Financing and Resolving Banking Groups*

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We study how banks' resolution regimes affect investment. Banking groups create financing synergies by transferring excess financing capacity across units and lowering bankers' agency rents from monitoring. Single-point-of-entry (SPOE) resolution preserves groups' structure, which permits ex post efficient reinvestment in weaker units hit by negative shocks, but can prevent optimal investment ex ante. Multiple-point-of-entry (MPOE) resolution separately resolves weaker units following negative shocks and prevents reinvestment, but can foster ex ante investment. We characterize the conditions under which SPOE or MPOE resolution is efficient as a function of banking groups' risk profile and overall profitability. The coexistence of both resolution regimes is more efficient than the adoption of a uniform resolution regime.

Keywords: Complex banking groups, Resolution regimes, Restructuring.

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1. Introduction

The financial crisis of 2007-2008 exposed the economic, fiscal, and social costs of bank failure, as well as the inadequacy of standard bankruptcy procedures for the banking system (Freixas, 2010; Lee, 2014). As a policy response, Title II of the U.S. Dodd-Frank Act and the E.U. Bank Recovery and Resolution Directive (BRRD) introduced new regulatory frameworks for the orderly resolution of banks, with the aims of lowering the public costs of bank failure and of minimizing market and operational disruptions.

The new regulations require banking institutions and groups to prepare (and update) detailed resolution plans (or "living wills"), which regulators must approve. The resolution frameworks allow for two broad types of resolution plans, the so-called "single-point-of-entry" (SPOE) and "multiple-point-of-entry" (MPOE) resolution plans. Under SPOE, resolution always ensues at the banking group's holding company level (or parent bank), which is the sole "entry point" at which regulators can take control. The banking group is resolved as a single entity, and its individual units' losses are mutualized. Under MPOE, the banking group specifies other legal entities as additional entry points. An entry point, can then be resolved separate from the rest of the banking group. In this case it does not receive transfers and its losses are not mutualized.

Both resolution regimes are regarded as major regulatory innovations, following intense policy debates (see Tucker, 2014a,b; Bolton et al., 2019, p. 12; Skeel Jr, 2014). Most large banks worldwide, including all U.S. G-SIBs, have adopted SPOE although some banks, such as HSBC (2021), Santander (2021), and BBVA (2021) have chosen MPOE. A possible explanation for the the predominance of SPOE might be that regulators seem to favor this approach (FDIC and BOE, 2012; Powell, 2013; Stein, 2013; Tarullo, 2013; Lee, 2017).[1] Recently, in the wake of the war in Ukraine, different European subsidiaries of Russia's Sberbank were resolved separately (König, 2022).

This paper argues that a trade-off exists between banking groups' ex post efficient resolution strategy and their ex ante financing capacities and (efficient) investment lev-

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[1] **?**, p. 466 argues that "FDIC staff, for instance, see the SPOE strategy as the more promising approach, particularly from the perspective of minimizing the potential for adverse consequences of a resolution of a large complex US financial institution".

Incidentally, the only two systemically important U.S. banking institutions that chose MPOE in 2016, Wells Fargo and Bank of New York Mellon, had their resolution plans rejected by U.S. regulators. Some commentators have explicitly argued that the failing grade was indeed because these banks had failed to pick up on the preference of the regulators for SPOE (Lee, 2017).

Still, the U.S. regulatory agencies officially claim that they "do not prescribe specific resolution strategies for any firm, nor do they identify a preferred strategy" (Federal Reserve and FDIC, 2019, p. 1442).

els, due to agency conflicts between banks' insiders and their outside investors. SPOE resolution may protect banking groups and their synergies because loss mutualization facilitates efficient reinvestment in units hit by negative shocks, which allows them to continue their operations. But when agency conflicts prevent investors from fully capturing the present value of banks' investments, the same ex post loss mutualization and reinvestment may also curb banks' ex ante financing and investment. MPOE resolution, in contrast, can prevent reinvestments in weaker units that do not benefit banks' investors. This may force these units to shut down following negative shocks. At the same time, MPOE resolution also limits investors' exposure to negative shocks, which increases banks' financing capacities and can be crucial to fund banks' investments ex ante. We characterize the conditions under which SPOE and MPOE resolutions are efficient and show that these conditions depend on the banking groups' characteristics, including the heterogeneity of their different units. We thus argue, that the coexistence of both resolution regimes increases economy wide efficiency relative to the adoption of a uniform resolution regime for all banks.

We build a model of two (potentially) asymmetric banking units that could either operate as single-unit banks or as parts of a banking group. One of the units is weak in the sense that it has a lower financing capacity than the other, strong, unit. The operation of both units is efficient, but their financing capacities fall short of the present values of their loans because bankers must receive agency rents to monitor the loans . Joining the two units together as part of a banking group centralizes decision-making and allows the bank to (i) transfer excess financing capacity from the strong to the weak unit, while (ii) creating "incentive synergies" that reduce the cost of providing monitoring incentives.[2] These two types of financing synergies allow weak units to operate as part of a banking group, even when they are not viable as single-unit banks.

The units' loan portfolios are susceptible to exogenous adverse shocks that necessitate further investment in them in order to generate returns. We focus on the case in which the shocks are small enough to make reinvestment for both units efficient, but large enough to force the bank into resolution because it cannot privately finance the necessary reinvestment. Resolution provides a mechanism to verify banks' reinvestment needs, restructure existing liabilities, bail-in investors, and raise new financing from capital

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[2]The use of a strong unit's excess financing capacity to finance a weak unit as part of a conglomerate is discussed in Fluck and Lynch (1999) and Inderst and Müller (2003). Diamond (1984), Laux (2001), and Cerasi and Daltung (2000) analyze incentive synergies that arise from combining multiple projects.

markets for reinvestment.[3] In resolution, a regulator temporarily takes over control and makes decisions with the objective of maximizing the net present value (NPV) ex post.[4]

As a benchmark against which to compare the resolution regimes, we derive the constrained optimal contract between bankers and outside investors. Because bankers are the residual claimants, the private and social optimum coincide in our model. We show that it may sometimes be ex ante optimal to commit not to reinvest in the weak unit following the realization of a negative shock, even if reinvestment is ex post efficient. The reason is that, when the financing capacity the weak unit adds to the banking group is smaller than the reinvestment need,, reinvestment in the weak unit requires a transfer of (additional) financing capacity from the strong unit. When investors' expected costs of making such a transfer are high enough, it becomes constrained optimal ex ante to commit not to reinvest in the weak unit; otherwise, outside investors will refuse to finance the banks' initial investment. At the same time, reinvesting in the the strong unit increases the bank's financing capacity and is always optimal.

We then consider the effects of different resolution regimes on a bank's ability to finance its initial operations and reinvestment following a negative shock. SPOE resolution mutualizes losses and thus uses both units' financing capacity to reinvest in any unit that suffers a negative shock. Hence, SPOE resolution can implement the constrained optimal contract when it includes reinvestment in the weak unit. However, SPOE resolution will not implement the constrained optimum when, in order to finance the weak unit's operation in the first place, reinvestment in it should be averted. Investors will anticipate that under SPOE the regulator will use the strong unit's financing capacity for reinvestment in the weak unit This risk of bail-in makes them unwilling to provide ex ante financing.

Conversely, under MPOE resolution, the banking group can specify its weak unit as an additional entry point that will be resolved separately and without transfers from the other parts of the banking group. This prevents the regulator, against its own preferences, from reinvesting in the weak unit when the weak unit cannot self-finance its reinvestment. Outside investors anticipate that MPOE resolution limits their losses from shocks and reinvestment in the weak unit. We show that MPOE resolution, with an entry point in the weak unit, can implement the constrained optimum when preventing

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[3]Our model focuses on the trade-off between different resolution regimes rather than the need for resolution a resolution regime per se. However, we explicitly model the need for a resolution in an extension that features a model of adverse selection.

[4]Note that this objective of resolution is different from typical bankruptcy procedures that are more creditor friendly and thus aim to maximizes investors' payoffs.

reinvestment in the weak unit is necessary to operate it in the first place.[5] In contrast, we demonstrate that the strong unit should never serve as a entry point for resolution because reinvestment in the unit following a shock is always optimal. In this case, resolution at the holding company level is more efficient because this preserves the banking group's corporate structure and the associated incentive synergies.

We derive a series of policy and empirical implications from our model. First, both resolution regimes should be part of the regulatory toolbox because their relative efficiency is bank specific. MPOE resolution is optimal for banking groups with sufficiently heterogeneous units that have different scopes and competencies (such as investment and commercial banks) or geographic focuses.

Second, banks under MPOE should designate large risky units as entry points so that they can be resolved separately.At the same time, strong units should not be designated as entry points so that shocks to these units do not alter the groups structure.

Third, once a banking group has adopted a resolution regime, this choice will affect its future investment. Banks under SPOE will find it difficult to finance large and risky investments precisely because outside investors might not be willing to bear the risk of a bail-in. Conversely, banks under MPOE will find it easier to make such investments because of their ability to fend off costly reinvestment and thus, limit investors' bail-in. Thus, banks under MPOE are also less likely to curtail investments during crises, when the risk of investment increases and bank profitability decreases.

Fourth, we argue that coordination failure between regulators in cross border contexts might be important to make MPOE resolution credible. MPOE resolution can only limit outside investor's losses when it prevents the regulator from enforcing transfers, even if these transfers would be ex post efficient. In practice, national regulators may find it easier to make such commitments for foreign, rather than for domestic, units.[6] Such regulatory biases may thus explain why MPOE resolution is primarily observed in a cross-border context. In response to regulatory commitment problems, banking groups may even spread their activities across borders in order to make an MPOE strategy credible and thereby increase their financing capacity and investment.

Fifth, we also show that banks opting for MPOE resolution can sometimes avoid resolution when their weak units suffer a shock. This is the case if the bank does not

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[5]Wells Fargo's 2017 resolution plan exemplifies an explicit case calling for the separate liquidation of its institutional broker-dealer in case of resolution: "Our institutional broker-dealer, WFS LLC, would be resolved through a liquidation proceeding under SIPA, which is the law that typically governs the resolution of a brokerage firm that fails" (Wells Fargo, 2017, p. 9).

[6]The FDIC in the United States, for example, requires bank holding companies to serve as a "source of strength" for their bank subsidiaries (Title 12 of the U.S. Code §1831).

depend on incentive synergies between the units in order to finance the initial operation, but reinvestment in the weak units would prevent investment ex ante. This is especially relevant if resolution entails significant (direct) costs.

Finally, resolution regimes also have implications for the total loss absorption capacity (TLAC) that regulators require from global systematically important banks (G-SIBs).[7] TLAC measures financial claims that can be written down or diluted to absorb losses during resolution. We show that MPOE resolution can require less TLAC compared to SPOE resolution because MPOE resolution limits outside investors' losses from reinvestment in weak units. In addition, loss absorption capacities could be shared across units in the form of "internal TLAC" provided by the holding company (cf. FSB, 2015) even under MPOE resolution. This result goes in the opposite direction of the standard argument that SPOE resolution requires less loss absorption capacity than MPOE resolution as the former mutualizes losses among multiple units (e.g. Bolton and Oehmke, 2019).

The literature on government intervention in failing banks has mostly focused on the timing of regulatory interventions (e.g., Mailath and Mester, 1994; Decamps et al., 2004; Freixas and Rochet, 2013) and the optimal design of bail-in and bail-out policies (e.g., Gorton and Huang, 2004; Diamond and Rajan, 2005; Farhi and Tirole, 2012; Bianchi, 2016; Keister, 2016; Walther and White, 2019; Colliard and Gromb, 2018; Keister and Mitkov, 2020).

Despite the intense policy debate on the resolution frameworks and the virtues of SPOE versus MPOE resolutions, the academic literature on the issue is scant. A notable exception is Bolton and Oehmke (2019), who discuss resolution regimes in a cross-border context. In their model, SPOE resolution is efficient because it provides diversification benefits and preserves operating synergies. But in a cross-border setting, national regulators are unable to commit to SPOE resolution, ex post, because doing so would involve transfers across jurisdictions. Furthermore, a lack of coordination among national regulators can result in an ex ante suboptimal choice of MPOE, even when regulators can commit to ex post transfers. MPOE resolution then emerges as a result of these regulatory frictions, even though SPOE resolution dominates MPOE resolution in the absence of such frictions. Faia and Weder di Mauro (2016) similarly argue that, when regulators coordinate, the most efficient resolution regime is SPOE resolution. They also contend that MPOE resolution can increase banks' cross-border activities by limiting their ex-

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[7]In the European Union, all banks (not just G-SIBs) are also subject to a minimum requirement for their own funds and eligible liabilities (MREL), which serves the same purpose as TLAC (SRB, 2021).

posure to foreign losses. We argue instead that MPOE resolution is primarily observed in cross border context because the regulators' reluctance to make cross-border transfers may make MPOE resolutions strategies credible. More importantly, the trade-off highlighted in our paper is not specific to cross-border entities and equally applies to banking groups operating within national borders.

2. Model

This section introduces a model of two banking units that raise financing from competitive capital markets and invest in two different pools of loans. Borrowers, and therefore the banking units they borrow from, are subject to exogenous adverse shocks that demand reinvestment. We use this model to compare the costs and benefits of different organizational forms and resolution regimes.

2.1. Organizational structure

We consider a model of two banking units, $i \in \{H, L\}$, that are asymmetric in the sense that the pools of loans they have access to may have different payoff and risk characteristics. The two banking units can operate as part of the same banking group or as two independent single-unit banks (see Figure 1). A banking group consists of three legal entities: the holding company and two wholly-owned subsidiaries that operate the two banking units. A single-unit bank, which consists of a holding company and a wholly-owned subsidiary, is equivalent to a banking group that operates a single unit.[8]

All banks are run by teams of "bankers" that take all the decisions as long as their bank is not in resolution. Decision-making within a banking group is centralized. We abstract away from any internal agency problems within the banking group or within the teams of bankers. Single-unit banks make decisions independent of each other.

