59), which can then be expressed as (25) and (26), respectively.

Under these assumptions, the bankers' optimization problem is to maximize their expected payoff as of $t = 1$, which is given by (60), subject to the two authorities' approval requirements given by (25) and (26), the budget constraints on the $t = 1$ capital movements (23) and (24), and the budget constraints on the $t = 2$ transfers (21) and (22).

We first perform a change of variables. Let $\tilde{x}_A = x_A - s$ and $\tilde{x}_B = x_B + s$. The resulting optimization problem is given by

$$\max_{(\tilde{x}_A,\tilde{x}_B,S_A,S_B)} \quad (p_\ell + p_h)R + 2r - 2 + \tilde{C}_1^A(\tilde{x}_A, \tilde{x}_B) + \tilde{C}_1^B(\tilde{x}_A, \tilde{x}_B) - (\tilde{x}_A + \tilde{x}_B)\Delta, \tag{67}$$

subject to the budget constraints on the $t = 1$ capital movements in each subsidiary:

$$\tilde{x}_A \geq -r, \tag{68}$$

$$\tilde{x}_B \geq -r, \tag{69}$$

and the budget constraints on the $t = 2$ transfers:

$$S_A \leq \phi(R + r + \tilde{x}_A - 1), \tag{70}$$

$$S_B \leq \phi(R + r + \tilde{x}_B - 1), \tag{71}$$

and the DIFs' approval constraints:

$$\tilde{C}_1^A(\tilde{x}_A, \tilde{x}_B) \equiv (1 - p_h)(1 - r - \tilde{x}_A) - (1 - \rho)p_\ell(1 - p_h)S_B \leq (1 - p_h)(1 - r), \tag{72}$$

$$\tilde{C}_1^B(\tilde{x}_A, \tilde{x}_B) \equiv (1 - p_\ell)(1 - r - \tilde{x}_B) - [(1 - \rho)p_\ell(1 - p_h) + (p_h - p_\ell)]\, S_A \leq 1 - L - r. \tag{73}$$

Notice $\tilde{x}_A^* < 0$, which follows from the first inequality in Part (i) of Assumption 3 and the DIF A's approval condition (72), and $\tilde{x}_B^* > 0$, which follows from Assumption 3D and the DIF B's approval condition (73). Thus the budget constraint on $t = 1$ capital movement in subsidiary A given in (69) is always satisfied.

Moreover, the two DIFs' approval conditions must bind. Suppose by way of contradiction that DIF A's approval condition (72) is slack. Then it is possible to increase the bankers' expected payoff while satisfying all constraints. If $S_B > 0$, then decreasing S_B increases $\tilde{C}_1^A(\cdot)$ and thus the bankers' expected payoff without affecting all other constraints. If $S_B = 0$, then a slack (72) implies $\tilde{x}_A > 0$ and it is possible to decrease $\tilde{x}_A$ by $\epsilon > 0$, decrease S_A by $\phi\epsilon$, and increase $\tilde{x}_B$ by $\frac{(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)}{1-p_\ell}\phi\epsilon < \epsilon$, which increases the bankers' expected payoff and keeps all constraints satisfied. Similarly, suppose by way of contradiction that DIF B's approval condition (73) is slack. If $S_A > 0$, then decreasing S_A increases $\tilde{C}_1^B(\cdot)$ and thus the bankers' expected payoff without affecting all other constraints. If $S_A = 0$, then a slack (73) implies $\tilde{x}_B > 0$ and it is possible to decrease $\tilde{x}_A$ by $\epsilon > 0$, decrease S_B by $\phi\epsilon$, and increase $\tilde{x}_A$ by $(1-\rho)p_\ell\phi\epsilon < \epsilon$, which increases the bankers' expected payoff and keeps all constraints satisfied.

We can now characterize the solution to this optimization problem in the following two cases depending on whether the budget constraint on $t = 1$ capital movement in subsidiary A given in (68) binds.

(i) First, we ignore the budget constraint (68) and solve a relaxed problem. This case characterizes the optimal capital plan if and only if the resulting capital plan satisfies (68).

Given that the two DIFs' approval conditions bind, the budget constraints on the $t = 2$ transfers (70) and (71) must also bind, because otherwise it is possible to increase S_A and/or S_B, which slackens the DIFs' approval conditions while keeping all other constraints satisfied and does not affect the bankers' expected payoff.

Therefore the solution to the optimization problem is given by substituting binding budget constraints on the $t = 2$ transfer (70) and (71) into the binding DIFs' approval conditions(72) and (73) to eliminate S_A and S_B, and solving for $\tilde{x}_A$ and $\tilde{x}_B$:

$$\tilde{x}_A^* = \frac{b_1c_2 - b_2c_1}{a_1b_2 - a_2b_1}, \tag{74}$$

$$\tilde{x}_B^* = \frac{a_2c_1 - a_1c_2}{a_1b_2 - a_2b_1}, \tag{75}$$

where

$$a_1 = -(1-p_h), \tag{76}$$

$$a_2 = -\left[(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)\right]\phi, \tag{77}$$

$$b_1 = -(1-\rho)p_\ell(1-p_h)\phi, \tag{78}$$

$$b_2 = -(1-p_\ell), \tag{79}$$

$$c_1 = -(1-\rho)p_\ell(1-p_h)\phi(R+r-1), \tag{80}$$

$$c_2 = [L - p_\ell(1-r)] - \left[(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)\right]\phi(R+r-1). \tag{81}$$

This is indeed the solution to the bankers' optimization problem if and only if $\tilde{x}_A$ given in (74) satisfies (68), or

$$\tilde{x}_A^* \geq -r \quad \Leftrightarrow \quad b_1c_2 - b_2c_1 + a_1b_2r - a_2b_1r \geq 0. \tag{82}$$

