Financing and Resolving Banking Groups*

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We study how bank's resolution regimes affect investment. Banking groups create financing synergies by transferring excess financing capacity across units and lowering bankers' agency rents. Single-point-of-entry (SPOE) resolution preserves groups' structure, which permits ex post efficient continuation of weaker units hit by negative shocks, but can prevent optimal investment ex ante. Multiple-point-of-entry (MPOE) resolution separately resolves and shuts down weaker units following negative shocks, but can foster ex ante investment. We characterize the conditions under which SPOE or MPOE resolution is efficient as a function of banking groups' characteristics, including their risk profile and overall profitability.

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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 (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. A few years on from their introduction, the building blocks of the resolution frameworks are likely to be tested by what the chairwoman of the European's Single Resolution Board has called the "extraordinary challenge" of the economic crisis caused by the COVID-19 pandemic (König, 2020).

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, together with its subsidiaries, can be separated and resolved independent of the rest of the banking group, and their 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). Regulators, however, seem to clearly favor SPOE (FDIC and BOE, 2012; Powell, 2013; Stein, 2013; Tarullo, 2013; Lee, 2017). As argued by Lee (2015), "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".[1] Regulatory preferences may explain why most large banks worldwide, including all U.S. G-SIBs, have adopted SPOE, although some banks, such as HSBC, Santander, and BBVA, have chosen MPOE (HSBC, 2021; Santander, 2021; BBVA, 2021).[2]

[1] This is true not only in a cross-border context but also in a domestic context. In a cross-border context, regulators recognize the possible difficulties to implement loss mutualization and thus SPOE.

[2] 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

This paper argues a trade-off exists between banking groups' ex post efficient resolution strategy and their ex ante financing capacities and (efficient) investment levels. SPOE resolution may protect banking groups and their synergies because loss mutualization facilitates the continuation of units hit by negative shocks. But the same ex post loss mutualization may also curb banks' financing and investment in the first place. MPOE resolution, in contrast, limits bank investors' exposure to negative shocks and thus increases the bank's financing capacity. Limiting investors' losses can be crucial to fund bank's efficient investment ex ante, even if it leads to the inefficient shut down of units hit by negative shocks ex post. We characterize the conditions under which SPOE and MPOE resolutions are efficient and show that these conditions depend on the banking groups' characteristics, including their overall profitability and risk profile.

We build a model of two asymmetric banking units, one strong and one weak, reflecting their different loan-making opportunities. The model has two key ingredients: First, the units' financing capacities fall short of the present value of their respective loan portfolios because bankers must be incentivized to monitor 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 synergies that reduce the cost of providing monitoring incentives (so-called "incentive synergies").[3] These two types of financing synergies allow weak units to operate as part of a banking group, even when they are not viable as stand-alone banks.

Second, loan portfolios are also subject to negative shocks that necessitate further investment.[4] Following a shock, the banking unit needs to raise additional funding to continue. We focus on the case in which the shocks are small enough to make operation and continuation of either unit efficient, but large enough to force the bank into resolution, because the bank cannot privately finance the resultant additional investment. Resolution provides a mechanism by which to restructure existing liabilities. A regulator who temporarily takes over control supervises the resolution process, allocates the bank's losses across the various investors, and raises new funding by issuing new claims. The regulator's objective is to maximize the (ex post) net present value (NPV).

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).

[3]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 ncentive synergies that arise from combining multiple projects.

[4]Holmström and Tirole (1998) were first to introduce this type of negative shock.

As a benchmark against which to compare the resolution regimes, we derive the constrained optimal contract between bankers and outside investors. We show that it may sometimes be ex ante optimal to commit to shut the weak unit down following the realization of a negative shock, even if continuation is ex post efficient. The reason is that, when the size of the negative shock exceeds the financing capacity the weak unit adds to the banking group, its continuation requires a transfer of (additional) financing capacity from the strong unit. Shutting down the weak unit is constrained optimal when the investors' expected costs of making such a transfer are high enough, ex ante, so as to prevent the banking group from financing the weak unit's operation in the first place. At the same time, continuing the strong unit with its higher financing capacity is always optimal.

We then consider the effect that the resolution regimes have on the bank's ability to finance its initial operations and to continue units following negative shocks. SPOE resolution mutualizes losses and thus uses a unit's financing capacity to continue the other unit when it suffers a negative shock. Hence, SPOE resolution can implement the constrained optimal contract when it includes the continuation of the weak unit. But SPOE resolution will prevent the weak unit's operation when it is constrained optimal to shut it down after a shock. Outside investors anticipate that the regulator will use the financing capacity of the strong unit to finance the continuation of the weak unit.