2.2. Investment

We compare the efficiency of the different organizational structures and resolution regimes using the three-date model represented in Figure 2. For a given organizational structure and resolution regime, bankers take decisions on how many units to finance, or "operate," and how to raise funding for their operation at $t = 0$. Each banking unit requires

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[8]In our model, a single-unit bank does not necessarily require a holding company. Including it allows for a clearer exposition of the core differences between banking groups and single-unit banks.
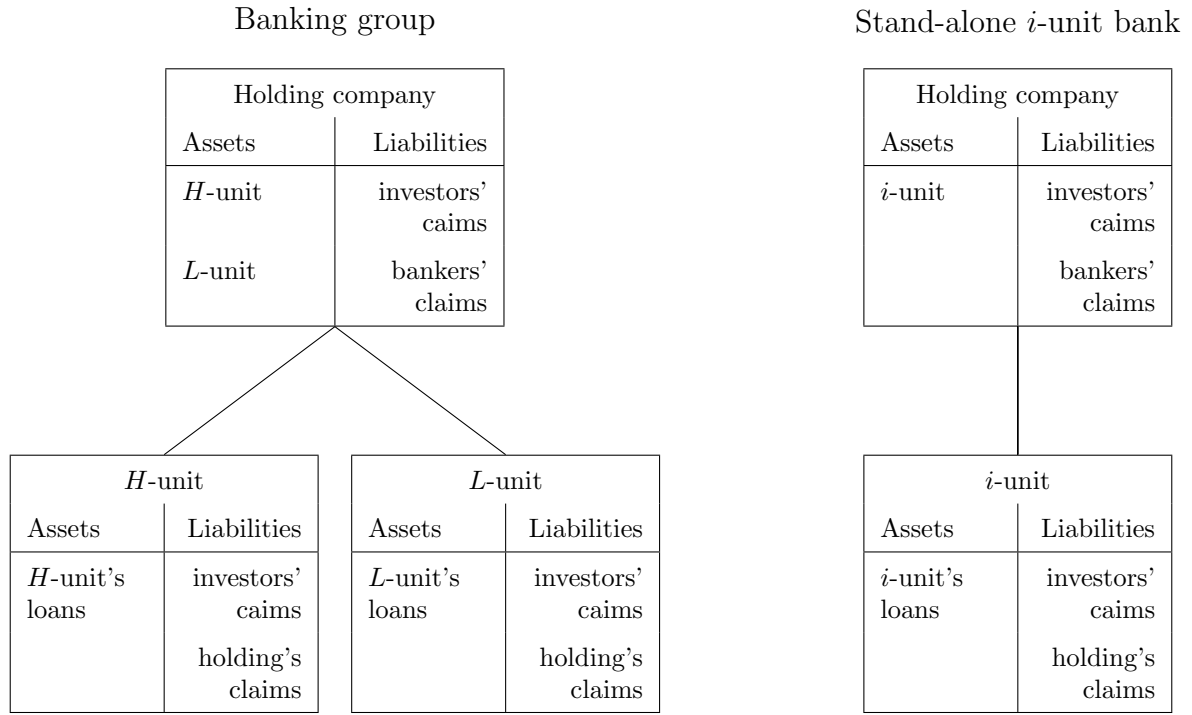
Banking group

Holding company	
Assets	Liabilities
H-unit	investors' caims
L-unit	bankers' claims

Stand-alone i-unit bank

Holding company	
Assets	Liabilities
i-unit	investors' caims
	bankers' claims

H-unit	
Assets	Liabilities
H-unit's loans	investors' caims
	holding's claims

L-unit	
Assets	Liabilities
L-unit's loans	investors' caims
	holding's claims

i-unit	
Assets	Liabilities
i-unit's loans	investors' caims
	holding's claims

Figure 1: Banks' organizational structure

$(1-q)$ No negative shock

q_H Negative shock for H-unit

q_L Negative shock for L-unit

p_i^m R_i

$(1-p_i^m)$ 0

$t = -1$

$t = 0$

$t = 1$

$t = 2$

Choice of organizational structure and resolution regime.

Bankers need to raise one unit of outside financing for each banking unit they operate.

Negative shocks realize. An affected unit does not generate a return at $t = 2$ unless it receives an additional unit of reinvesment.

Resolution ensues when bankers declare that a unit suffers a shock.

Bankers decide which units they monitor.

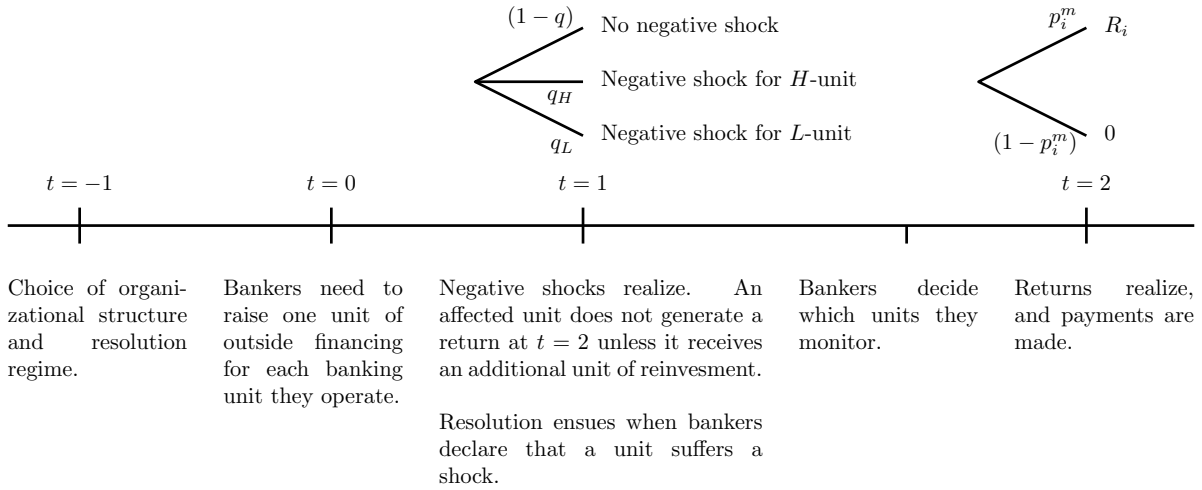Returns realize, and payments are made.

Figure 2: Timeline

one unit of funding to make loans that return a final payoff at $t = 2$. A banking unit $i \in \{H, L\}$ generates a positive payoff R_i with probability p_i and a payoff of zero with the complementary probability. Bankers can increase the probability of a positive return of each i-unit from p_i to $p_i^m \equiv p_i + \Delta p_i$ if they monitor the i-unit's loans between dates $t = 1$ and $t = 2$. Monitoring is not observable and imposes a per-unit non-pecuniary cost c on bankers. The banking units' payoffs are assumed to be independent.

Banking units may be subject to exogenous adverse shocks that increase their financing needs. These shocks can be interpreted as shocks to the units' borrowers who require additional investment to complete their investment projects.[9] At $t = 1$, one of the two banking units may suffer a shock, in which case it requires an additional unit of funding.[10] The ex-ante probability that an i-unit is affected by a shock is equal to q_i, where $q_H + q_L = q$.[11] If the additional investment is not made, the banking unit does not generate any return from its loans at $t = 2$. In this case, monitoring is irrelevant. If the additional investment takes place, the bank's return distribution is the same as before the shock. Whether a banking unit suffers a shock is bankers' private information. We call units that receive a shock but no reinvestment "non-performing" and units that either receive reinvestment or do not suffer a shock "performing."

2.3. Financing

Bankers do not possess funds of their own and need to raise outside financing. Capital markets are competitive and thus outside investors provide resources as long as they break even in expectation. Bankers are, thus, the residual claimants in our model. The inability of markets to observe the shock prevents parties from writing financing contracts that are contingent on the realization of the shock. We also follow Innes (1990) and require that contracts are such that outside investors' cash flows are monotonous in each unit's cash flow.[12] All parties are risk neutral, have a discount factor of one, and are protected by limited liability.

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[9]Holmström and Tirole (1998) call such shocks "liquidity" shocks.

[10]It is straightforward to generalize our model to different shock sizes, s_i that can differ across units. We further discuss this in Section 6.

[11]This formulation allows us to encompass the case in which the two units are symmetric in terms of the shock ($q_H = q_L = q/2$), as well as the case in which the shock can only affect one of the two units ($q_i = q$, $q_{-i} = 0$). Bolton and Oehmke (2019) use a similar shock structure but, in their setup, the shock to one of the two units always occurs ($q = 1$) and the two units are symmetric ($q_H = q_L = q/2$).

[12]The rationale for this assumption is that otherwise outside investors would have an incentive to sabotage operations and bankers would have incentives to boost cash flows through personal borrowing. To satisfy this assumption, we will restrict the set of parameters in Section 3.2.1.

2.4. Resolution

Resolution ensues if bankers report to the regulatory and supervisory authorities, who we call the "regulator", that one of their banking units suffered a shock. In resolution, the regulator temporarily takes control of the bank, which allows it to verify that the bank has indeed suffered a shock. The regulator can restructure existing financial contracts and enter into new ones to raise new financing from capital markets for reinvestment. We assume that the regulator's objective is to maximize "ex-post efficiency" or NPV at $t = 1$, when resolution ensues. It imposes the minimum losses, first on bankers and then on outside investors, that are necessary to maximize NPV. If the regulator cannot help the bank raise sufficient resources to reinvest in the affected unit, the unit becomes non-performing. Once resolution is complete, bankers retake control of the bank.[13]

2.4.1. Entry points

Resolution plans designate one or more entities as "entry points" at which the regulator can take control. Resolution ensues at an entry point if the corresponding entity, or one of its subsidiaries that is not an entry point itself, suffers a shock. Resolution at an entry point (i) separates the corresponding entity from its parent company and other subsidiaries of the parent company and (ii) encompasses all subsidiaries of the corresponding entity, except for those subsidiaries that are themselves entry points, at which resolution ensues independently at the same time. If separation of an entity impairs the operational efficiency of the remaining parts of the banking group because it destroys monitoring incentives, the remaining parts of the banking group enter resolution as well. The holding company must always be an entry point to ensure that all parts of the banking group can be resolved. Further entry points can be defined at the level of the units.

When multiple entities are resolved together, their losses are mutualized, while there are no transfers between entities that are resolved separately. If resolution separates a part of the banking group from the holding company, some of the members of the original team of bankers will form a new, independent team to run the new bank. These bankers lose their claims in the remaining part of the banking group and obtain new claims on the new bank. We assume that the allocation of bankers and their claims among these different subgroups of bankers is such that it does not affect bankers' ex ante incentives at $t = 0$.

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[13]Since the occurrence of a negative shock is exogenous to the bank, there is no reason to replace the bankers following a shock in our model.

2.4.2. Resolution regimes

We compare different configuration of entry points, which give rise to different "resolution regimes." An "SPOE" regime arises if a banking group specifies its holding company as its sole entry point. In this case, resolution always ensues at the holding company level, all entities are resolved jointly, and losses are mutualized. An "MPOE" regime arises instead if the banking group specifies multiple entry points and resolves different parts of a banking group separately. In our setting, MPOE resolution encompasses three different entry point configurations, depending on which units are specified as entry points. The banking group can specify its L-unit, its H-unit, or both as entry points, in addition to the holding company. We sometimes call banks subject to the different resolution regimes SPOE and MPOE banks, respectively.

For single-unit banks, the choice of resolution regime does not make any difference because the bank operates a single unit that cannot be split up.

2.4.3. The role of resolution

In our model resolution serves as a state verification device, similar to bankruptcy in Giammarino (1989) and Webb (1987). Unlike these papers, from the costly state verification literature (Townsend, 1979), we abstract from verification costs and any other direct costs of resolution (or default). As a result, resolution eliminates the threat from false claims about the occurrence of a shock.[14]

Our model focuses on the comparison between different resolution regimes, and more generally on the different configurations of entry points. We thus assume in the main body of the paper that resolution is essential, in the sense that, if it did not exist, reinvestment would never occur in the banking group nor in the single-unit banks.

Assumption 1. *In the absence of resolution, banks cannot raise sufficient financing to reinvest in the units that suffer negative shocks.*

We assume thus that capital markets would not provide additional funding without the involvement of the regulator. This assumption is satisfied if raising financing in response to a shock is subject to severe asymmetric information problems. In reality, banks are especially prone to such asymmetric information problems due to the opacity of their investments (Morgan, 2002; Iannotta, 2006; Flannery et al., 2013).

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[14]Our model and results would not change if the regulator could directly observe the occurrence of shocks as a result of regulatory monitoring and reporting requirements.

We develop an extension of our model in Appendix A that provides explicit conditions under which Assumption 1 holds. In this extension, we assume that bankers can misappropriate funds that are not necessary to cover the bank's funding needs, which can be used to obtain non-pecuniary private benefits. This possibility of misappropriation captures the idea that excess cash gives management the possibility to make decisions that benefit themselves at the expense of investors. While appropriate financial contracts may still lead to truthful reporting of the shock and avoid misappropriation of funds, such incentive schemes are costly, lower the returns that can be pledged to investors, and can thus prevent financing. We show that when the non-pecuniary benefits from "consuming" excess funds are large, the presence of resolution is essential in the sense of Assumption 1. Under this condition, the expressions, trade-offs and results of the extended model would be the same as in the simplified model of the main text (where we do not consider the possibility of misappropriation).

2.5. Efficiency

We measure the performance or the ex ante efficiency of the different organizational structures and resolution regimes or entry point configurations in terms of the overall expected NPV creation. As bankers are the residual claimants, the bankers' private optimum and the social optimum coincide ex ante.

We make two parameter assumptions to ensure that the decisions of operating either of the two units, as well as of reinvesting in a unit that suffers a negative shock, are efficient if and only if bankers will monitor that unit. We assume first that, with monitoring, each unit generates positive (expected) NPV at $t = 0$, even when reinvestment following a shock at $t = 1$ does not occur:

$$(1 - q_i)(p_i^m R_i - c) - 1 > 0 \ \forall i \in \{H, L\}.$$

Note that this condition implies that reinvesting in the unit following a shock at $t = 1$ also generates positive NPV: $p_i^m R_i - c - 1 > 0$. The NPV from reinvestment at $t = 1$ is higher than from investment at $t = 0$ because, in our setting, the unit will not suffer any other shock after $t = 1$. These two conditions in turn imply that operating the unit at $t = 0$ must also create positive NPV when reinvestment following a shock occurs: $p_i^m R_i - c - (1 + q_i) > 0$. Overall, since both units' operation at $t = 0$, as well as the reinvestment at $t = 1$, have positive NPV, we measure efficiency in terms of whether these investments can be financed.

Conversely, we assume that if the unit will not be monitored, reinvestment following a shock at $t = 1$ creates negative NPV:

$$p_i R_i - 1 < 0 \; \forall i \in \{H, L\}.$$

This condition in turn implies that, without monitoring, operating a unit at $t = 0$ is never efficient. The reason is that at $t = 0$, the possibility of a $t = 1$ shock implies higher expected costs (with reinvestment), or a lower expected payoff (without reinvestment), when compared to the reinvestment decision at $t = 1$.

3. Optimal Contracting Benchmark

As a benchmark to compare the resolution regimes against, we first derive a constrained optimal contract, which maximizes the bank's NPV creation. Bankers have an incentive to choose an optimal contract because they are the residual claimants.