Notice that we have

$$\frac{d(b_1c_2 - b_2c_1 + a_1b_2r - a_2b_1r)}{dr} = b_1p_\ell + (a_1 - b_1)b_2 = (1-p_h)\left[(1-p_\ell) - (1-\rho)p_\ell\phi\right]. \tag{83}$$

Moreover, $\tilde{x}_A > 0$ given in (74) does not (68) as $r \to 0$. It then follows that, if $(1-p_\ell) > (1-\rho)p_\ell\phi$, then there exists $\bar{r} > 0$, such that $\tilde{x}_A$ given in (74) satisfies (68) if and only if $r \geq \bar{r}$, whereas if $(1-p_\ell) \leq (1-\rho)p_\ell\phi$, then $\tilde{x}_A$ given in (74) does not satisfy (68) for all $r > 0$. We define $\bar{r} = \infty$ in this case.

(ii) If $\tilde{x}_A$ given in (74) does not satisfy (68), the above reasoning implies that the solution to the bankers' optimization problem must bind (68); that is, $\tilde{x}_A^* = -r$.

In this case, S_B^* binds DIF A's approval constraint. As in the previous case, the budget constraint on S_B must bind. Otherwise, it is possible to increase S_B by $\epsilon > 0$ and decrease $\tilde{x}_B$ by $\frac{(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)}{1-p_\ell}\epsilon$, which increases the bankers' expected payoff and keeps all constraints satisfied.

Substituting the binding budget constraint on the $t = 2$ transfer (70) into a binding DIF B's approval conditions (73) to eliminate S_A and solving for $\tilde{x}_B$ yields

$$\tilde{x}_B^* = \frac{L - p_\ell(1-r) - [(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)]\,\phi(R-1)}{1-p_\ell}. \tag{84}$$

To summarize, there exists $\bar{r} > 0$ such that, if $r \geq \bar{r}$, the solution is given by $\tilde{x}_A^*$ and $\tilde{x}_B^*$ in (74) and (75) such that the budget constraint (68) is slack, whereas if $r < \bar{r}$, the solution is given by $\tilde{x}_A^* = -r$ and $\tilde{x}_B^*$ in (84) such that the budget constraint (68) binds.

We turn to verify that this solution satisfies $r + s + x_B + S_A \leq 1$ and $r - s + x_A + S_B \leq 1$. Using the fact that S_A and S_B bind the budget constraints (21) and (22), these conditions are equivalent to

$$r + \tilde{x}_B + \phi(R + r + \tilde{x}_A - 1) \leq 1, \tag{85}$$

$$r + \tilde{x}_A + \phi(R + r + \tilde{x}_B - 1) \leq 1. \tag{86}$$

Notice that Assumption 1D is equivalent to

$$r + \bar{x} + (R + r + \bar{x} - 1) \leq 1, \tag{87}$$

where $\bar{x} = \frac{L - p_\ell(1-r)}{1-p_\ell}$ is defined in Lemma 1. Therefore the solution indeed satisfies these conditions because we have $\tilde{x}_A, \tilde{x}_B < \bar{x}$ and $\phi \leq 1$.

Next, we show that the overall net equity injection $\tilde{x}^* = \tilde{x}_A^* + \tilde{x}_B^*$ is strictly increasing in ρ and strictly negative if and only if $\rho \leq \tilde{\rho}$. Consider the two cases of the solution.

(i) If $r \geq \bar{r}$, the solution is such that the two DIFs' approval constraints (72) and (73) bind.

Totally differentiating the binding constraints with respect to ρ yields:

$$-(1-p_h)\frac{\partial \tilde{x}_A^*}{\partial \rho} - (1-\rho)p_\ell(1-p_h)\phi\frac{\partial \tilde{x}_B^*}{\partial \rho} + p_\ell(1-p_h)\phi(R + r + \tilde{x}_B^* - 1) = 0, \tag{88}$$

$$-(1-p_\ell)\frac{\partial \tilde{x}_B^*}{\partial \rho} - [(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)]\,\phi\frac{\partial \tilde{x}_A^*}{\partial \rho} + p_\ell(1-p_h)\phi(R + r + \tilde{x}_A^* - 1) = 0. \tag{89}$$

After solving for $\frac{\partial \tilde{x}_A^*}{\partial \rho}$ and $\frac{\partial \tilde{x}_B^*}{\partial \rho}$, we have that

$$\begin{aligned}\frac{\partial \tilde{x}^*}{\partial \rho} &= \frac{\partial \tilde{x}_A^*}{\partial \rho} + \frac{\partial \tilde{x}_B^*}{\partial \rho} \\ &= \frac{\begin{array}{l}[1-(1-\rho)p_\ell\phi]\, p_\ell(1-p_h)\phi(R+r+\tilde{x}_A^*-1) \\ \quad + p_\ell\phi\left((1-p_\ell) - [(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)]\,\phi\right)(R+r+\tilde{x}_B^*-1)\end{array}}{(1-p_\ell) - [(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)]\,\phi(1-\rho)p_\ell\phi} > 0. \qquad (90)\end{aligned}$$

(ii) If $r < \bar{r}$, the solution is such that $\tilde{x}_A^* = -r$ and $\tilde{x}_B^*$ is given by (84). Then we have $\tilde{x}_B^*$ and thus $\tilde{x}^* = \tilde{x}_A^* + \tilde{x}_B^*$ are strictly increasing in ρ.