Conversely, under MPOE resolution, the banking group can specify its weak unit as a separate entry point that will be resolved separately and without transfers from other parts of the banking group. This setup forces the regulator to shut down the weak unit, against his own preferences, when the weak unit cannot self-finance its continuation. Outside investors anticipate that MPOE resolution limits their losses from shocks to the weak unit. MPOE resolution, with an entry point at the weak unit, can thus lead to the constrained optimum when shutting down the weak unit is necessary to operate it in the first place.[5] In contrast, a strong unit should never serve as a entry point for resolution because its continuation is always optimal. Thus, following a shock to the strong unit, resolution at the holding company level is more efficient because this preserves the banking group's corporate structure and any resultant synergies.

We show that shutting down the weak unit after a negative shock, and thus MPOE resolution, is optimal if the likelihood of a shock is sufficiently high and if the two

[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).

units are sufficiently asymmetric. Our model includes several dimensions of potential asymmetry between units, all of which point toward the optimality of MPOE resolution: first, the risk of an adverse shock can be different for strong and weak units; second, banking units may differ in their self-financing capacities. Asymmetry between the units also lowers the banking group's incentive synergies and thus, the banking group's overall financing capacity. This effect further strengthens the association between asymmetric banking units and MPOE resolution.

We show that MPOE resolution, compared with SPOE resolution, can also reduce the reach and the scope of resolution. MPOE resolution strategies thus create natural firewalls and generate inbuilt limits to contagion, as have suggested by some commentators (see, e.g., Fernández de Lis et al., 2014). Indeed, an MPOE banking group suffering a shock to its weak units can avoid the resolution of the rest of the banking group. This is the case if the strong unit's pledgeable income is high enough so as to allow the banking group to finance the initial investment. This is going to be the case if the units are even more asymmetric. This is especially relevant if resolution entails significant (direct) costs.

We derive a series of policy implications for our results. We first argue that the coexistence of both resolution regimes increases economywide efficiency relative to the adoption of a uniform resolution regime for all banks in the economy. MPOE resolution can strictly increase efficiency and reduce the reach and scope of resolution in some banking groups. Second, our model argues that national regulators with an MPOE framework find it easier to commit not to make transfers between cross-border banking units rather than between units operating within national boundaries. 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.

Resolution regimes also have implications for the total loss absorption capacity (TLAC) that regulators require from global systematically important banks (G-SIBs).[6] TLAC includes financial claims that can be written down or diluted to absorb potential losses during resolution. We show that MPOE resolution can require less TLAC compared to SPOE resolution because MPOE resolution limits outside investors' losses from the investments in weak units. In addition, loss absorption capacities could be shared across

[6]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).

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 (e.g., in Bolton and Oehmke, 2019) as the former mutualizes losses among multiple units.

Our model generates several empirical predictions. We show that MPOE resolution can be optimal for banking groups that consist of units with heterogeneous operations, with different scopes and competencies (such as investment and commercial banks) or geographic focuses, and therefore are inherently dissimilar. Our model also predicts how MPOE banks choose their entry points. Banking groups should designate its weak units as separate entry points, to make sure that weak units are resolved separately in case they suffer a negative shock. Instead, resolution following a shock to the strong units preserves the structure of the banking group. Once a banking group has adopted a resolution regime, this choice will affect its future investment decisions. SPOE banks 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, MPOE banks will find it easier to make such investments because of their ability to limit investors' bail-in. Thus, MPOE banks are also less likely to curtail investments during crises, when the risk of investment increases and bank profitability decreases.

Finally, we compare the outcomes in a frictionless restructuring to those in resolution. We show that restructuring, even when frictionless, can fail to implement the constrained optimal contract. The reason is that private restructuring and bankruptcy proceedings only continue the weak unit when this benefits investors. This problem does not arise with resolution, where a regulator can force the restructuring of the bank's liabilities. Under SPOE, the regulator will use its powers to continue banking units that receive negative shocks, at the expense of outside investors, when doing so increases NPV. This constitutes an important difference between bank resolution and bankruptcy procedures, the latter typically being more creditor friendly.

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 a frictionless world.[7]

Instead, we argue that coordination failures between regulators actually 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 though 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.[8] Such regulatory biases may thus explain why MPOE resolution is primarily observed in a cross-border context, although the trade-off in this 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 can raise money from competitive capital markets and invest the proceeds in two different pools of loans. The two units are asymmetric, in the sense that the pools of loans they have access to have different payoff and risk characteristics (see Section 2.1). Borrowers and therefore the banking units are subject to exogenous adverse shocks that increase financing needs. This multiunit banking model allows us to compare the ex ante benefits and costs of running banking units together, as parts of the same "banking group," versus running them separately, as independent "stand-alone" banks (see Section 2.2). It also allows us to examine and compare the performance of the different resolution regimes that banking groups are required to choose from (see Section 2.3).

[7]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 exposure to foreign losses.