Since resolution allows the regulator to (i) verify whether a shock has occurred or not and (ii) control the bank's reinvestment decision, we analyze in this section the optimal contract when both of these features are contractible.[15] Bankers' monitoring decisions remain non-contractible, whereas the banks' returns at $t = 2$ remain contractible.

The constrained optimal contract consists of two parts. The first part specifies the distribution of cash flows between bankers and outside investors at $t = 2$. The incentive payments that bankers require to monitor determine the maximum payments that can be credibly promised to outside investors at $t = 1$, that is a bank's $t = 1$ pledgeable income. We can restrict ourselves to contracts that ensure the monitoring of all units since, otherwise, the initial investment as well as reinvestment would be inefficient.

The optimal contract's second part determines the bank's operation decision at $t = 0$ and its reinvestment policy in case of a shock at $t = 1$. The optimal contract must satisfy outside investors' participation constraint, which requires them to break even in expectation, and bankers' participation constraint, which is always satisfied because their outside option is zero.

We first analyze the case in which the two individual units are operated as single-unit banks and then the case in which the two units are part of a banking group. In both cases, we solve the model by backward induction. We first identify the incentive contract that maximizes outside investors' cash flows at $t = 2$. We then determine the bank's

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[15]We restrict ourselves to reinvestment decisions that are deterministic functions of the shock.

reinvestment policy at $t = 1$ and the number of units it operates at $t = 0$.

3.1. Single unit banks

To ensure monitoring, bankers of a single-i-unit bank must be provided with an incentive payment τ in case the bank generates a positive return. In the absence of a return, the contract that maximizes financing subject to limited liability pays the bankers zero. The incentive compatibility constraint for monitoring a performing i-unit is

$$p_i^m \tau - c \geq p_i \tau. \tag{1}$$

The lowest incentive payment that ensures monitoring of an i-unit bank is thus given by

$$\tau^i \equiv \frac{c}{\Delta p_i}.$$

Note that bankers require the same (minimum) incentive payment (or agency rent) in the absence of a shock and if the the bank reinvests at $t = 1$ following a shock. The i-unit's $t = 1$ pledgeable income is then given by

$$P_i^1 \equiv p_i^m (R_i - \tau^i).$$

The pledgeable income at $t = 0$ depends on the bank's reinvestment policy following a negative shock, $\rho \in \{0, i\}$, where $\rho = 0$ denotes no reinvestment and $\rho = i$ denotes reinvestment. If the bank plans to reinvest (the one unit needed), its expected cost of reinvestment is q_i; if it does not plan to reinvest, it will only be performing with probability $(1 - q_i)$. Hence, the $t = 0$ pledgeable income of an i-unit bank is given by

$$P_i^0(\rho) \equiv \begin{cases} P_i^1 - q_i & \text{if } \rho = i, \\ (1 - q_i)P_i^1 & \text{if } \rho = 0. \end{cases}$$

A stand alone i-unit bank can operate at $t = 0$ if and only if its pledgeable income exceeds the initial financing costs, such that $P_i^0(\rho) \geq 1$ for some reinvestment policy ρ.

We now argue that when the bank can finance its operations at $t = 0$, the bank will reinvest at $t = 1$. The reason is that in our setup the expected present value from reinvestment is higher than from the initial investment because the initial investment might suffer a negative shock, while the bank will never suffer another shock after reinvestment. A higher present value implies a higher pledgeable income because the monitoring

decision occurs after $t = 1$. Because the initial investment and reinvestment have the same cost in our setup, it follows that if investors can break even on their $t = 0$ initial investment, they will also be able to break even on the $t = 1$ reinvestment in case of a shock. Hence, reinvestment is constrained optimal, as it also creates positive NPV.

Lemma 1. *It is constrained optimal to operate a single-i-unit bank if and only if the $t = 0$ pledgeable income is such that*

$$P_i^0(i) \equiv P_i^1 - q_i \geq 1. \tag{2}$$

In this case it is also constrained optimal to reinvest following a negative shock at $t = 1$.

Proof. See Appendix B.1. □

Our single-unit bank model makes three important points. First, a bank's ability to operate at $t = 0$ only depends on its $t = 1$ pledgeable income P_i^1 and the probability of receiving a shock q_i. Second, in our set-up, a single-unit bank will always reinvest following a shock. The reason is that doing so is both efficient and maximizes the bank's pledgeable income when the bank can finance its operations at $t = 0$. Third, some units may not be able to finance themselves, even if their initial operation and reinvestment following a negative shock are efficient. The reason is that the bank's financing capacity falls short of the present value of the bank's assets because bankers must be incentivized to monitor loans: $P_i^0(i) = p_i^m(R_i - \tau^i) - q_i < p_i^m R_i - c - q_i$.

To facilitate the exposition we will distinguish between the H- and L-unit based on their $t = 1$ pledgeable income.

Assumption 2. *Without loss of generality, we assume that the pledgeable income of a single-H-unit bank at $t = 1$ is weakly higher than that of an L-unit bank: $P_H^1 \geq P_L^1$.*

3.2. Banking groups

We now analyze the formation of a banking group that owns the H- and the L-unit and centralizes decision-making with a single team of bankers. As we will show below, a banking group can operate units that would not have been viable as single-unit banks.

Two effects of centralized decision-making make this possible. First, a unit's excess pledgeable income can be used to provide financing to a unit that cannot finance itself. Bankers are willing to make these transfers because they will earn extra agency rents

from operating the second unit.[16] As a result, the operation decisions of a banking group only depend on its overall pledgeable income, and not on the pledgeable income of the individual units. This advantage of group formation has been studied before by Fluck and Lynch (1999) and Inderst and Müller (2003).

Second, centralized decision-making for multiple units relaxes bankers' incentive compatibility constraints and reduces the minimum compensation that provides monitoring incentives. The reason is that bankers can cross-pledge the incentive payments they receive for monitoring a given unit such that they only receive compensation when both units succeed. These "incentive synergies" have been studied before by Laux (2001) and Diamond (1984). Cerasi and Daltung (2000) discuss them in the banking context.

3.2.1. Incentive contract

We first derive the incentive contract that maximizes outside investors' payment for a banking group with two performing units at $t = 1$. An incentive contract T_G is a vector of three different payments (τ_L, τ_H, τ_2) that bankers respectively receive when only the L-unit, only the H-unit, or both units generate a positive return at $t = 2$, respectively. As before it is optimal to make no payment in the absence of a return.

The following incentive compatibility constraints ensure that bankers monitor both units, rather than only the L-unit (IC:L), only the H-unit (IC:H), or neither unit (IC:0), respectively:

$$p_H^m p_L^m \tau_2 + p_H^m (1 - p_L^m) \tau_H + (1 - p_H^m) p_L^m \tau_L - 2c$$

$$\geq p_H p_L^m \tau_2 + p_H (1 - p_L^m) \tau_H + (1 - p_H) p_L^m \tau_L - c, \qquad \text{(IC:L)}$$

$$\geq p_H^m p_L \tau_2 + p_H^m (1 - p_L) \tau_H + (1 - p_H^m) p_L \tau_L - c, \qquad \text{(IC:H)}$$

$$\geq p_H p_L \tau_2 + p_H (1 - p_L) \tau_H + (1 - p_H) p_L \tau_L. \qquad \text{(IC:0)}$$

We require that outside investor's cash flows are monotonous in each unit's cash flow,[17]

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[16]This would not be possible if the other unit were run by a different group of bankers, who would require monitoring incentives of their own.

[17]We do not require that outside investors cash flows are monotonous across units' cash flows, i.e., we do not require $R_H - \tau_H \geq R_L - \tau_L \Leftrightarrow R_H \geq R_L$.

which yields the following conditions:

$$R_H + R_L - \tau_2 \geq \max_{i \in \{H,L\}} (R_i - \tau_i) \tag{3}$$

$$R_i - \tau_i \geq 0 \; \forall i \in \{H, L\}. \tag{4}$$

Bankers' limited liability constraints are given by $\tau_2, \tau_H, \tau_L \geq 0$.

Deriving the minimum compensation necessary to provide monitoring incentives for both units yields the following proposition.

Proposition 1. *There exists a threshold on the monitoring cost $\bar{c}$ such that for $c \leq \bar{c}$:*

1. *There exists an incentive contract $T_G^* \equiv (\tau_L^*, \tau_H^*, \tau_2^*)$ with $\tau_2^* > 0$ and $\tau_H^* = \tau_L^* = 0$ that maximizes the banking group's financing capacity.*

2. *The banking group's $t = 1$ pledgeable income P_G^1 is strictly larger than the sum of the pledgeable incomes of two single-unit banks $P_H^1 + P_L^1$. We call the additional $t = 1$ pledgeable income, $P_S^1 \equiv P_G^1 - P_H^1 - P_L^1$, the group's "incentive synergies."*

3. *For given average success probabilities $(p_L + p_H)/2$ and $(\Delta p_L + \Delta p_H)/2$, the incentive synergies are maximal when the two banking units are symmetric, that is, when $p_H = p_L$ and $\Delta p_H = \Delta p_L$.*

Proof. See Appendix B.2. □

This proposition allows us to make three important points. First, the bank can maximize its financing using a simple incentive contract T_G^* as long as the costs of monitoring is not too high.[18] Since the exact shape of the incentive contracts does not directly affect the role of resolution regimes in our setting, we focus on the simple case explicitly described in Proposition 1:

Assumption 3. *For simplicity, we assume that the monitoring cost c is smaller than the threshold $\bar{c}$ in Proposition 1.*

Second, Proposition 1 also shows that forming a banking group increases the overall pledgeable income due to incentive synergies. These synergies represent a form of cost

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[18]Formally, Expression (19) in Appendix B.2 shows that the incentive payment τ_2^* is proportional to the monitoring costs c. The simple incentive contract T_G^* thus satisfies the monotonicity constraint (3) when the monitoring cost c does not exceed a threshold $\bar{c}$. When the cost is higher, the monotonicity constraint (3) is binding, and the optimal contract will contain incentive payments for the success of the individual units, $\tau_H^*, \tau_L^* > 0$. For a discussion of optimal contracts in a multitask agency setting with a monotonicity constraint, see Bond and Gomes (2009).

savings that allow the bank to overcome the agency problems with lower amounts of agency rents, due to the cross-pledging of the rents from the two units.[19]

Third, the proposition also shows that the incentive synergies, P_S^1, are maximal when the two units are symmetric. The reason is that the sum of the single-unit banks' agency rents $p_H^m \tau^H + p_L^m \tau^L$ is maximal for symmetric units. Thus, cross-pledging these rents when the other unit succeeds relaxes the IC-constraints the most.

Finally, we note that when a banking group does not reinvest into a unit that suffers a shock at $t = 1$, the affected unit becomes non performing and never generates a positive return. Bankers' incentives to monitor the remaining performing i-unit are then exclusively determined by the payment τ_i, which they receive in case only the i-unit generates a return. Bankers will monitor the performing i-unit if the incentive compatibility constraint for a single-i-unit bank (1) is satisfied. As a result, the $t = 1$ pledgeable in this case is also given by P_i^1.

3.2.2. Operation and Reinvestment

We now turn to the description of the banking group's optimal reinvestment policy at $t = 1$ and operation decision at $t = 0$. We first analyze how the group's reinvestment policies, affect its $t = 0$ pledgeable income. We then show that a banking group that operates both units at $t = 0$ will always reinvest when the H-unit suffers a negative shock at $t = 1$. In contrast, it may not reinvest if the L-unit receives a shock.

The pledgeable income of a banking group that operates both units at $t = 0$ depends on the reinvestment decision $\rho \in \{2, H, L, 0\}$ at $t = 1$, where $\rho = 2$ denotes the case in which the bank reinvests into any unit that receives a shock; $\rho = i$ the case in which the bank reinvests into the i-unit if it receives a shock but not the other j-unit if that one receives the shock; and $\rho = 0$ the case in which the bank does not reinvest into any unit. If the bank reinvests in an i-unit, the associated expected cost is given by q_i; if not, outside investors maximum cash flows are P_j^1 $(j \neq i)$ rather than P_G^1 with probability q_i. Hence, the $t = 0$ pledgeable income for each reinvestment policy is given by

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[19]In practice, these synergies could correspond to overall lower bonus pools and less-generous incentive payment schemes.

$$P_G^0(\rho) \equiv \begin{cases} P_G^1 - q & \text{if } \rho = 2, \\ (1-q_L)P_G^1 + q_L P_H^1 - q_H & \text{if } \rho = H, \\ (1-q_H)P_G^1 + q_H P_L^1 - q_L & \text{if } \rho = L, \\ (1-q)P_G^1 + q_L P_H^1 + q_H P_L^1 & \text{if } \rho = 0. \end{cases} \qquad (5)$$

A banking group can operate both units at $t = 0$ if and only if its pledgeable income exceeds the initial financing costs, such that $P_G^0(\rho) \geq 2$ for some reinvestment policy ρ.

To understand the optimal reinvestment consider the effect of reinvestment in an i-unit on the banking group's $t = 0$ pledgeable income. A performing unit's marginal contribution to the banking group's $t = 1$ pledgeable income is $P_i^1 + P_S^1$, which includes the incentive synergies of operating both units together.[20] If the unit contributes more than the cost of reinvestment following a shock, $P_i^1 + P_S^1 \geq 1$, we say that the unit can "fund its reinvestment." In this case reinvesting in the i-unit increases the bank's $t = 0$ pledgeable income. Otherwise, when the unit cannot fund its reinvestment, then reinvestment requires a transfer of pledgeable income from the other unitand decreases the income that can be pledged by the banking group at $t = 0$.

Lemma 2. *Reinvesting in an i-unit that receives a shock at $t = 1$ increases the banking group's $t = 0$ pledgeable income if and only if the unit can "fund its reinvestment"*

$$P_G^0(2) > P_G^0(j) \Leftrightarrow P_G^0(i) > P_G^0(0) \Leftrightarrow P_i^1 + P_S^1 > 1$$

for any i-unit, where $j \neq i$ denotes the other banking unit.

Proof. Follows from the arguments in the text and trivial algebra. $\square$

We now argue that a banking group that can operate both units at $t = 0$ will always finance the reinvestment into its H-unit. As in the case of single-unit bank, the $t = 1$ pledgeable income of a banking group with two performing units is higher than the $t = 0$ pledgeable income of a banking group that operates both units because the initial investment is subject to shocks, while the reinvestment is not: $P_G^1 > P_G^0(\rho) \, \forall \rho$. Since a bank can only operate both units if there exists a reinvestment policy ρ such that $P_G^0(\rho) \geq 2$, a necessary condition for the operation of both units is

$$P_G^1 \equiv P_H^1 + P_L^1 + P_S^1 > 2. \qquad (6)$$

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[20]If unit i receives a shock, the other unit does not.