Finally, we show if $r \geq \frac{L-p_\ell}{1-2p_\ell}$, then $\tilde{x}^* < 0$ as $\phi \to 1$ and $\rho < \tilde{\rho}$. Consider the two cases of the solution.

(i) If $r \geq \bar{r}$, the solution is such that the two DIFs' approval constraints (72) and (73) bind.

Let us define $\tilde{x}'_A$ and $\tilde{x}'_B$ as the solution to

$$(1-p_h)(1-r-\tilde{x}_A) - (1-\rho)p_\ell(1-p_h)(R+r+\tilde{x}_B-1) = (1-p_h)(1-r), \qquad (91)$$

$$(1-p_\ell)(1-r-\tilde{x}_B) = 1-L-r. \qquad (92)$$

By comparing (91) and (92) to (72) and (73), we have that, as $\phi \to 1$, $\tilde{x}^* = \tilde{x}_A^* + \tilde{x}_B^* < \tilde{x}'_A + \tilde{x}'_B$. This is because (92) does not have the second term representing the $t = 2$ transfer from subsidiary A to subsidiary B, which relaxes DIF B's approval constraint.

In particular, we have that $\tilde{x}'_B = \bar{x}$, and for $\rho = 0$, $\tilde{x}'_A = -p_\ell(R+r+\bar{x}-1)$. Using $\bar{x} = \frac{L-p_\ell(1-r)}{1-p_\ell}$, we have $\tilde{x}'_A + \tilde{x}'_B = L - p_\ell R < 0$.

Therefore as $\phi \to 1$, for $\rho = 0$, we have $\tilde{x}^* = \tilde{x}_A^* + \tilde{x}_B^* < \tilde{x}'_A + \tilde{x}'_B < 0$.

(ii) If $r < \bar{r}$, the solution is such that $\tilde{x}_A^* = -r$ and $\tilde{x}_B^*$ is given by (84). We thus have $-\tilde{x}_A^* = r \geq \frac{L-p_\ell(1-r)}{1-p_\ell} > \tilde{x}_B^*$ if $r \geq \frac{L-p_\ell}{1-2p_\ell}$.

This and the fact that $\tilde{x}^*$ is increasing in ρ as shown above then implies that, if $r \geq \frac{L-p_\ell}{1-2p_\ell}$ and ϕ is sufficiently large, then there exists $\tilde{\rho} < 1$ such that $\tilde{x}^* < 0$ for all $\rho < \tilde{\rho}$.

$\square$

Proof of Proposition 2D. As in the proof of Proposition 1D, we first solve the CBB's optimization problem assuming that the solution satisfies $r+s+x_B+S_A \leq 1$ and $r-s+x_A+S_B \leq 1$. This allows us to drop all "+" superscripts in the common DIF's approval condition. It will be straightforward to verify that these conditions are indeed satisfied by the solution.

Under these assumptions, the bankers' optimization problem is to maximize their expected payoff as of $t = 1$, which is given by (60), subject to the common DIF's approval requirement, the budget constraints on the $t = 1$ capital movements (23) and (24), and the budget constraints on the $t = 2$ transfers (21) and (22).

As in the proof of Proposition 1D, the budget constraints on the $t = 2$ transfers (21) and (22) bind.

After imposing binding budget constraints (21) and (22) into the bankers' objective function and the the common DIF's approval condition to eliminate S_A and S_B, we can perform a change of variables. Let $\tilde{x}_A = x_A - s$ and $\tilde{x}_B = x_B + s$. The resulting optimization problem is given by objective function (67) subject to the budget constraints on the $t = 1$ capital movements (68) and (69), and the common DIF's approval constraint:

$$\tilde{C}_1^A(\tilde{x}_A, \tilde{x}_B) + \tilde{C}_1^B(\tilde{x}_A, \tilde{x}_B) \leq (1 - p_h)(1 - r) + (1 - L - r), \tag{93}$$

where $\tilde{C}_1^A(\tilde{x}_A, \tilde{x}_B)$ and $\tilde{C}_1^B(\tilde{x}_A, \tilde{x}_B)$ are defined in (72) and (73), respectively.

We first show that the budget constraints on the $t = 1$ capital movement in subsidairy A (68) binds, i.e., $\tilde{x}_A = -r$. Suppose by way of contradiction that $\tilde{x}_A > -r$. It is then possible to increase $\tilde{x}_B$ by some $\epsilon > 0$ and decrease $\tilde{x}_A$ by $\frac{(1-p_\ell)+(1-\rho)p_\ell(1-p_h)\phi}{(1-p_h)+[(1-\rho)p_\ell(1-p_h)+(p_h-p_\ell)]\phi}\epsilon > \epsilon$, such that the common DIF's approval condition is unchanged while the bankers' expected payoff increases.

Given $\tilde{x}_A = -r$, $\tilde{x}_B$ is given by either a binding common DIF's approval condition, or $\tilde{x}_B = -r$. This is because, whenever $\tilde{x}_B > -r$ and the common DIF's approval condition is slack, it would be possible to reduce $\tilde{x}_B$ such that the common DIF's approval condition remains satisfied while the bankers' expected payoff increases. That is,

$$\tilde{x}_B^{**} = \max\left\{-r, \frac{\begin{array}{r}(1-p_h)r - (1-L-r) + (1-p_\ell) - (1-\rho)p_\ell(1-p_h)\phi(R+r-1)\\ - \left[(1-\rho)p_\ell(1-p_h) + (p_h - p_\ell)\right]\phi(R-1)\end{array}}{(1-p_\ell) + (1-\rho)p_\ell(1-p_h)\phi}\right\}. \quad (94)$$

It follows that the overall net equity injection $\tilde{x}^{**} = \tilde{x}_A^{**} + \tilde{x}_B^{**}$ is increasing in ρ, because both DIFs' approval constraints areincreasing in ρ and decreasing in $\tilde{x}_A$ and $\tilde{x}_B$.