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Intuitively, this condition captures the fact that outside investors must be willing to finance the operation of both units in the absence of any (future) shocks. Condition (6) and $P_H^1 \geq P_L^1$ together imply that the H-unit can fund its reinvestment: $P_H^1 + P_S^1 > 1$. Otherwise, the units will never be able to finance their joint operation at $t = 0$ because each unit would require a transfer of pledgeable income from the other at $t = 0$. This implies, from Lemma 2, that reinvestment in the H-unit increases the banking group's $t = 0$ pledgeable income. In turn, this implies that reinvestment in the H-unit is constrained optimal, as it creates positive NPV.

Lemma 3. *If a banking group operates both units at $t = 0$, then the H-unit can fund its reinvestment at $t = 1$ ($P_H^1 + P_S^1 > 1$), and the banking group reinvests into the H-unit when it suffers a negative shock at $t = 1$.*

Proof. This proof follows from the arguments in the text. □

We will now determine the bank's reinvestment policy for its L-unit and its initial operation decisions. Because operation and reinvestment are efficient for both units, these decisions are determined by the banks' ability to finance them. Since a two-unit banking group always reinvests in the H-unit, the bank's financing capacity is determined by $P_G^0(H)$ and $P_G^0(2)$. Moreover, if a bank can operate both units, doing so is constrained optimal because it creates positive NPV, regardless of the reinvestment policy for the L-unit. We obtain the following result.

Proposition 2. *A banking group operates both units at $t = 0$ if and only if*

$$\max\{P_G^0(2), P_G^0(H)\} \geq 2. \tag{7}$$

It always reinvests in the H-unit when it receives a negative shock at $t = 1$. It withholds reinvestment when the L-unit suffers a shock if and only if

$$P_G^0(2) < 2 \leq P_G^0(H). \tag{8}$$

Proof. This proof follows from the arguments in the text. □

We illustrate the results of this proposition in Figure 3. First, to operate both units, the pledgeable income must be sufficiently high. Second, it might be optimal not to reinvest into the L-unit following a shock in order to finance its operation in the first place. This can occur when the L-unit cannot fund its reinvestment, which thus, decreases the bank's pledgeable income at $t = 0$:
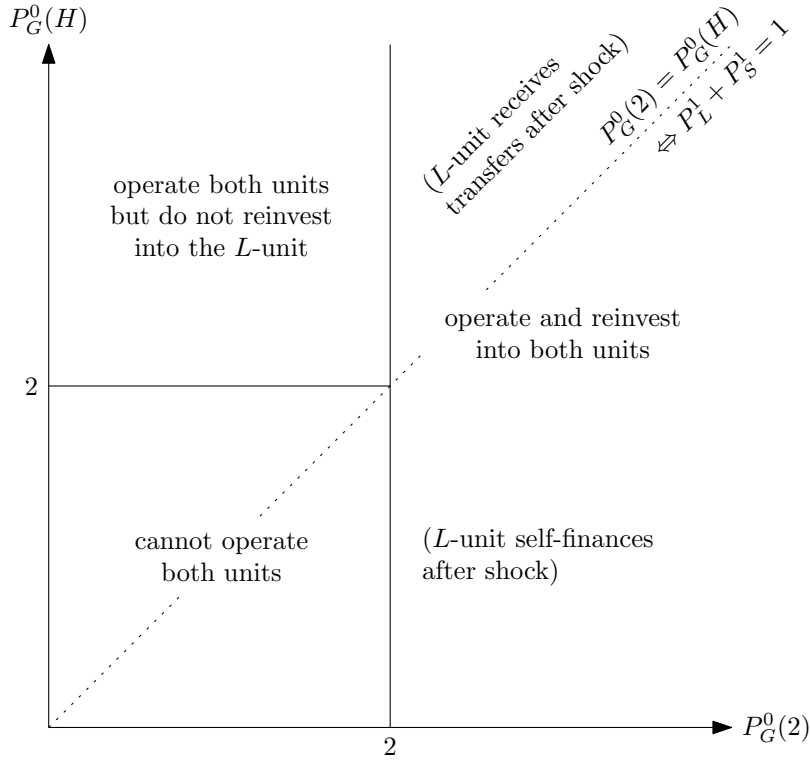
Figure 3: Constrained optimal reinvestment policies

$$P_G^0(2) < P_G^0(H) \Leftrightarrow P_L^1 + P_S^1 < 1. \tag{9}$$

If this condition is satisfied, reinvestment in the L-unit requires a transfer from the H-unit. If the expected size of this transfer $q_L(1 - P_L^1 - P_S^1)$ is large enough relative to the overall $t = 0$ pledgeable income, withholding reinvestment from the L-unit is necessary to operate both units at $t = 0$. Importantly, the reinvestment decision for the L-unit only depends on the group's joint pledgeable income as bankers are willing to make transfers between units.

3.3. Forming banking groups

Forming a banking group strictly increases efficiency when it increases investment relative to two single-unit banks. Lemma 1 shows that this is only possible when at least one i-unit lacks the pledgeable income to operate independently: $P_i^0(i) < 1$. In this case forming a banking group strictly increases efficiency when the group has sufficient pledgeable income to operate both units, regardless of whether it can reinvest in the

L-unit or not: $\max\{P_G^0(2), P_G^0(H)\} \geq 2$. We, thus, obtain the following corollary.

Corollary 1. *Forming a banking group strictly increases efficiency when at least one unit cannot operate as a single-unit bank and the banking group can operate both units.*

Proof. This proof follows from Lemma 1 and Proposition 2. $\square$

Sine we are interested in the resolution of multi-unit banking groups we will focus on the cases where a banking group can operate both units.

Assumption 4. *We assume that the banking group can operate both units:* $\max\{P_G^0(2), P_G^0(H)\} \geq 2$.

4. Resolution

This section examines the extent to which the resolution regimes can implement the constrained optimal contract described in the previous section. We show that the resolution regimes impact a bank's reinvestment policy and its ability to raise funding for its initial operations. The reason is that the resolution regime affect the regulator's ability to raise additional financing in case of a shock. Whether SPOE or MPOE resolution can implement the constrained optimum depends on a bank's constrained optimal reinvestment policy for the L-unit.[21]

At the same time, the different resolution regimes have no impact on the banks' ability to implement the incentive contracts τ^i and T_G^*. We later show in Section 4.6 that these incentive contracts can be implemented by issuing simple debt securities.[22]

4.1. SPOE resolution

An SPOE resolution regime corresponds to a single entry point at the holding company. With such a sole entry point, resolution always ensues at the holding company, all entities are resolved jointly, losses of any of the two units are mutualized, and the corporate structure does not change. As a result, upon resolution, the regulator can issue new claims backed by the cash flows of the entire banking group to finance reinvestment.

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[21]Recall that we assume that the asymmetric information problem between bank and investors is so severe that banks cannot raise sufficient financing to reinvest in units that suffered negative shocks without resolution (Assumption 1).

[22]We consider complex securities with payoffs that condition on bankers' announcements about the occurrence of a shock in Appendix A, where we analyze banks' financing in the absence of resolution. With a resolution regime in place that will restructure financial claims when bankers report a shock there is no use for such complex securities.

Because the $t = 1$ pledgeable income of a two-unit banking group must satisfy $P_G^1 > 2$ (cf. Condition 6), the regulator can always finance reinvestment, after imposing sufficient write downs on existing claims. Since the regulator maximizes NPV and reinvestment is efficient, resolution of an SPOE bank will result in reinvestment for any unit that suffers a shock.

We now show, in three steps, that the $t = 0$ pledgeable income of an SPOE bank is $P_G^0(2)$. This is the maximum possible that results from an optimal contract with reinvestment in both units. First, to maximize its financing the bank must sell securities that implement the incentive contract T_G^*. These securities are worth P_G^1 in the absence of shock.

Second, if a shock occurs, bankers have an incentive to declare so: if they hide it and forego reinvestment, their payoff from the incentive contract T_G^* will be zero because the non-performing unit will not create a positive return at $t = 2$, and the payments for a single positive return are zero $(\tau_i^* = 0)$.[23]

Third, when resolution ensues following a shock, the regulator will write down outside investors' claims to the extent that is necessary for financing reinvestment and maintaining bankers' monitoring incentives. The (initial) outside investors will, thus, obtain a payoff $P_G^1 - 1$, as bankers must retain the incentive contract T_G^* to continue monitoring. Taking into account the probability of a shock, we can derive outside investors' expected payoff at $t = 0$ and obtain following Lemma.

Lemma 4. *SPOE resolution always reinvests in any unit that suffers a shock. The $t = 0$ pledgeable income of an SPOE bank is $P_G^0(2)$.*

Proof. Follows from the arguments in the text. □

4.2. MPOE resolution

MPOE resolution encompasses different configurations of entry points. In our setting, an MPOE bank can specify entry points at the L-unit, the H-unit, or both, in addition to the holding company. These entry points determine an MPOE bank's reinvestment decisions and the amount of funding it can raise at $t = 0$.

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[23]If banker would falsely claim that a shock has occurred the regulator would discover this once resolution ensues and only take actions that are warranted by the shock that have indeed occurred, irrespective of bankers original claims. Thus, bankers never have incentive to make any false reports.

4.2.1. Entry points and reinvestment

We first consider the effect of designating a unit as an entry point on the bank's reinvestment. If bankers report a shock and the affected i-unit is *not* an entry point, resolution ensues at the holding, and it proceeds as in the previous Section 4.1, resulting in reinvestment. Conversely, if the affected i-unit is an entry point, resolution ensues at the i-unit, which gets separated from the rest of the banking group. As a result, the regulator can only pledge the i-unit's cash flows to raise funding for reinvestment and he cannot use the other unit's pledgeable income to make transfers. It follows that the regulator will only reinvest in the i-unit if its pledgeable income as a single-unit bank exceeds the cost of reinvestment: $P_i^1 > 1$. Otherwise, the i-unit becomes non-performing. We thus obtain the following lemma.

Lemma 5. *MPOE resolution will* not *reinvest in an i-unit that suffers a shock if and only if that unit is an entry point and its $t = 1$ pledgeable income is $P_i^1 < 1$.*

Proof. This proof follows from the arguments in the text. $\square$

4.2.2. Entry points and pledgeable income

We now turn to the effects of designating a unit as an entry point on the bank's pledgeable income. As in the previous Section 4.1, a bank that maximizes its financing must sell securities that implement the incentive contract T_G^*. These securities are worth P_G^1 in the absence of shock; bankers have an incentives to truthfully report shocks; and if a shock occurs to a unit that is not an entry point, then resolution ensues at the holding company and outside investors' payoff is $P_G^1 - 1$.

However, if a shock occurs to an i-unit that is an entry point, that unit gets resolved separately. If $P_i^1 < 1$, the regulator cannot finance the unit's reinvestment and outside investors' payoff from the unit is 0. Conversely, if $P_i^1 \geq 1$, the regulator restructures the claims such that it can raise sufficient financing for reinvestment and banker obtain the minimum incentive payments that ensure monitoring τ^i. Doing so minimizes the losses of outside investors, who obtain a payoff $P_i^1 - 1$ from the i-unit.

The other j-unit ($j \neq i$), will also enter resolution because the incentive contract T_G^*, with $\tau_j^* = 0$, does not ensure monitoring of a single-j-unit bank.[24] The regulator will, thus, restructure claims such that banker's obtain the minimum incentive payment that

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[24]We discuss financing contracts that avoid the resolution of the unit that does not suffer a shock in Section 4.5.

ensures monitoring τ^j, and outside investors' payoff from the j-unit is P_j^1. It follows that outside investors' total payoff is

$$\max\{P_i^1 - 1, 0\} + P_j^1. \tag{10}$$

where the maximum term accounts for the reinvestment decision.

Since outside investors break even in expectation, the effect of designating a unit as an entry point on their expected payoff at $t = 0$ corresponds to a change in the bank's $t = 0$ pledgeable income. The overall pledgeable income of an MPOE banking group can then be derived by adding the effects of designating additional entry points to the pledgeable income of an SPOE banking group, which does not designate its units as entry points, $P_G^0(2)$. We, thus, obtain the following lemma.

Lemma 6. *The pledgeable income of an MPOE banking group is*

$$P_G^0(2) + \sum_{i \in EP} q_i(\max\{1 - P_i^1, 0\} - P_S^1) \tag{11}$$

where $EP \in \{\{L\}, \{H\}, \{L, H\}\}$ denotes the units that the bank designates as entry points.

Designating an i-unit as an entry point increases the bank's $t = 0$ pledgeable income if and only if this i-unit cannot fund its reinvestment: $P_i^1 + P_S^1 < 1$.

Proof. See Appendix B.3. □

Intuitively, resolving an i-unit that suffers a shock separately has two effects on outside investors: (i) it destroys the incentive synergies P_S^1 because resolution splits up the banking group and (ii) saves outside investors from the possible losses due to reinvestment when the regulator cannot raise sufficient funding. The sum of these two effect is positive if and only if the i-unit cannot fund its reinvestment because outside investors would always make losses from providing the required financing in this case.

We know that the H-unit must be able to fund its reinvestment (cf. Lemma 3). It thus follows from Lemma 6 that MPOE resolution can only increase a bank's pledgeable income if the L-unit cannot fund its reinvestment. Otherwise designating either unit as an entry point will decrease the bank's pledgeable income. Using Expression (11) to calculate the bank's pledgeable income when it designates the L-unit as an entry point we obtain the following lemma.

Lemma 7. *MPOE resolution increases the banking groups' pledgeable income if and only if the L-unit cannot fund its reinvestment ($P_L^1 + P_S^1 < 1$) and the bank designates its L-unit subsidiary and its holding company as its entry points. In this case the bank's pledgeable income is $P_G^1(H)$.*

Proof. This proof follows from the arguments in the text. □

4.3. Efficient Resolution

We will now show that SPOE and MPOE resolution regimes can respectively implement the contained optimum depending on the constrained optimal reinvestment policy for the L-unit in Proposition 2.[25] SPOE resolution ensures that the banking group's structure remains intact, the regulator reinvests in both units, and the bank's pledgeable income is $P_G^1(2)$ (cf. Lemma 4). Hence, SPOE resolution can implement the constrained optimum when it involves reinvestment in both units: $P_G^0(2) \geq 2$. Conversely, SPOE resolution will altogether prevent the $t = 0$ operation of the L-unit when it is constrained optimal to withhold its reinvestment: $P_G^0(2) < 2 \leq P_G^0(H)$. In this case, the expected transfers of pledgeable income that the L-unit requires for its operation at $t = 0$ and its reinvestment at $t = 1$ exceed the free pledgeable income of the H-unit.

MPOE resolution can prevent the regulator from reinvesting in the L-unit by specifying it as an entry point because the L-unit cannot raise the necessary financing for its reinvestment when it gets resolved separately and $P_L^1 < 1$ (cf. Lemma 5). At the same time, MPOE resolution will be able to ensure reinvestment and preserve the group's incentive synergies in case the H-unit suffers a shock when the H-unit is *not* specified as an entry point. As a result MPOE resolution allows for a pledgeable income of $P_G^0(H)$ when the L-unit cannot fund its reinvestment (cf. Lemma 7). It follows that MPOE resolution can achieve the constrained optimum when the L-unit must not reinvest due to $P_G^0(2) < 2 \leq P_G^0(H)$.

However, when $P_G^0(2) \geq 2$, MPOE resolution can create inefficiencies in two ways. First, if it designates an i-unit with $P_i^1 < 1$ as an entry point it will prevent reinvestment in this unit. This strictly reduces efficiency as compared to SPOE. Second, if it designates an i-unit with $P_i^1 \geq 1$ as an entry point, it destroys the incentive synergies P_S^1 when the unit gets separated from the rest of the group following a shock. Thus, although resolution will lead to reinvestment at $t = 1$ the loss in incentive synergies yields a lower $t = 0$ pledgeable income $P_G^0(2) - q_i P_S^1$, which we calculate using Expression (11).

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[25]Remember that operating both units is constrained optimal due to Assumption 4.

_MPOE resolution, thus, prevents the efficient operation of the L-unit if its pledgeable income does not cover the initial investment costs when it designates an i-unit with $P_i^1 \geq 1$ as an entry point.

The above analysis of the two resolution regimes yields the following result.

Proposition 3. *The constrained optimal operation and reinvestment decisions can always be implemented by one of the two resolution regimes:*

1. *When $P_G^0(2) \geq 2$, SPOE resolution can implement the constrained optimum. SPOE resolution strictly increases efficiency over MPOE resolution if $P_G^0(2) - q_i P_S^1 < 2$ for all i such that $P_i^1 \geq 1$.*

2. *When $P_G^0(2) < 2 \leq P_G^0(H)$, MPOE resolution with the L-unit as an entry point can implement the constrained optimum. MPOE resolution strictly increases efficiency over SPOE resolution.*

Proof. This proof follows from the arguments in the text. $\square$

Whether SPOE or MPOE resolution can implement the constrained optimum thus depends on the units' pledgeable incomes and their financing synergies, as well as on the likelihood of adverse shocks that increase the future financing need of the different parts of the group. Clearly these parameters are banking group specific. It follows that a resolution framework can only ensure the implementation of the constrained optimum for all banking groups if it permits different resolution regimes for different banks.

Corollary 2. *A bank-specific choice between SPOE and MPOE resolution increases efficiency relative to the adoption of a uniform resolution regime for all banks.*

Proof. This proof follows from the arguments in the text. $\square$

In practice, SPOE and MPOE resolutions do coexist, although regulators appear to prefer SPOE. One reason for this preference could be that SPOE resolution is ex post efficient while MPOE resolution is not precisely in those instances when it increases efficiency ex ante. Hence, we argue that both SPOE and MPOE resolutions should remain part of the regulatory toolbox because either resolution regime may be more efficient ex ante, depending on the characteristics of the banking group in question.

4.4. Which banks should choose which resolution regime?

Proposition 3 allows us to derive comparative static results on when MPOE resolution is more efficient than SPOE resolution and vice versa. We argue that MPOE resolution is optimal for banking groups that operate sufficiently asymmetric units that have sufficiently diverse operations, and include weaker units facing sizable negative shocks.

To gain intuition, we revisit and rewrite the condition under which MPOE resolution optimal: $P_G^0(2) < 2 \leq P_G^0(H)$. The first inequality states that reinvestment into the L-unit after a shock must not be feasible. Rewriting this inequality as

$$q > P_G^1 - 2$$

shows hat the probability of a negative shock q must be high enough relative to the banking group's $t = 1$ pledgeable income P_G^1 net of the initial investment costs. The second inequality states that withholding reinvestment in the L-unit must free up enough pledgeable income so that the bank can operate both units at $t = 0$. Rewriting this inequality as

$$P_G^0(H) - P_G^0(2) \geq 2 - P_G^0(2) \Leftrightarrow q_L(1 - P_L^1 - P_S^1) \geq 2 + q - P_G^1$$

shows that, MPOE resolution is optimal if, for given P_G^1, P_S^1 and q, the L-unit's $t = 1$ pledgeable income P_L^1 is low and the probability that the unit suffers a shock q_L is high.

We summarize this discussion in the following corollary.

Corollary 3. *MPOE resolution is constrained optimal for a banking group if and only if*

1. *the probability of a shock q is high enough and the $t = 1$ pledgeable income P_G^1 is low enough.*

2. *for a given shock probability q, $t = 1$ pledgeable income P_G^1, and incentive synergies P_S^1, the L-unit's $t = 1$ pledgeable income P_L^1 is low enough and the probability that the unit suffers a shock q_L is high enough..*

Proof. This proof follows from the arguments in the text. □

Another important implication of Proposition 3 is that MPOE resolution is only more efficient than SPOE resolution if the two units are asymmetric: Otherwise, the two units must have the same pledgeable incomes $P_H^1 = P_L^1$ and Lemma 3 implies that both

units must be able to fund their reinvestment. In this case, Lemma 2 implies that $P_G^0(2) \geq P_G^0(H)$ and it follows from Assumption4 that SPOE resolution is optimal. We obtain the following corollary.

Corollary 4. *Symmetric banking groups should always choose SPOE resolution. A necessary condition for MPOE resolution is that the two banking units are asymmetric.*

Proof. This proof follows from the arguments in the text. $\square$

Our model has several dimensions of asymmetry: the probability with which each unit receives a shock q_i for a given overall shock probability q, and the units' pledgeable incomes P_i^1, which in turn depend on the units' risk and return characteristics, p_i^m, Δp_i, and R_i. Note that asymmetry between the units also lowers the banking group's incentive synergies, P_S^1, and thus a banking group's overall financing capacity (cf. Proposition 1, Part 3). This effect further strengthens the association between asymmetric banking units and MPOE resolution, since MPOE resolution is efficient when a banking group's pledgeable income is too low to finance reinvestment in the L-unit.

4.5. Avoiding resolution

In our framework, resolution has no direct costs. More generally though, resolution can be costly, in which case it becomes relevant whether banking groups can limit the occurrence of resolution following a negative shock to one of their units.

Resolution is necessary when it is constrained optimal to reinvest in a unit that suffered a shock, because reinvestment can only be financed through resolution that verifies if and where a shock has occurred. In contrast, if it is constrained optimal not to reinvest in the L-unit after a shock, then the only function of resolution is to restructure claims of the remaining part of the banking group to ensure that bankers will monitor the H-unit. Thus, resolution would not be necessary if the original financing creates an incentive contract that ensures monitoring of the H-unit after the L-unit becomes non-performing.

To see how a bank may avoid resolution following a shock while implementing the constrained optimum, consider a bank under MPOE resolution with its holding company and L-unit as entry points. If the L-unit becomes non-performing following a shock, bankers have an incentive to monitor the H-unit if the banking group's incentive contract includes a payment $\tau_H \geq \tau^H$ in case only the H-unit generates a return at $t = 2$. In this case, there is no reason to resolve the holding company and the H-unit because there is

no need to restructure the bank's finances.[26] Still, the entire banking group would enter resolution in case the H-unit receives a shock.

However, implementing an incentive contract with $\tau_H \geq \tau^H$ decreases the group's financing capacity because it cannot exploit the incentive synergies of forming a banking group P_S^1 in the absence of a shock. The following lemma describes the associated loss in pledgeable income and the bank's maximum financing capacity.[27]

Lemma 8. *Consider an MPOE bank with its holding company and the L-unit as entry points that issues claims at $t = 0$ such that bankers monitor (i) the the H-unit in case the L-unit becomes non performing and (ii) both units in the absence of shock. The bank maximizes its financing capacity with an incentive contract $T_G = (\tau_L, \tau_H, \tau_2) = (\tau^L, \tau^H, \tau^L + \tau^H)$ and has a pledgeable income of $P_G^0(H) - (1 - q_L - q_H)P_S^1$.*

Proof. See Appendix B.4. □

Thus, a bank can only implement the constrained optimum and avoid resolution when the L-unit suffers a shock if (i) it has sufficient excess pledgeable income if it does not reinvest into the L-unit and (ii) reinvestment into the L-unit is ex ante not desirable. In all other instances avoiding resolution would prevent reinvestment (that is constrained efficient) or the banking group's initial operation. Since bankers are the residual claimants they will not avoid resolution if it creates major inefficiencies.

Proposition 4. *A bank can implement the constrained optimum and avoid resolution in case its L-unit receives a shock when*

$$P_G^0(H) - (1 - q_L - q_H)P_S^1 \geq 2 > P_G^0(2).$$

Otherwise, a bank can only implement the constrained optimum if it enters resolution following a shock.

Proof. Follow from Lemma 8 and the discussion in the text. □

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[26]Indeed, when the L-unit receives a shock bankers are actually indifferent about announcing the shock to trigger resolution of the L-unit. Since the L-unit does not receive reinvestment whether it enter resolution or not the outcome in our model is the same. Thus, the value of resolution this case depends on whether resolving a non-performing banking unit is more or less costly than keeping the unit as part of the original banking group - which we do not model.

[27]We show how a financing contract with $\tau_H \geq \tau^H$ that maximizes a bank's pledgeable income can be implemented by issuing simple debt claims in Section 4.6.

4.6. Debt securities and incentives

We now show that, although our model does not restrict the set of financial contracts, the incentive contracts τ^i and T_G^* that maximize banks' financing can be implemented by issuing simple debt securities. To see this, suppose that the banking group's holding company issues debt with a face value F that matures at $t = 2$, bankers hold the holding's equity, and no outside claims are issued at the subsidiary units. Setting $F = R_i - \tau^i$ implements the contract that pays τ^i in case of success for a single-unit bank. Similarly, setting $F = R_H + R_L - \tau_2^*$ implements the contract T_G^*. (The monotonicity constraint (3) ensures that $F = R_H + R_L - \tau_2^* \geq \max\{R_i\}$.) In resolution, the regulator can implement the same incentive contracts by writing down (some of) the existing debt and issuing new debt with the same characteristics. Simple debt securities can, thus, pledge the maximum possible income to outside investors at $t = 1$.

Finally, consider the incentive contract that allows a banking group to avoid resolution, as discussed in Section 4.5. The banking group can implement the incentive contract $(\tau_L, \tau_H, \tau_2) = (\tau^L, \tau^H, \tau^L + \tau^H)$ by issuing external debt at its subsidiary units. To do so the bank must issue debt with face value $F_H = R_H - \tau^H$ at the H-unit, debt with face value $F_L = R_L - \tau^H$ at the L-unit, and not issue any external claims at the holding company, such that bankers hold all claims there.

5. Policy and Empirical Implications

This section presents a number of policy and empirical implications of our model. First, our model predicts which banking groups should prefer MPOE over SPOE and vice versa. Second, our model has implications how MPOE banks should choose their entry points. Third, the model provides insights on how resolution and a given resolution regime affect the future investment decisions of banking groups. Fourth, the model envisages the possible consequences of a (sudden) change in economic conditions, for instance, as a result of a crisis. Finally, the model generates predictions about the viability/feasibility of the different resolution regimes in national and cross-border contexts.

5.1. Choice of resolution regimes and entry points

Our model predicts which banking groups should favor SPOE and MPOE, respectively. Corollaries 3 and 4 show that three features make a banking group more likely to choose MPOE resolution: First, units must be sufficiently asymmetric. This is likely to hold

for units with heterogeneous operations, different scopes, and different competencies (such as investment and commercial banks) or geographic focuses. Second, the banking group's weak units must have large expected financing deficits with a relevant impact on the group's financing capacity. This is likely to be the case when the banking group's risky units are large relative to its strong units. Third, the group's overall riskiness must be sufficiently high relative to its expected return, to constrain its investment. This is more likely to happen when the group's overall profitability is low. We thus make the following prediction.

Prediction 1. *A banking group is more likely to choose MPOE over SPOE if (i) it consists of heterogeneous units, with different scopes, and different competencies or geographic focuses, (ii) it encompasses large risky units, and (iii) its overall profitability is low.*

Our model also predicts that the efficiency of MPOE resolution relies on the asymmetric treatment of different parts of a banking group. Lemma (7) shows that only those units should serve as entry points whose financing deficits in case of a shock can be large enough so that they can endanger the (ex-ante) funding of the banking group. This will be the case for large risky units.[28] At the same time, other parts of the banking group must not be entry points to preserve synergies when these units suffer shocks that lead to resolution.

Prediction 2. *A banking group opting for MPOE resolution should specify entry points at its large risky units, enabling their separate resolution. Strong units should not be entry points so that resolution after a shock to these units can preserve the group structure.*

HSBC (2021) provides one example of such a structure. The banking group specifies its holding company and its U.S. and Asian operations as separate individual entry points (using intermediate holding companies for these activities), while its other subsidiaries, including its European operations, are not entry points. Hence, shocks to its U.S. or Asian operation may trigger a separate resolution of these parts, while shocks to its European operations will preserve the banking group's structure.

Other banks, particularly in Europe, achieve a similar outcome with a parent bank that is itself an operating unit and owns further operating subsidiaries. A negative shock to the parent will then lead to the joint resolution of the entire group, while operating

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[28]If there are several layers of legal entities, as in the case of intermediate holding companies, a part of the banking group can be resolved separately if there exists an entry point between the parent bank and operating unit that suffers a negative shock.

subsidiaries that are specified as entry points will be resolved separately if they receive a shock. Santander (2021), for example, consists of a parent bank, which includes its Spanish operations, and large international subsidiaries that are separate entry points.

5.2. Financing and investment decisions

The choice of a resolution regime will affect banks' future investment decisions (including M&A activities). The reason is that SPOE banks' outside investors are more exposed to the risks of new investments than are the investors of MPOE banks. Indeed, the former will more likely be bailed-in to reinvest into weak units. Thus, SPOE banks will find it more difficult than MPOE banks to finance large, risky units with potentially high financing deficits. Because MPOE banks can commit not to reinvest into failing units, they will be more capable of financing such large, risky units.

Naturally, these arguments depend on resolution regimes being fixed in the short to medium terms. However, resolution planning and regulatory approval are lengthy processes that make it difficult for banks to quickly adjust their resolution regimes.

Prediction 3. *MPOE banks are more likely than SPOE banks to finance large, risky investments with potentially high financing deficits.*

Our model also provides predictions on what may happen to an existing bank if economic conditions change. Consider, for instance, an economic crisis, in which the profitability of the banking units is likely to decrease and the probability of negative shocks is likely to increase. In turn, the potential financing deficits of the bank's weak units increase.