Finally, we show that the overall net equity injection into the CBB $\tilde{x} = \tilde{x}_A + \tilde{x}_B$ is lower under a common DIF than under national DIFs. Consider the two cases of the solution under national DIFs.

(i) If $r \geq \bar{r}$, $\tilde{x}_A^*$ and $\tilde{x}_B^*$ are such that the two national DIFs' approval conditions bind. Then they also bind the common DIF's approval condition. However, the solution under national DIFs is not the solution under a common DIF, implying that the bankers' expected payoff is strictly higher at the solution under a common DIF. Given that $\tilde{C}_1^A(\tilde{x}_A^*, \tilde{x}_B^*) + \tilde{C}_1^B(\tilde{x}_A^*, \tilde{x}_B^*) = (1-p_h)(1-r)+(1-L-r) \geq \tilde{C}_1^A(\tilde{x}_A^{**}, \tilde{x}_B^{**})+\tilde{C}_1^B(\tilde{x}_A^{**}, \tilde{x}_B^{**})$, this then implies $\tilde{x}_A^*+\tilde{x}_B^* > \tilde{x}_A^{**}+\tilde{x}_B^{**}$.

(ii) If $r < \bar{r}$, $\tilde{x}_A^* = -r$ and $\tilde{x}_B^*$ binds DIF B's approval condition, and DIF A's approval condition is slack. We now show that this implies $\tilde{x}_A^* + \tilde{x}_B^* > \tilde{x}_A^{**} + \tilde{x}_B^{**}$. Consider the two cases of the solution under a common DIF.

(a) Suppose $\tilde{x}_A^{**} = -r$ and $\tilde{x}_B^{**}$ is such that the common DIF's approval condition binds. Since the common DIF's approval condition is slack at $(\tilde{x}_A^*, \tilde{x}_B^*)$ and it is decreasing in $\tilde{x}_B$, this implies that $\tilde{x}_B^{**} < \tilde{x}_B^*$ and thus $\tilde{x}_A^* + \tilde{x}_B^* > \tilde{x}_A^{**} + \tilde{x}_B^{**}$.

(b) Suppose $\tilde{x}_A^{**} = \tilde{x}_B^{**} = -r$. Since $\tilde{x}_B^* > 0$, we have $\tilde{x}_A^* + \tilde{x}_B^* > \tilde{x}_A^{**} + \tilde{x}_B^{**}$.

□

Proof of Proposition 3D. Restricting to symmetric capital plans as discussed in the text preceding this proposition, the bankers' optimization problem at $t = 1$ when it has two impaired or two healthy subsidiaries is to minimize net equity injection x subject to the DIF's apporval condition givens by (62) and (63), respectively, and the budget constraint on the $t = 2$ transfer:

$$S \leq \phi(R + r + x + s - 1). \tag{95}$$

As in the proof of Proposition 1D, we first solve the CBB's optimization problem assuming that the solution satisfies $r + s + x_B + S_A \leq 1$ and $r - s + x_A + S_B \leq 1$. This allows us to drop all "+" superscripts in the DIF's approval conditions (62) and (63). It will be straightforward to verify that these conditions are indeed satisfied by the solution.

Consider first the case of two impaired subsidiaries. The second inequality of Assumption 3D implies that $x_{\ell\ell} > 0$ and thus the budget constraint on $t = 1$ resources is slack. Following similar arguments as in the proofs of Propositions 1D, the budget constraint on the $t = 2$ transfer and the DIF's approval conditions (62) bind. This implies that

$$x_{\ell\ell} = \frac{L - p_\ell(1 - r) - (1 - \rho)p_\ell(1 - p_\ell)\phi(R + r - 1)}{[1 + (1 - \rho)p_\ell\phi]\,(1 - p_\ell)}. \tag{96}$$

Consider next the case of two healthy subsidiaries. The first inequality of Assumption 3D implies that $x_{hh} < 0$. Following similar arguments as in the proof of Propositions 1D, we can show that the DIF's approval condition binds, and there are two cases depending on whether the budget constraint on $t = 1$ capital movements binds.

(i) If $r > (1-\rho)p_h\phi(R-1)$, the budget constraint on $t = 1$ capital movements is slack. Following similar arguments as in the proofs of Propositions 1D, the budget constraint on the $t = 2$ transfer and the DIF's approval conditions (63) bind. This implies that

$$x_{hh} = -\frac{(1 - \rho)p_h\phi(R + r - 1)}{1 + (1 - \rho)p_h\phi}. \tag{97}$$

(ii) If $r \leq (1-\rho)p_h\phi(R-1)$, the budget constraint on $t = 1$ capital movement binds and $x_{hh} = -r$. It then follows that S_{hh} is such that the DIF's approval conditions (63) bind.

□

Proof of Proposition 4D. Equilibrium effort levels $\tilde{e}^*$ and $\tilde{e}^{**}$ characterized by the first-order condition (32) exist and are unique because the second order condition is satisfied:

$$2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x})\right]\Delta - k''(e) < 0, \tag{98}$$

which follows because of Assumption 2D and the fact that $x_{hh} \in [-\frac{R+r-1}{2}, 0]$, $\bar{x} - x_{\ell\ell} \in \left[0, \frac{R+2r-1}{2}\right]$ and $\bar{x} - \tilde{x} \geq 0$.