SPOE banks are likely to curtail investments into weak units when their risks increase, in order to reduce their exposure. This effect will be amplified by decreasing profitability that increases the weak units' financing deficits and decreases overall financing capacity. In extreme cases, SPOE banks may find it necessary to divest their weak units. The effects for MPOE banks are likely to be muted because their weak units will be resolved separately, and, thus, the banking group is partially protected from increases in riskiness.

Prediction 4. *In a crisis, when risks increase and profitability decreases, MPOE banks are less likely to curtail investment into weak units than are SPOE banks.*

5.3. Cross-border banking and regulatory commitment

MPOE resolution in our setting requires regulators not to use the H-unit's pledgeable income for transfers to the L-unit when it suffers a negative shock. This requirement prevents reinvestment into the L-unit, even though reinvestment would be efficient ex post. In reality, regulators may not be easily able to rule out transfers and commit to withholding reinvestment from units for which the are responsible.[29] But, without such commitment, MPOE resolution loses its raison d'être.

In a cross-border context, however, regulators may more easily be able to refuse transfers to units outside of their own jurisdiction. Thus, when banks spread their activities across multiple jurisdictions, this might serve as a credible commitment against reinvestment into weak units in case of a shock. As a result, MPOE resolution may be more viable in a cross-border context (where it is, actually, predominantly observed).

In addition, cross-border banks are more likely to include asymmetric units, some of which can be weaker and riskier, especially when their operations are located both in developed and in developing countries. As explained in Section 5.1, such banking groups will typically prefer MPOE resolution.

Prediction 5. *Cross-border banking groups are more likely to choose MPOE resolution than are banking groups operating within national borders.*

Finally, assuming that national regulators cannot commit to MPOE resolution strategies for banking groups operating within national borders, our model has predictions for banks' cross-border activities and asset allocation choices. MPOE banks might be more willing to engage in cross-border activities because they are partially protected from the risks associated with these activities. Banks may even opt to strategically spread their activities and assets across borders in order to make an MPOE resolution strategy credible by exploiting national regulators' reluctance to make cross-border transfers.

Prediction 6. *Banks that prefer MPOE are more likely to spread their activities and assets across borders.*

A similar prediction appears in Faia and Weder di Mauro (2016) who argue that MPOE bank may increase their cross–border activities because they can limit their exposure to foreign losses.[30] Our argument differs from that of Bolton and Oehmke (2019),

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[29]The FDIC in the United States, for example, requires bank holding companies to serve as a "source of strength" for their bank subsidiaries (Title 12 of the U.S. Code §1831)). As of 2009, the US requires foreign banks to establish intermediate holding companies for their U.S. activities in order to facilitate their supervision and resolution (Federal Reserve, 2019).

[30]Bebchuk and Guzman (1999) make related arguments in the context of cross-border bankruptcies.

who see MPOE resolution as the result of a coordination problem between different regulators. In their model, SPOE resolution is efficient because it provides diversification benefits and preserves operating synergies. But national regulators are unable to commit to SPOE resolution in a cross-border setting because doing so would involve ex post transfers across jurisdictions. Furthermore, a lack of coordination among national regulators can result in an ex ante sub-optimal choice of MPOE, even when regulators can commit to ex post transfers. Instead, we argue that coordination failures between regulators actually might be important to make MPOE resolution credible.

6. TLAC

Global systemically important banks (G-SIBs) are required to have certain financial instruments available to absorb potential losses during resolution, the so-called "total loss-absorbing capacity" (TLAC). The purpose of TLAC is to ensure that bank losses can be absorbed by debt and equity holders as part of a bail-in. The aim of both translates into an orderly resolution and recapitalization of the bank and avoids a bail-out with public funds. To ensure that a bail-in is always possible, the bank's TLAC must be able to absorb the highest level of possible losses (FSB, 2015). In the European Union, all banks (not just G-SIBs) are subject to a so-called "minimum requirement for own funds and eligible liabilities" (MREL), which serves the same purpose as TLAC (SRB, 2021).

In our setup, we define TLAC as the maximum amount of losses outside investors will need to absorb in the event of resolution. We measure these losses as the difference between the value of the outside investors' claims at $t = 0$ (equal to two) and the value of their claims following resolution. This definition excludes the losses bankers suffer in resolution. We account for losses at the group level and do not separately account for the banking units' losses. This corresponds to a financing structure where TLAC is centrally issued at the holding level and the individual units' TLAC is provided by the holding company in the form of so-called "internal TLAC" (cf. FSB, 2015). Such central issuing of TLAC allows banks to reduce the amount of TLAC they issue due to diversification benefits among units.

Clearly banks' required loss absorption capacity depends on the sizes of their units' shocks. In this section we, thus, allow the two units to suffer from different shock sizes s_L and s_H, respectively (rather than a uniform shock size s). In this setup, we will distinguish strong and weak units according to their excess pledgeable incomes in case of

a shock at $t = 1$: $P_H^1 - s_H \geq P_L^1 - s_L$ (rather than $P_H^1 \geq P_L^1$ in Assumption 2). Note that, the results of our main model continue to hold as long as each unti's shock size is smaller than the units' $t = 0$ expected costs of operating and reinvesting: $s_i < (1 + q_i s_i)$. This condition ensures that reinvestment following a shock creates a positive NPV whenever the unit's investment creates positive NPV (cf. Section 2.5). It follows further that for a banking group that can operate both units $P_H^1 + P_S^1 > s_H$, and it is always constrained optimal to reinvest in the H-unit (cf. Lemma 3).

Outside investors' losses depend on the banking groups reinvestment decisions. If an i-unit receives reinvestment after a shock, its expected payoff is given by $P_G^1 - s_i$. If it doesn't , its expected payoff is P_j^1, where $j \neq i$ denotes the remaining unit. Since outside investors provide two units of financing at $t = 0$ and break even in expectation, their losses are given by $2 - (P_G^1 - s_i)$ and $2 - P_j^1$, respectively. It follows that reinvestment in an i-unit increases outside investors' losses if and only if the unit cannot fund its reinvestment: $P_i^1 + P_S^1 < s_i$.

SPOE resolution reinvests into either unit following a shock. Thus, the maximum losses outside investors must be ready to absorb are

$$\max\{2 - (P_G^1 - s_H), 2 - (P_G^1 - s_L)\}. \tag{12}$$

where the to terms correspond to the H-unit and the L-unit suffering a shock, respectively.

An MPOE bank does not reinvest in an i-unit if (i) the unit is an entry point and (ii) its pledgeable income $P_i^1 < s_i$. It follows that designating an i-unit as an entry point reduces outside investors losses when the unit cannot fund its reinvestment: $P_H^1 + P_S^1 < s_H$. Otherwise it increases their losses. Since $P_H^1 + P_S^1 > s_H$, MPOE resolution can reduce outside investors' losses if and only if $P_L^1 + P_S^1 < s_L$ and the L-unit is designated as an entry point. In this case the maximum losses outside investors must be ready to absorb are

$$\max\{2 - (P_G^1 - s_H), 2 - P_H^1\}. \tag{13}$$

Comparing the terms in Expressions (12) and (13), we obtain the following result.

Proposition 5. *MPOE resolution requires* less *loss absorption capacity than SPOE resolution if and only if* $P_L^1 + P_S^1 < s_L$ *and* $s_H < s_L$.

Proof. Follows from the arguments in the text. $\square$

MPOE resolution thus reduces TLAC if (i) it reduces outside investors' losses from

shocks to the L-unit by withholding reinvestment and (ii) shocks to the L-unit cause higher losses than shocks to the H-unit and thus, determine the overall required loss absorption capacity. Note that withholding reinvestment from the L-unit destroys the associated (positive) NPV and, thus, increases overall losses. However, part of these losses is borne by the bankers, who loose their agency rents for monitoring the L-unit. In SPOE resolution, bankers do not lose their agency rents as both units receive reinvestment after a shock, and, therefore, existing outside investors absorb the losses. Thus, MPOE resolution reduces the losses outside investors need to absorb by changing the distribution of losses between bankers and outside investors.

A common argument is that SPOE resolution requires less loss absorption capacity than does MPOE (e.g., in Bolton and Oehmke, 2019). The reason is that SPOE banks can share the same loss absorption capacity across multiple units. In contrast, MPOE banks require separate loss absorption capacity in each unit and thus cannot benefit from diversification. However the the use of internal TLAC provided by the holding company (cf. FSB, 2015) allows both SPOE and MPOE banks to share their loss absorption capacity across units because the individual units' TLAC.[31] MPOE banks may in practice fail to share their loss absorption capacities across units when they raise their external financing through their subsidiaries and, thus, require more loss absorption capacity. Still, MPOE banks might need less loss absorption capacity than do SPOE banks because of the limits MPOE resolution imposes on outside investors' losses.

7. Conclusions

This paper analyzes how the choice of resolution regimes affects banking groups' financing and investment decisions. SPOE resolution mutualizes banking groups' losses, which allows for ex post efficient reinvestment in weak units that enables them to continue following a negative shock. However, loss mutualization increases the losses outside investors must bear in the case of shocks due to agency frictions. As a result, SPOE resolution can prevent financing of ex ante efficient investment opportunities. MPOE resolution separately resolves banking units and prevents transfers from strong to weak units. As a result, MPOE resolution will prevent reinvestment in weaker units and ultimately force them to shut down after a negative shock. This in turn limits outside investors' losses and can increase ex ante (efficient) investment.

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[31]Note that diversification can only reduce the maximum possible losses in literal sense if units' losses exhibit perfect negative correlation, which is the assumption in Bolton and Oehmke (2019) and our paper.

MPOE resolution increases efficiency for banking groups with sufficiently asymmetric units, which can, for example, result from units with heterogeneous business lines and/or diverse geographic footprints. For a given resolution regime, Banks opting for MPOE will be more likely to make large and risky investments and less likely to curtail investments in crises periods compared to SPOE banks.

To achieve efficiency, MPOE banks should designate their weak units as separate entry points to make sure that weak units are resolved separately in case they experience a negative shock. If an MPOE bank does not depend on incentive synergies between units for obtaining financing, it can avoid resolution following shocks to any of its units that would not receive reinvestment. This can reduce any possible direct and indirect costs that are associated with resolution (which we do not model, though). MPOE banks may also require less TLAC than SPOE banks because MPOE resolution limits outside investors' losses from reinvestment in weaker units.

Our model suggests that the coexistence of both resolution regimes in the regulatory tool kit increases economy wide efficiency relative to the adoption of a uniform resolution regime for all banks. This supports the current regulatory practice of allowing banks to choose between MPOE and SPOE resolution subject to regulatory approval. MPOE resolution plans may, however, suffer from regulatory commitment problems when they prevent regulators from reinvesting in units that suffer negative shocks and ultimately force these units to shut down. One way to circumvent these commitment problems could be to engage in cross border activities in order to exploit regulators' reluctance to make transfers across jurisdictions. Limiting regulator's ability to make transfers ex post would be even more important when, unlike in our model, regulators have strict preference for reinvestment in order to continue banking operations even when doing so is inefficient ex post.

A. Contracting in the Absence of Resolution

This appendix develops an extension to show under which conditions resolution is essential, in the sense that reinvestment would not occur without a resolution framework. More precisely, we provide conditions under which capital markets would not provide sufficient funding at $t = 0$ if the regulator is not involved at $t = 1$.

A.1. Model extension

We extend our model from Section 2 by introducing the possibility that bankers can misappropriate funds. We assume that if bankers raise additional funds at $t = 1$ in the absence of any shock, they can take a hidden action that uses these funds to create a non-pecuniary private benefit $b < 1$.[32] Because $b < 1$, raising and misappropriating funds in the absence of a shock is inefficient. The threat of misappropriation creates an agency problem between bankers and outside investors.

In the presence of resolution, the possibility of misappropriation does not alter the results of our main model. The reason is that bankers can never raise excess funds for misappropriation because resolution allows the regulator to verify whether a shock has occurred. In the absence of resolution, however, implementing efficient reinvestment policies and avoiding misappropriation at the same time will only be possible if bankers have incentives to truthfully report the occurrence of shocks. We show that, while appropriate financial contracts lead to truthful reporting, they are costly, lower the returns that can be pledged to investors, and can thus prevent bank financing.

As in Section 3 we analyze the design of an optimal contract at $t = 0$ that specifies a bank's operation decisions at $t = 0$, the reinvestment decision at $t = 1$, and the distribution of cash flows at $t = 2$. Contrary to Section 3.1, the occurrence of a shock at $t = 1$ is bankers' private information and not contractible, due to the absence of a resolution process that serves as a verification device. Instead the provision of funds and the distribution of cash flows will depend on a "message" about the occurrence of a shock that bankers can send to outside investors.

Bankers, who are the residual claimants, will choose a financing contract at $t = 0$ that maximizes NPV, subject to the outside investors' break even condition. Since there is symmetric information at $t = 0$ this is a mechanism design problem and we exploit the revelation principle to focus on contracts where bankers are given incentives to truthfully report whether a shock has occurred and which unit has been affected. Moreover, bankers will never choose a contract that involves misappropriation of funds as it involves an inefficient destruction of resources. For the same reason, bankers will never choose a contract that does not provide monitoring incentives on the equilibrium path, where bankers truthfully reveal their private information.

We introduce the following notation. For a single-i-unit bank, a message $\mu = 0$ indicates that the bankers claim that the banking unit has not suffered a shock whereas

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[32]For tractability we do not consider the possibility of misappropriation if a shock occurs. Doing so would complicate the analysis without providing additional insights.

$\mu = i$ indicates that they claim it has suffered a shock. Bankers' payments at $t = 2$ are given by $\tau(\mu)$ in case of a positive return (zero in case of zero return), where the payments now depend on the message μ that bankers send. A reinvestment policy $\rho = i$ indicates that outside investors provide additional funds at $t = 1$ when bankers claim that a shock occurred whereas $\rho = 0$ indicates that outside investors do not provide such funds despite bankers claiming that the shock has occurred.

Similarly, for a banking group a message $\mu = 0$ indicates that bankers claim no shock occurred and $\mu = i$ indicates that they claim the i-unit of the group suffered a shock. Bankers' payments at $t = 2$ are given by $T_G(\mu) \equiv (\tau_L(\mu), \tau_H(\mu), \tau_2(\mu))$ for $\mu \in \{0, H, L\}$, where the subscripts denote the unit or units with positive returns, as in the main text. A reinvestment policy $\rho = 2$ indicates that investors provide additional funds when bankers claims that either unit has suffered a shock, $\rho = i$ indicates that investors provide additional funds if and only if bankers claim that the i-unit suffers a shock, and $\rho = 0$ indicates that investors never provide additional funds.

A.2. Single-unit banks

In the absence of resolution bankers need incentives to truthfully reveal the occurrence of shock, in addition to monitoring incentive. Bankers' truth telling incentives will depend on the banks reinvestment policy, which determines bankers' opportunities for misappropriation.

First, consider a bank that reinvests in case its bankers claim it has suffered a shock ($\rho = i$). In this case, the contract must ensure that bankers do not have incentives to falsely report a shock ex post, in order to raise and misappropriate funds from outside investors. Such truth telling will be incentive compatible when bankers' compensation in case no shock occurs exceeds the benefits of misappropriation they forego. We thus obtain the incentive compatibility constraint

$$p_i^m \tau(0) \geq p_i^m \tau(i) + b \tag{14}$$

where we assume that bankers monitor on the equilibrium path. Bankers always have incentives to truthfully report when a shock occurs because their payoff is zero when the bank's single unit becomes non performing.

The truth-telling constraint (14) implies that bankers will earn an information rent in case the bank does not receive a shock. This rent will equal the expected benefit of misappropriation the bankers could obtain from falsely reporting shocks $(1 - q_i)b$. These

rents reduce the bank's pledgeable income from a pure market solution $P_i^M(i)$ relative to the bank's pledgeable income in the presence of resolution $P_i^0(i)$, which we derive in the main text. As a result, the bank's ability to finance reinvestment is reduced.

Second, consider a bank that does not reinvest when its bankers claim that it has suffered a shock: $\rho = 0$. In this case, outside investors never provide additional funds and there will never be an opportunity to misappropriate funds. Hence, bankers' truth-telling constraints will not be binding, bankers do not earn any truth telling rents, and $P_i^M(0) = P_i^0(0)$.

Combing the two cases we obtain the following result.

Lemma 9. *In the absence of resolution, the $t = 0$ pledgeable income of a single-unit bank is*

$$P_i^M(\rho) = \begin{cases} P_i^0(i) - (1 - q_i)b & \rho = i \\ P_i^0(0) & \rho = 0. \end{cases}$$

The bank cannot finance reinvestment when $P_i^M(i) = P_i^0(i) - (1 - q_i)b < 1$.

Proof. See Appendix B.5 □

A.3. Banking groups

With two banking units, bankers' messages contain two types of information. They report (i) whether a shock has occurred or not and (ii) which unit has suffered the shock. As in the single-unit case, the contract must ensure that bankers do not have incentives to falsely report a shock in order to raise and misappropriate funds. The contract must provide these incentives whenever there is reinvestment following a shock to one of the two units ($\rho \in \{H, L, 2\}$). As in the single-unit case, the associated agency rent will equal the expected benefit of misappropriation the bankers could obtain from falsely reporting shocks in their absence $(1 - q)b$.

Unlike the single-unit case bankers have the possibility to misreport which of the two units has actually suffered the shock. Thus, if the reinvestment policy only provides reinvestment for the H-unit ($\rho = H$), the contract must ensure that bankers do not falsely report a shock to the H-unit when the L-unit suffer a shock, in order to obtain financing to reinvest in the L-unit. Because the L-unit becomes non-performing and does not require monitoring when it does not receive reinvestment, the associated incentive compatibility constraint is

$$p_H^m \tau_H(L) - c \geq p_H^m p_L^m \tau_2(H) + p_H^m(1 - p_L^m)\tau_H(H) + (1 - p_H^m)p_L^m \tau_L(H) - 2c. \tag{15}$$

where we again assume that bankers monitor on the equilibrium path.

The truth-telling constraint (15) implies that for the reinvestment policy $\rho = H$ the bankers will earn an information rent if the L-unit receives a shock. The size of this rent will equal the expected gain, in the bankers minimum payoff, from monitoring both units (which they do following a shock to the H-unit) rather than only the H-unit (which they do following a shock to the L-unit): $q_L[(p_H^m p_L^m \tau_2^* - 2c) - (p_H^m \tau^H - c)]$, which can be rewritten as

$$q_L(p_H^m p_L^m \tau_2^* - p_H^m \tau^H - c).$$

Crucially, Condition (15) implies that bankers' compensation when the L-unit receives a shock must be at least as high as when the H-unit receives a shock and receives reinvestment. But, when bankers' compensation does not decrease as a result of withholding reinvestment from the L-unit outside investors gains from withholding reinvestment from the L-unit are smaller or equal to the change in NPV $1 - p_L R_L$, which is negative. Intuitively, outside investors could only gain from withholding reinvestment from the L-unit at the expense of bankers, who loose monitoring rents, which is not possible when bankers can misreport which unit has suffered a shock. It follows that the pledgeable income must be higher when the there is reinvestment in both units rather than only the H-unit: $P_G^M(2) > P_G^M(H)$. Clearly, analogous arguments apply in case there is only reinvestment in the L-unit ($\rho = L$).

It follows that the bank can only operate both units when it has enough pledgeable income to be able to reinvest into both units when bankers obtain rents to prevent misappropriation in the absence of shocks.

Lemma 10. *In the absence of resolution, the $t = 0$ pledgeable income of a banking group is*

$$P_G^M(\rho) \equiv \begin{cases} P_G^0(2) - (1-q)b & \text{if } \rho = 2, \\ P_G^0(H) - (1-q)b - q_L(p_H^m p_L^m \tau_2^* - c - p_H^m \tau^H) & \text{if } \rho = H \\ P_G^0(L) - (1-q)b - q_H(p_L^m p_H^m \tau_2^* - c - p_L^m \tau^L) & \text{if } \rho = L, \\ P_G^0(0) & \text{if } \rho = 0. \end{cases}$$

The banking group cannot finance reinvestment into any unit ($\rho \neq 0$) when $P_G^M(2) < 2$.

Proof. See Appendix B.6 □

A.4. Essential resolution

Banks that reinvest ($\rho \neq 0$) in the absence of resolution have a lower $t = 0$ pledgeable income than in the presence of resolution (cf. Lemmas 9 and 10). When this decrease prevents banks from financing reinvestment without resolution Assumption (1) in the main text is satisfied. This case occurs when bankers private benefits from misappropriating funds b are large enough such that neither a banking group nor a single-unit bank can finance itself at $t = 0$ when it chooses to reinvest following a shock at $t = 1$. These different types of banks are captured by the maximum term in the following proposition.

Proposition 6. *Banking groups and single-unit banks cannot finance reinvestment in the absence of resolution when*

$$b > \max \left\{ \frac{P_G^0(2) - 2}{1 - q}, \frac{P_H^0(H) - 1}{1 - q_H}, \frac{P_L^0(L) - 1}{1 - q_L} \right\}.$$

Proof. Follows from Lemmas 9 and 10. □

As we have mentioned earlier, banks ability to finance themselves in the presence of resolution regime is not affected by b because the regulator can verify whether a shock has occurred and which unit is affected. Thus, bankers can never raise funds for misappropriation or for reinvestment into a unit that should not receive it. Hence, in the presence of resolution, the extended model yields the same trade-offs results and expressions as the simplified model we use in the main text.

B. Proofs

B.1. Lemma 1

Inspection of $P_i^0(\rho)$ shows that (i) $P_i^0(\rho) < P_i^1$ for any reinvestment policy ρ and (ii) $P_i^0(i) \geq P_i^0(0) \Leftrightarrow P_i^1 \geq 1$. The bank can operate the i-unit as a single-unit bank if and only if there exists a reinvestment policy $\rho \in \{i, 0\}$ such that $P_i^0(\rho) \geq 1$. From (i) and (ii) above it follows that for all ρ

$$P_i^0(\rho) \geq 1 \Rightarrow P_i^1 > 1 \Rightarrow P_i^0(i) \geq P_i^0(0).$$

It follows that when a bank can operate it can also refinance following a shock. Since refinancing creates positive NPV it is contained optimal to do so.

B.2. Proof of Proposition 1

Proof of Part 1. In order to show that $\tau_2^* > 0$ and $\tau_H^* = \tau_L^* = 0$ minimizes bankers' compensation, we first show that for any incentive contract (τ_L, τ_H, τ_2) that satisfies the three IC constraints (IC:L,IC:H,IC:0) there exists another incentive contract $(0, 0, \tau_2')$ that yields the same expected compensation and satisfies the IC constraints. The contract $(0, 0, \tau_2')$ yields the same expected compensation when it satisfies

$$p_H^m p_L^m \tau_2' = p_H^m p_L^m \tau_2 + p_H^m (1 - p_L^m) \tau_H + (1 - p_H^m) p_L^m \tau_L.$$

To check that the resultant contract $(0, 0, \tau_2')$ satisfies the IC constraints, first note, that the left-hand-side of the IC constraints does not change by construction. Second, substituting the contracts $(0, 0, \tau_2')$ and (τ_L, τ_H, τ_2) into the IC constraints (IC:L,IC:H,IC:0) shows that their respective right-hand-sides decrease:

$$p_H p_L^m \tau_2' - c - (p_H p_L^m \tau_2 + p_H (1 - p_L^m) \tau_H + (1 - p_H) p_L^m \tau_L - c) = -\Delta p_H \frac{p_L^m}{p_H^m} \tau_L$$

$$p_H^m p_L \tau_2' - c - (p_H p_L^m \tau_2 + p_H (1 - p_L^m) \tau_H + (1 - p_H) p_L^m \tau_L - c) = -\Delta p_L \frac{p_H^m}{p_L^m} \tau_H$$

$$p_H p_L \tau_2' - (p_H p_L \tau_2 + p_H (1 - p_L) \tau_H + (1 - p_H) p_L \tau_L) = -\Delta p_L \frac{p_H}{p_L^m} \tau_H - \Delta p_H \frac{p_L}{p_H^m} \tau_L.$$

We now derive the lowest incentive payment τ^* such that $(0, 0, \tau_2^*)$ satisfies the three IC constraints. Clearly at least one IC constraint must be binding.[33] First, suppose that the (IC:L) constraint is satisfied with equality which yields

$$p_H^m p_L^m \tau_2^* - 2c = p_H p_L^m \tau_2^* - c \Rightarrow \tau_2^* = c(\Delta p_H p_L^m)^{-1}$$

It is easy to show that this compensation contract satisfies the other IC constraints if and only if

$$\Delta p_H p_L^m \leq p_H \Delta p_L. \tag{16}$$

Second, when the (IC:H) constraint is binding

$$p_H^m p_L^m \tau_2^* - 2c = p_H^m p_L \tau_2^* - c \Rightarrow \tau_2^* = c(\Delta p_L p_H^m)^{-1}$$

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[33]Unlike in Laux, 2001 it is possible that one of the IC constraints for monitoring a single unit (IC:L,IC:H) is binding because of the units' asymmetry.

and the other IC constraints are satisfied if and only if

$$\Delta p_L p_H^m \leq p_L \Delta p_H. \tag{17}$$

Third when the (IC:0) constraint is binding

$$p_H^m p_L^m \tau_2^* - 2c = p_H p_L \tau_2^* \Rightarrow \tau_2^* = 2c(p_H^m p_L^m - p_H p_L)^{-1}$$

and the other IC constraints are satisfied if and only if

$$\Delta p_H p_L^m \geq p_H \Delta p_L \text{ and } \Delta p_L p_H^m \geq p_L \Delta p_H. \tag{18}$$

Together the conditions (16–18) partition the entire parameter space. Hence, the three case together yield

$$\tau_2^* = c \begin{cases} (\Delta p_H p_L^m)^{-1} & \Delta p_H p_L^m \leq p_H \Delta p_L \\ (\Delta p_L p_H^m)^{-1} & \Delta p_L p_H^m \leq p_L \Delta p_H \\ 2(p_H^m p_L^m - p_H p_L)^{-1} & \text{otherwise.} \end{cases} \tag{19}$$

which is continuous.

Since $\tau_H^* = \tau_L^* = 0$, it follows that the incentive contract T_G^* always satisfies the monotonicity constraint (3) and the monotonicity constraint (3) is satisfied when

$$c \leq \bar{c} \equiv \min_{i \in \{H,L\}} R_i \begin{cases} \Delta p_H p_L^m & \Delta p_H p_L^m \leq p_H \Delta p_L \\ \Delta p_L p_H^m & \Delta p_L p_H^m \leq p_L \Delta p_H \\ \frac{1}{2}(p_H^m p_L^m - p_H p_L) & \text{otherwise.} \end{cases}$$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\square$

Proof of Part 2. When $\tau_2^* > 0$ and $\tau_H^* = \tau_L^* = 0$, the banking group's pledgeable income is given by

$$P_G^1 = p_H^m R_H + p_L^m R_L - p_H^m p_L^m \tau_2^*.$$

The incentive synergies are thus given by

$$P_S^1 \equiv P_G^1 - P_H^1 - P_L^1 = p_H^m \tau^H + p_L^m \tau^L - p_H^m p_L^m \tau_2^*$$

Substituting for τ^H, τ^L, and τ^* (Expression (19)) yields the incentive synergies

$$P_S^1 = c \left(\frac{p_H^m}{\Delta p_H} + \frac{p_L^m}{\Delta p_L} - \begin{cases} \frac{p_H^m}{\Delta p_H} & \Delta p_H p_L^m \leq p_H \Delta p_L \\ \frac{p_L^m}{\Delta p_L} & \Delta p_L p_H^m \leq p_L \Delta p_H \\ \frac{2 p_H^m p_L^m}{p_H^m p_L^m - p_H p_L} & \text{otherwise} \end{cases} \right) \tag{20}$$

Inspection of the expression shows that $P_S^1 > 0$ in all three cases. $\square$

Proof of Part 3. We let $\bar{p} \equiv \frac{p_L + p_H}{2}$ and $\Delta \bar{p} \equiv \frac{\Delta p_H + \Delta p_L}{2}$ denote the average success probability without monitoring and the average impact of monitoring respectively. We define the following two vectors $\mathbf{p} \equiv (p_H, p_L, \Delta p_H, \Delta p_L)$ and $\bar{\mathbf{p}} \equiv (\bar{p}, \bar{p}, \Delta \bar{p}, \Delta \bar{p})$. We are going to solve the following maximization program for any given $\bar{\mathbf{p}}$:

$$\max_{\mathbf{p}} P_S^1 \tag{21}$$

subject to

$$p_L + p_H = 2\bar{p} \tag{22}$$

$$\Delta p_H + \Delta p_L = 2\Delta\bar{p} \tag{23}$$

First, consider the parameter range where $\Delta p_H p_L^m > p_H \Delta p_L$ and $\Delta p_L p_H^m > p_L \Delta p_H$, which includes the case $\mathbf{p} = \bar{\mathbf{p}}$. In this case Expression (20) implies that $P_S^1 = c(\frac{p_H^m}{\Delta p_H} + \frac{p_L^m}{\Delta p_L} - \frac{2 p_H^m p_L^m}{p_H^m p_L^m - p_H p_L})$. Checking the first and second order conditions (after substituting for p_H^m and p_L^m) it is easy to show that $\mathbf{p} = \bar{\mathbf{p}}$ is a local maximum within the parameter range.