Let us define $\tilde{\gamma}$ such that $\tilde{\gamma} + \tilde{e}^* = \tilde{\gamma} + \tilde{e}^{**} = \frac{1}{2}$, i.e.,

$$k'(\frac{1}{2} - \tilde{\gamma}) = p_h(R + r - 1) + \left[(p_\ell R - L) - \bar{x}\Delta\right] + \left[(-x_{hh}) - (\bar{x} - x_{\ell\ell})\right]\Delta. \tag{99}$$

We now show that $\gamma + \tilde{e}^*$ and $\gamma + \tilde{e}^{**}$ are increasing in γ. By the first-order condition that determines bankers' effort given by (32) and the implicit function theorem, we have

$$\frac{\partial \tilde{e}^*}{\partial \gamma} = \frac{2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}^*)\right]\Delta}{-2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}^*)\right]\Delta + k''(\tilde{e}^*)} > -1, \tag{100}$$

$$\frac{\partial \tilde{e}^{**}}{\partial \gamma} = \frac{2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}^{**})\right]\Delta}{-2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}^{**})\right]\Delta + k''(\tilde{e}^{**})} > -1, \tag{101}$$

and

$$\frac{\partial \gamma + \tilde{e}^*}{\partial \gamma} = \frac{k''(\tilde{e}^*)}{-2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}^*)\right]\Delta + k''(\tilde{e}^*)} > 0, \tag{102}$$

$$\frac{\partial \gamma + \tilde{e}^{**}}{\partial \gamma} = \frac{k''(\tilde{e}^{**})}{-2(1-\rho)\left[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}^{**})\right]\Delta + k''(\tilde{e}^{**})} > 0, \tag{103}$$

Therefore we have $\gamma + \tilde{e}^*, \gamma + \tilde{e}^{**} \geq \frac{1}{2}$ if and only if $\gamma \geq \tilde{\gamma}$.

Finally, since $\tilde{x}^* > \tilde{x}^{**}$, the above property implies that $\tilde{e}^* \leq \tilde{e}^{**}$ if and only if $\gamma \leq \tilde{\gamma}$.

□

Proof of Proposition 5D. We first show that, if $\gamma \leq \tilde{\gamma}$, then welfare for a CBB is higher under a common DIF than under national DIFs. This then implies that welfare increases if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $[0, \tilde{\kappa}^*]$, in which case most banks set up CBBs under both deposit insurance architectures and thus generate higher welfare under a common DIF.

We compare welfare generated by a CBB under both deposit insurance architectures by decomposing it into the expected payoff of the bankers less the expected DIF costs:

$$\tilde{W}^{CBB}(e, \tilde{x} \mid \kappa) = \tilde{\Pi}_0^{CBB}(e, x \mid \kappa) - 2\tilde{C}_0(x_A, x_B, s, S_A, S_B), \tag{104}$$

where $\tilde{\Pi}_0^{CBB}(\cdot)$ is given in (64) and $\tilde{C}_0(\cdot)$ is the $t = 0$ costs of the deposit insurance for effort e. By the Envelop Theorem, $\tilde{x}^* > \tilde{x}^{**}$ implies that $\tilde{\Pi}_0^{CBB}(\tilde{e}^*, \tilde{x}^* \mid \kappa) < \tilde{\Pi}_0^{CBB}(\tilde{e}^{**}, \tilde{x}^{**} \mid \kappa)$. Moreover, consider the two cases the solution of the optimal capital plan under national DIFs characterized in the proof of Proposition 1D.

(i) If $r \geq \bar{r}$, $\tilde{x}_A^*$ and $\tilde{x}_B^*$ are such that the two national DIFs' approval conditions bind. $\tilde{C}_0(\cdot)$ coincides with $C_0(e)$ given by (18) as in the baseline model with $e = \tilde{e}^*$ and $e = \tilde{e}^{**}$ under national DIFs and under a common DIF, respectively. Therefore, if $\gamma \leq \tilde{\gamma}$, $\tilde{e}^* \leq \tilde{e}^{**}$ by Proposition 4D, which implies that $C_0(\tilde{e}^*) > C_0(\tilde{e}^{**})$. Therefore welfare for a CBB is strictly higher under a common DIF than under national DIFs.

(ii) If $r < \bar{r}$, $\tilde{x}_A^*$ and $\tilde{x}_B^*$ are such that $\tilde{x}_A^* = -r$ and $\tilde{x}_B^*$ binds DIF B's approval condition while leaving DIF A's approval condition slack. $\tilde{C}_0(\cdot)$ is strictly higher than $C_0(e)$ given by (18) with $e = \tilde{e}^*$. Therefore, by similar reasoning as the above case, welfare for a CBB is strictly higher under a common DIF than under national DIFs.

Next, we show that, if $\gamma > \tilde{\gamma}$ and condition (66) is satisfied, then a CBB under a common DIF generates strictly lower welfare than a pair of standalone banks for some setup cost $\kappa \in (\tilde{\kappa}^*, \tilde{\kappa}^{**})$. This then implies that there exists $\breve{\kappa} \in (\kappa^*, \kappa^{**})$, such that welfare decreases when moving to a common DIF if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $(\breve{\kappa}, \tilde{\kappa}^{**}]$.

We now compare welfare generated by a CBB under a common DIF to that generated by a pair of standalone banks. Welfare generated by a standalone bank is given by $\Pi_0^{SA}(e^{SA}) - C_0(e^{SA})$, where e^{SA} is given by (16), and welfare generaged by a CBB under a common DIF is given by $\Pi_0^{CBB}(\tilde{e}^{**}) - 2C_0(\tilde{e}^{**})$, where $\tilde{e}^{**}$ is given by (32) with $\tilde{x} = \tilde{x}^{**} < \bar{x}$. Compared to (16), (32) has an extra term equal to

$$[(-x_{hh}) - (\bar{x} - x_{\ell\ell})]\,\Delta - (1-\rho)(1-2(\gamma+e))\,[(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x})]\,\Delta, \tag{105}$$

Using the expressions for x_{hh} and $x_{\ell\ell}$ given by (97) and (96), we have that $(-x_{hh}) - (\bar{x} - x_{\ell\ell}) \leq 0$ if and only if

$$\frac{(1-\rho)p_h\phi}{1+(1-\rho)p_h\phi}(R+r-1) \leq \frac{(1-\rho)p_\ell\phi}{1+(1-\rho)p_\ell\phi}\frac{(R+r-1)-(p_\ell R - L)}{1-p_\ell}, \tag{106}$$

which is equivalent to $\phi = 0$ or

$$\frac{1+(1-\rho)p_\ell\phi}{1+(1-\rho)p_h\phi} \leq \frac{p_\ell}{p_h}\frac{R+r+\bar{x}-1}{R+r-1}. \tag{107}$$

Since the left-hand side of the above expression is decreasing in ϕ and the above expression is equivalent to condition (66) as $\phi \to 0$, (66) implies $(-x_{hh}) - (\bar{x} - x_{\ell\ell}) \leq 0$.

Moreover, by comparing the national DIFs' approval conditions in the scenario of one healthy and one impaired subsidiaries, given by (25) and (26), to that in the scenario of two impaired subsidiaries, given by (62), we have $\tilde{x}^* < x_{\ell\ell}$. This then implies that $\tilde{x}^{**} < x_{\ell\ell}$, and thus $(-x_{hh}) + (\bar{x} - x_{\ell\ell}) - (\bar{x} - \tilde{x}) > -x_{hh} > 0$. This and the fact that $\gamma + \tilde{e}^{**} > \frac{1}{2}$ for all $\gamma > \tilde{\gamma}$ as shown in the proof of Proposition 4D then implies that $e^{SA} > e^{**}$. This then implies that the deposit insurance costs generated by a pair of standalone banks are strictly lower.

Finally, the bankers' payoff difference $\Pi_0^{CBB} - 2\Pi_0^{SA}$ is strictly decreasing in κ and is equal to 0 for $\kappa = \tilde{\kappa}^{**}$. This implies the welfare difference between a CBB under a common DIF and a pair of standalone banks is strictly decreasing in κ and is strictly negative at $\tilde{\kappa}^{**}$. Therefore there exists merger cost $\kappa \in (\tilde{\kappa}^*, \tilde{\kappa}^{**})$, such that the welfare generated by a pair of bankers with merger cost κ decreases when moving from national DIFs to a common DIF.

□

B.2 Alternative effort modeling

This appendix provides a detailed analysis of the extension outlined in Section 5.2.

In this extension, we modify Assumptions 2–4 as follows. First, the cost function $k(\cdot)$ ensures interior solutions and thresholds:

Assumption 2E. *$k(0) = 0$, $k'(0) = 0$, $k'(1) > \gamma p_h'(1)(R+r-1)+(1-\gamma)p_\ell'(1)R+(1-\gamma)\frac{1-L-r}{(1-p_\ell(1))^2}$, and $k''(e) > \gamma p_h''(e)(R+r-1)+(1-\gamma)p_\ell''(e)R+(1-\gamma)\frac{2(1-L-r)}{(1-p_\ell(e))^3}$ for all $e \in [0,1]$.*

Second, for all effort levels, the DIF liquidates at $t = 1$ a bank if and only it is impaired in the absence of a recapitalization and that liquidation is inefficient:

Assumption 3E. *(i) $p_h(e) > \frac{L}{1-r} > p_\ell(e)$ for all $e \in [0,1]$, and (ii) $p_\ell(0)R > L$.*

Third, for all effort levels, we maintain the simplifying assumption that a healthy subsidiary has an interim payoff large enough to recapitalize and avoid the liquidation of an impaired subsidiary, and that bankers are willing to recapitalize an impaired standalone bank using their own funds to avoid liquidation:

Assumption 4E. *(i) $r \geq \frac{L-p_\ell(e)}{1-2p_\ell(e)}$, and (ii) $\Delta \leq \frac{1-p_\ell(e)}{L-p_\ell(e)(1-r)}(p_\ell(e)R-L)$ for all $e \in [0,1]$.*

We proceed to formally characterize the outcome of the intervention game at $t = 1$ and the bankers' effort decisions in a CBB at $t = 0$.

B.2.1 Intervention game

Effort influences the outcome of the intervention game at $t = 1$ through its impact on the variables p_ℓ and p_h in the baseline model.

Consider first a standalone bank. It follows from Proposition 1 that the equity injection required to recapitalize an impaired bank in the baseline model, $\bar{x}$, is decreasing in p_ℓ. Therefore in this extension, the corresponding equity injection required, $\bar{x}(e)$, is decreasing in e.

Consider next a CBB with a healthy subsidiary and an impaired subsidiary. The equity injection under national DIFs in the baseline model x^* is given in (45) in the proof of Proposition 1. Notice that x^* depends only on p_ℓ and not on p_h. For $\rho \leq \underline{\rho}$, $x^* = 0$. For $\rho > \underline{\rho}$, the optimal recapitalization plan binds DIF A's approval constraint given by (8). After some algebraic manipulation of a binding (8) given $S = R + r + x + s - 1$ and $x + s = \bar{x}$, x^* satisfies

$$1 - r + \bar{x} - x^* - (1-\rho)p_\ell(R + r + \bar{x} - 1) = 1 - r. \tag{108}$$

Totally differentiating this expression with respect to p_ℓ yields:

$$\frac{\partial \bar{x}}{\partial p_\ell}\left[1 - (1-\rho)p_\ell\right] - \frac{\partial x^*}{\partial p_\ell} - (1-\rho)(R + r + \bar{x} - 1) = 0. \tag{109}$$

$\frac{\partial \bar{x}}{\partial p_\ell} < 0$ then implies that $\frac{\partial x^*}{\partial p_\ell} < 0$. That is, x^* is decreasing in p_ℓ. Therefore in this extension, the corresponding equity injection, $x^*(e)$, is decreasing in e and strictly so for all $\rho < \underline{\rho}$.