Second, consider the parameter range $\Delta p_H p_L^m \leq p_H \Delta p_L$. Expression (20) implies that $P_S^1 = c\frac{p_L^m}{\Delta p_L}$. The directional derivative towards $\bar{\mathbf{p}}$,

$$\nabla_{\mathbf{p}} P_S^1 \cdot (\bar{\mathbf{p}} - \mathbf{p}) = c\frac{p_H \Delta p_L - \Delta p_H p_L}{2\Delta p_L^2}.$$

This expression is positive in the parameter range we consider because $p_H \Delta p_L \geq \Delta p_H p_L^m > \Delta p_H p_L$. Since the parameter range $\Delta p_H p_L^m \leq p_H \Delta p_L$ does not include $\mathbf{p} = \bar{\mathbf{p}}$ the solution to the maximization program (21–23) cannot be in the interior of the parameter range. Analogous arguments apply to the third parameter range $\Delta p_L p_H^m \leq p_L \Delta p_H$.

Because P_S^1 is continuous, the three cases above imply that $\mathbf{p} = \bar{\mathbf{p}}$ is the solution to the maximization program (21–23). $\square$

B.3. Lemma 6

Proof. From the main text it follows that designating an i-unit as an entry point, changes outside investors' payoff in case that i-unit suffers a shock. Since outside investors break even in expectation, their change in expected payoff at $t = 0$ corresponds to the change in the bank's pledgeable income. Hence, the payoffs we derive in the main text and the probability that an i-unit suffers a shock q_i imply that the effect of designating an i-unit as an entry point on the bank's pledgeable income is

$$q_i(\max\{P_i^1 - 1, 0\} + P_j^1 - (P_G^1 - 1)).$$

Substituting for $P_G^1 \equiv P_i^1 + P_j^1 + P_S^1$ and some algebra allows us to rewrite the above expression as

$$q_i(\max\{1 - P_i^1, 0\} - P_S^1). \tag{24}$$

Since $P_S^1 > 1$, it follows that the change in pledgeable income (24) is positive if and only if $P_i^1 + P_S^1 \leq 1$.

From Lemma 4 we know that the pledgeable income of a banking group that does not specify any i-unit as an entry point is given by $P_G^0(2)$. Adding the effects of designating different i-units as entry point from Expression (24) for the different possible sets of additional entry points EP $\in \{\{L\}, \{H\}, \{L, H\}\}$ yields the pledgeable income (11). $\square$

B.4. Lemma 8

Proof. When the L-unit receives a shock and no reinvestment, bankers will continue to monitor the H-unit without any financial restructuring if and only if $\tau_H \geq \tau^H$. From (IC:H) it follows that the in the absence of a shock the bank will only monitor the L-unit when

$$p_H^m(\tau_2 - \tau_H) + (1 - p_H^m)\tau_L \geq \frac{c}{\Delta p_L}.$$

These two conditions imply that bankers' minimum payoff from monitoring both units

$$p_H^m p_L^m \tau_2 + p_H^m(1 - p_L^m)\tau_H + (1 - p_H^m)p_L^m \tau_L - 2c$$
$$= (p_H^m(\tau_2 - \tau_H) - (1 - p_H^m)\tau_L)p_L^m + p_H^m \tau_H - 2c \geq p_L^m \frac{c}{\Delta p_L} + \tau^H - 2c. \tag{25}$$

The compensation contract $(\tau_L, \tau_H, \tau_2) = (\tau^L, \tau^H, \tau^L + \tau^H)$ satisfies the monitoring IC-constraints (IC:L–IC:0) and $\tau_H \geq \tau^H$ as well as the monotonicity and limited liability

constraints. Because $(\tau_L, \tau_H, \tau_2) = (\tau^L, \tau^H, \tau^L + \tau^H)$ satisfies Expression (25) with equality it follows that it minimizes bankers' payments when the bank ensures monitoring of the H-unit in case the L-unit become non-performing and monitoring of both units in the absence of shock.

The above compensation contract implies that the bank's $t = 1$ pledgeable income in the absence of a shock is given by

$$p_H(R_H - \tau^H) + p_L(R_L - \tau^L) = P_H^1 + P_L^1.$$

If the L-unit receives a shock the outside investors' payoff is $p_H(R_H - \tau^H) = P_H^1$. If the H-unit receives a shock the bank will enter resolution to finance the H-unit's reinvestment. In this case the regulator minimizes outside investor's losses and their payoff is $P_G^1 - 1$. It follows that the bank's $t = 0$ pledgeable income is given by

$$(1 - q_L - q_H)(P_H^1 + P_L^1) + q_L P_H^1 + q_H(P_G^1 - 1) = P_G^0(H) - (1 - q_L - q_H)P_S^1.$$

$\square$

B.5. Lemma 9

First, consider the case of a bank that reinvests in case bankers claim it suffered a shock ($\rho = i$). Truth telling requires that Condition (14) is satisfied. To ensure monitoring on the equilibrium path, the payments $\tau(0)$ and $\tau(i)$ must both satisfy the monitoring IC-constraint (1): $p_i^m \tau - c \geq p_i \tau$. Combining the monitoring IC constraint with the truth-telling constraint (14), the bankers' payoffs are minimized when $\tau(i) = \tau^i \equiv c/\Delta p_i$ and $\tau(0) = \tau^i + b/p_i^m$.

Second, consider a bank that chooses not to reinvest when the bankers claim it suffered a shock ($\rho = 0$). When no shock occurs, bankers will report truthfully if and only if $p_i^m \tau(0) \geq p_i^m \tau(i)$. If a shock occurs bankers' payoffs are zero, independently of the message. In addition, monitoring on the equilibrium path requires that $\tau(0)$ satisfies the monitoring IC-constraint (1). It follows that $\tau(0) = \tau^i$ and $\tau(i) \in [0, \tau^i]$ minimize bankers' expected payment subject to the relevant IC constraints.

Based on these compensation contracts and reinvestment policies, we obtain the fol-

lowing $t = 0$ pledgeable income

$$P_i^M(\rho) = \begin{cases} P_i^1 - (1 - q_i)b - q_i & \rho = i \\ (1 - q_i)P_i^1 & \rho = 0. \end{cases}$$

Comparing $P_i^M(\rho)$ above and $P_i^0(\rho)$ from our main model yields the Lemma.

B.6. Lemma 10

We consider the different reinvestment policies of the banking group in turn. First, consider a banking group that reinvests into any unit when either of them suffers a shock ($\rho = 2$) and thus obtain funds whenever bankers claim that a unit suffers a shock. As before, bankers must have monitoring incentives on the equilibrium path. Since both units will always be performing, this requires that the incentive contract $T_G(\mu) \equiv (\tau_L(\mu), \tau_H(\mu), \tau_2(\mu))$ satisfies the monitoring IC-constraints for two units (IC:L,IC:H,IC:0) for all μ.

Let us now consider in turn the three possible shock realizations. Bankers have an incentive to truthfully report the absence of a shock rather than to falsely claim the occurrence of a shock and misappropriate the funds they would obtain from outside investors if and only if

$$p_H^m p_L^m \tau_2(0) + p_H^m(1 - p_L^m)\tau_H(0) + (1 - p_H^m)p_L^m \tau_L(0)$$
$$\geq p_H^m p_L^m \tau_2(i) + p_H^m(1 - p_L^m)\tau_H(i) + (1 - p_H^m)p_L^m \tau_L(i) + b \; \forall i \in \{H, L\}. \quad (26)$$

Since outside investors will provide funds for reinvestment into either unit, bankers only have an incentive to truthfully report the identity of either unit when it suffers a shock, respectively, if the identity of the unit does not affect their expected payoff:

$$p_H^m p_L^m \tau_2(L) + p_H^m(1 - p_L^m)\tau_H(L) + (1 - p_H^m)p_L^m \tau_L(L)$$
$$= p_H^m p_L^m \tau_2(H) + p_H^m(1 - p_L^m)\tau_H(H) + (1 - p_H^m)p_L^m \tau_L(H). \quad (27)$$

As we discuss below the IC-constraints for truthfully reporting that a shock occurs (to either unit) will not be binding.

Let us now solve for the contract that minimizes bankers' payments. The IC-constraint (27) and Proposition 1 imply that $T_G(L) = T_G(H) = (0, 0, \tau_2^*)$ minimizes bankers' payoff in case the bank suffers a shock. In the absence of a shock, bankers' payoffs are minimized

49

when, in addition, the IC-constraints (26) are binding.[34] This can be achieved by setting

$$T_G(0) = (0, 0, \tau_2^* + \frac{b}{p_H^m p_L^m})$$

which obviously satisfies the monitoring IC-constraint. Finally, note again, that bankers have an incentive to truthfully report that a shock has occurred because their payoff, in the absence of reinvestment, would be zero.

Second, consider a banking group that reinvests when its H-unit suffers a shock but not when its L-unit suffers a shock $\rho = H$). (The case of a banking group that only reinvests when its L-unit suffered a shock, $\rho = L$, is analogous.) As before bankers must have monitoring incentives on the equilibrium path. Since both units will be performing if no shock occurs or the H-unit suffers a shock, the incentive contract $T_G(\mu)$ must satisfy the monitoring IC-constraints for two units (IC:L,IC:H,IC:0) for messages $\mu \in \{0, H\}$. Since the L-unit becomes non performing when it suffers shock the incentive contract $T_G(\mu)$ for a message $\mu = L$ must include a payoff for success of the H-unit $\tau_H(L)$ that satisfies the single-unit monitoring IC-constraint (1).

Let us consider the three possible shock realizations in turn. In the absence of a shock, bankers have an incentive to truthfully report the absence of a shock, rather claiming that the H-unit suffered a shock, if

$$p_H^m p_L^m \tau_2(0) + p_H^m(1 - p_L^m)\tau_H(0) + (1 - p_H^m)p_L^m \tau_L(0)$$
$$\geq p_H^m p_L^m \tau_2(H) + p_H^m(1 - p_L^m)\tau_H(H) + (1 - p_H^m)p_L^m \tau_L(H) + b. \qquad (28)$$

The IC constraint for bankers not to claim that the L-unit suffered a shock, depends on the monitoring incentives $T_G(L)$ provides off the equilibrium path when both units operate. We will show below that this IC constraint is not binding.

If the L-unit suffers a shock, the following two IC-constraints ensure bankers' truthful reporting, in which case the bank obtains no funds for reinvestment, rather than claiming (i) the H-unit suffered a shock, in which case the bank receives funds that can be reinvested into the L-unit[35] or (ii) no unit suffered a shock, in which case the bank

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[34]Both IC constraints will bind at the same time due to the IC-constraint (27).

[35]This yields Expression (15) in the text above, which we reproduce below for convenience.

obtains no funds for reinvestment, respectively:

$$p_H^m \tau_H(L) - c$$
$$\geq p_H^m p_L^m \tau_2(H) + p_H^m(1 - p_L^m)\tau_H(H) + (1 - p_H^m)p_L^m \tau_L(H) - 2c \tag{29}$$
$$\geq \max\{p_H^m \tau_H(0) - c, p_H \tau_H(0)\}. \tag{30}$$

where the maximum operator accounts for the fact that monitoring may not occur off the equilibrium path.

If the H-unit suffers a shock, truthfully reporting ensues when the following two IC-constraints hold:

$$p_H^m p_L^m \tau_2(H) + p_H^m(1 - p_L^m)\tau_H(H) + (1 - p_H^m)p_L^m \tau_L(H) - 2c$$
$$\geq \max\{p_L^m \tau_L(L) - c, p_L \tau_L(L)\} \tag{31}$$
$$\geq \max\{p_L^m \tau_L(0) - c, p_L \tau_L(0)\}. \tag{32}$$

Let us now solve for the contract that minimizes bankers' payments. In case the H-unit receives a shock, it follows from Proposition 1 that setting $T_G(H) = (0, 0, \tau_2^*)$ minimizes bankers' payoffs. Bankers' payoffs from reporting that the L-unit suffered a shock are minimized when the IC-constraint (29) is binding, which can be achieved by setting

$$T_G(L) = (0, p_L^m \tau_2^* - c/p_H^m, 0).$$

Note that in the absence of a shock, $T_G(H)$ yields higher off-the-equilibrium-path payoffs for bankers than $T_G(L)$. As a result, bankers' payoffs from reporting that no shock occurs are minimized when the IC-constraint (28) is binding. The IC-constraint no to report that the L-unit has suffered a shock will not be binding. Setting

$$T_G(0) = (0, 0, \tau_2^* + \frac{b}{p_H^m p_L^m}).$$

ensures that the IC-constraint (26) is binding for $\mu = H$. It is easy to check that $T_G(L)$ and $T_G(0)$ satisfy the remaining IC-constraints for truthful reporting (29-32) and monitoring.

Finally, consider a banking group that never reinvests ($\rho = 0$). Bankers' payoffs are minimized subject to the relevant monitoring IC-constraints when $T_G(0) = (0, 0, \tau_2^*)$, $T_G(L) = (0, \tau^H, 0)$, and $T_G(H) = (\tau^L, 0, 0)$. It is easy to check that these contracts also ensure truthful revelation of the shock state.

Based on the above compensation contracts and reinvestment policies, rearrangement of terms yields the following $t = 0$ pledgeable income

$$P_G^M(\rho) \equiv \begin{cases} P_G^1 - q - (1-q)b & \text{if } \rho = 2, \\ P_G^1 - q_H - q_L p_L R_L - (1-q)b & \text{if } \rho = H, \\ P_G^1 - q_L - q_H p_H R_H - (1-q)b & \text{if } \rho = L, \\ (1-q)P_G^1 + q_L P_H^1 + q_H P_L^1 & \text{if } \rho = 0. \end{cases}$$

Comparing $P_G^M(\rho)$ above and $P_G^0(\rho)$ from our main model yields the expression for $P_G^M(\rho)$ we report in the lemma.

Finally, substitution and algebra show that

$$P_G^M(H) < P_G^M(2) \Leftrightarrow P_G^1 - q_H - q_L p_L R_L - (1-q)b < P_G^1 - q - (1-q)b \Leftrightarrow p_L R_L > 1.$$

This condition must hold true because reinvestment creates positive NPV. An analogous arguments yields $P_G^M(H) < P_G^M(2)$. We thus obtain second part of the the Lemma.

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