Under a common DIF, as in Proposition 2 for the baseline model, we have $x^{**}(e) = x^{**} = 0$.

B.2.2 Risk-taking and welfare

We now turn to characterizing the bankers' effort decisions in a CBB at $t = 0$. The bankers' expected payoff from a standalone bank as a function of their effort e is given by

$$\Pi_0^{SA}(e) = q\left[R + r(1+\Delta) - 1\right] + \\ + (1-q)\big[\gamma p_h(e)(R + r - 1) + (1-\gamma)\left[(p_\ell(e)R - L) - \bar{x}(e)\Delta\right]\big] - (1-q)k(e). \tag{110}$$

The bankers' expected payoff from a CBB as a function of their effort e, taking into account the amount of overall equity injection $x(e)$ at $t = 1$ as an outcome of the intervention game at $t = 1$, is given by

$$\Pi_0^{CBB}(e, x|\kappa) \equiv 2\Pi_0^{SA}(e) - \kappa + \underbrace{2(1-q)(1-\rho)\gamma(1-\gamma)}_{\text{Probability of intragroup support}} \underbrace{(\bar{x}(e) - \tilde{x}(e))\Delta}_{\text{Support gains}}, \tag{111}$$

respectively. The expressions (110) and (111) are analogous to (13) and (14), respectively, in the baseline model. In particular, the last term of (111) captures the increase in the bankers' expected payoff relative to standalone banks due to the intragroup support, which depends on effort and on the DIF architecture.

The optimal effort choice of bankers in a standalone bank and in a CBB are thus characterized by the first-order conditions given by (36) and (37), respectively. Since the last term on the right-hand side of (37) is negative under a common DIF (that is, $\frac{d(\bar{x}(e)-x^{**}(e))}{de} = \frac{d\bar{x}(e)}{de} < 0$), effort in a CBB under a common DIF is also lower than that in a standalone bank. Moreover, It is immediate to see that, as $\frac{dx^{*}(e)}{de} \leq \frac{dx^{**}(e)}{de} = 0$, the optimal effort is lower under a common DIF than under national DIFs.

Finally, we can evaluate the welfare effect of moving to a common DIF. A trade-off between ex-post risk-sharing gains and ex-ante risk-taking losses emerges that is analogous to that in the baseline model for low ρ. Hence, analogous to Proposition 5 in the baseline model, the introduction of a common DIF can lead to a reduction of welfare. Specifically, let $\breve{\kappa}^{*}$ and $\breve{\kappa}^{**}$ denote the cost thresholds for bankers to set up a CBB under national DIFs and a common DIF, respectively, analogous to those in the baseline model defined in Proposition 3; we obtain the following formal result.

Proposition 5E. *Moving from national DIFs to a common DIF changes the overall welfare in the economy as follows: There exists $\acute{\kappa} \in (\breve{\kappa}^{*}, \breve{\kappa}^{**})$ such that welfare strictly decreases if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $(\acute{\kappa}, \breve{\kappa}^{**}]$.*

Proof. Welfare generated by a pair of bankers can be decomposed into the bankers' payoff less the expected deposit insurance costs. For $\kappa \in (\breve{\kappa}^{*}, \breve{\kappa}^{**})$, the banks remain standalone under national DIFs and merge to form a CBB under a common DIF. Because effort is strictly lower in a CBB under a common DIF than in standalone banks (by (37)), the expected deposit insurance costs are strictly higher for a CBB under a common DIF than for standalone banks. Moreover, the bankers' payoff difference between a CBB under a common DIF and standalone banks is strictly increasing in κ and is equal to 0 for $\kappa = \breve{\kappa}^{**}$. This implies the welfare difference between a CBB under a common DIF and a pair of standalone banks is strictly decreasing in κ and is strictly negative at $\breve{\kappa}^{**}$. Therefore there exists $\acute{\kappa} \in (\breve{\kappa}^{*}, \breve{\kappa}^{**})$ such that welfare generated by a pair of bankers with merger cost $\kappa \in (\breve{\kappa}^{*}, \breve{\kappa}^{**})$ decreases when moving from national DIFs to a common DIF. This then implies that welfare strictly decreases if the CBB setup cost distribution $F(\kappa)$ is sufficiently concentrated within $(\acute{\kappa}, \breve{\kappa}^{**}]$. $\square$

References

Acharya, V. V. (2003). Is the International Convergence of Capital Adequacy Regulation Desirable? *Journal of Finance*, 58(6):2745–2782.

Banal-Estanol, A., Lóránth, G., and David, P. (2026). Resolution design and investment in banking groups. *Journal of Financial and Quantitative Analysis*. accepted for publication.

Beck, T., Brunno, B., and Carletti, E. (2024). Can the Banking Union foster market integration, and what lessons does this hold for Capital Markets Union? IN-DEPTH ANALYSIS Requested by the ECON committee, European Parliament.

Bolton, P. and Oehmke, M. (2019). Bank resolution and the structure of global banks. *The Review of Financial Studies*, 32(6):2384–2421.

Boot, A. W. A. and Schmeits, A. (2000). Market discipline and incentive problems in conglomerate firms with applications to banking. *Journal of Financial Intermediation*, 9:240–273.

Calzolari, G., Colliard, J.-E., and Lóránth, G. (2019). Multinational banks and supranational supervision. *The Review of Financial Studies*, 32(8):2997–3035.

Carletti, E., Dell'Ariccia, G., and Marquez, R. (2021). Supervisory incentives in a banking union. *Management Science*, 67(1):455–470.

Colliard, J.-E. (2020). Optimal supervisory architecture and financial integration in a banking union. *Review of Finance*, 24(1):129–161.

Dell'Ariccia, G. and Marquez, R. (2006). Competition among regulators and credit market integration. *Journal of Financial Economics*, 79(2):401–430.

Demirgüç-Kunt, A., Kane, E., and Laeven, L. (2015). Deposit insurance around the world: A comprehensive analysis and database. *Journal of financial stability*, 20:155–183.

ECB (2024). Financial integration and the structure of the euro area. Technical report.

Enria, A. (2023). Exogenous shocks and endogenous challenges: five years of european banking supervision (and beyond). Speech by Andrea Enria, Chair of the Supervisory Board of the ECB, at the London School of Economics, Financial Markets Group, London, 30 October 2023.

Enria, A. and Fernandez-Bollo, E. (2020). Fostering the cross-border integration of banking groups in the banking union. The Supervisory Blog, 9 October 2020.

European Commission (2012). A roadmap towards a banking union. COM(2012) 510 final, Brussels, 12 September 2012.

Freixas, X. (2003). Crisis management in europe. In Kremers, J. J., Schoenmaker, D., and Wierts, P. J., editors, *Financial Supervision in Europe*, pages 102–119. Edward Elgar.

Freixas, X., Lóránth, G., and Morrison, A. D. (2007). Regulating financial conglomerates. *Journal of Financial Intermediation*, 16:479–514.

Gertner, R., Scharfstein, D., and Stein, J. (1994). Internal versus external capital markets. *Quarterly Journal of Economics*, 109:1211–1230.

Goodhart, C. and Schoenmaker, D. (2009). Fiscal burden sharing in cross-border banking crises. *International Journal of Central Banking*, 5(1):141–165.

Gopalan, R. and Xie, K. (2011). Conglomerates and industry distress. *Review of Financial Studies*, 24:3642–3687.

Gorton, G. B. and Souleles, N. S. (2007). Special purpose vehicles and securitization. In Carey, M. and Stulz, R. M., editors, *The Risks of Financial Institutions*, pages 549–602. University of Chicago Press, Chicago, IL.

Holthausen, C. and Rønde, T. (2004). Cooperation in international banking supervision. ECB Working Paper No. 316.

Kroszner, R. S. (2006). The effect of removing geographic restrictions on banking in the United States - lessons for europe. Remarks by Mr Randall S Kroszner, Member of the Board of Governors of the US Federal Reserve System, at the Conference on the Future of Financial Regulation, London School of Economics, London, 6 April 2006.

Kuncl, M. (2019). Securitization under asymmetric information over the business cycle. *European Economic Review*, 111:237–256.

Lagarde, C. (2024). Hearing of the committee on economic and monetary affairs of the european parliament. Speech President.

Lautenschläger, S. (2019). Cross-border banking since the crisis – lessons for supervisors. Statement by Sabine Lautenschläger, Member of the Executive Board of the ECB, at the 10 Years Vienna Initiative - Anniversary Conference 2019, in Vienna, Austria, 27 March 2019.

Matvos, G. and Seru, A. (2014). Resource allocation within firms and financial market dislocation: Evidence from diversified conglomerates. *Review of Financial Studies*, 27:1143–1189.

Ordoñez, G. (2018). Confidence banking and strategic default. *Journal of Monetary Economics*, 100:101–113.

Parlatore, C. (2016). Fragility in money market funds: Sponsor support and regulation. *Journal of Financial Economics*, 121(3):595–623.

Rajan, R., Servaes, H., and Zingales, L. (2000). The cost of diversity: The diversification discount and inefficient investment. *Journal of Finance*, 55:35–80.

Reuters (2024). Why euro zone banks don't yet buy into cross-border mergers. Reuters 2024-05-29.

Saleem, B. and Malherbe, F. (2024). The cross-border effects of bank capital regulation. *Journal of Financial Economics*, 12(2):221–268.

Santioni, R., Schiantarelli, F., and Strahan, P. E. (2020). Internal capital markets in times of crisis: The benefit of group affiliation. *Review of Finance*, 24:773–811.

Scharfstein, D. and Stein, J. (2000). The dark side of internal capital markets: Divisional rent–seeking and inefficient investment. *Journal of Finance*, 55:2537–2564.

Segura, A. (2017). Why did sponsor banks rescue their SIVs? A signaling model of rescues. *Review of Finance*, 22(2):661–697.

Segura, A. and Vicente, S. (2026). Collective moral hazard, risk sharing, and banking unions.

Segura, A. and Zeng, J. (2020). Off-balance sheet funding, voluntary support and investment efficiency. *Journal of Financial Economics*, 137(1):90–107.

Stein, J. (1997). Internal capital markets and the competition for corporate resources. *Journal of Finance*, 52:111–133.

Stein, J. (2003). Agency, information and corporate investment. In Constantinides, G. M., Harris, M., and Stulz, R. M., editors, *Handbook of the Economics of Finance*. Elsevier, Amsterdam.

Villeroy de Galhau, F. (2024). Ten years of SSM: great achievements, and new journeys to complete. Speech Governor.