[8]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).

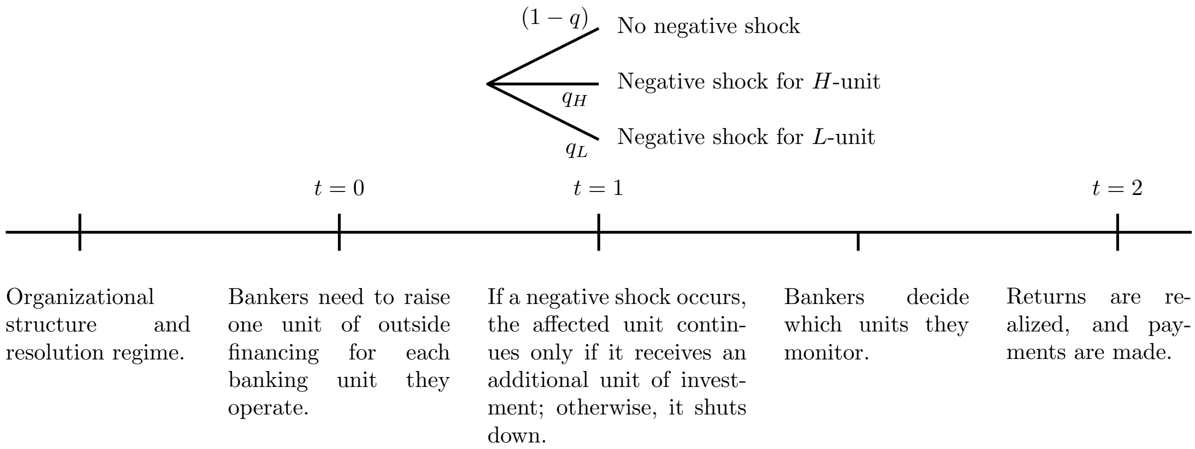

Figure 1: Timeline

We assume that banks are run by a team of "bankers" that makes all the decisions, as long as the bank is not in resolution.[9] Bankers need to raise financing from outside investors who provide resources as long as they break even in expectation. Bankers do not possess any funds of their own and have an outside option worth zero. All parties are risk neutral, have a discount factor of one, and are protected by limited liability. We measure the performance or the "efficiency" of the different organizational structures, as well as of the different resolution regimes, in terms of the overall expected NPV creation. As bankers are the residual claimants, bankers' private optimum and the social optimum coincide ex ante.

2.1. Banking units

We compare the efficiency of the different organizational structures and resolution regimes, using the two-unit, three-date model represented in Figure 1. Depending on the organizational structure and the resolution regime, bankers decide on how many units to finance, or "operate," and how to raise funding for their operation at $t = 0$. Each of the two banking units, $i \in \{H, L\}$, requires one unit of funding to make loans. As we shall see below, the two units may have different payoff and risk characteristics.[10]

At $t = 1$, an observable negative shock is realized with probability q. When the shock occurs, one of the two banking units requires an additional unit of funding. This may be, for instance, because the unit's borrowers require extra funding to complete their

[9] A bank may be either a banking group or a stand-alone bank.
[10] In general, subscript i denotes all parameters that may differ between the two units.

projects.[11] We assume, for simplicity, that if the additional investment is not made, the banking unit does not generate any return from its loans and it shuts down. The ex ante probability that each i-unit is affected by the shock is equal to q_i, where $q_H + q_L = q$.[12]

Between $t = 1$ and $t = 2$, bankers decide whether to monitor the loans. Monitoring is not observable and imposes a per-unit nonpecuniary cost c on bankers. Monitoring the loans of the i-unit increases the probability that the loans generate a positive payoff, R_i, from p_i without monitoring to $p_i^m \equiv p_i + \Delta p_i$ with monitoring. With the complementary probability, the unit obtains a payoff of zero. The returns of the two units are assumed to be independent.

We make two parameter assumptions to ensure that the decisions of operating either of the two units, as well as continuing a unit, that suffers a negative shock are efficient if and only if bankers monitor that unit. We assume first that, with monitoring, each unit generates a positive (expected) NPV at $t = 0$, even when the unit shuts down following a shock at $t = 1$:

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

Note that this condition implies that continuing the unit following a shock at $t = 1$ generates a positive NPV ($p_i^m R_i - c - 1 > 0$). At $t = 1$, the NPV is higher because the unit will not suffer another shock in our setting. These two conditions in turn imply that operating the unit at $t = 0$ must also create a positive NPV when the unit continues following a shock ($p_i^m R_i - c - (1 + q_i) > 0$). Since both units' operation at $t = 0$, as well as their continuation at $t = 1$, have a positive NPV, we measure efficiency in terms of whether these investments can be financed.[13]

Conversely, we assume that, without monitoring, continuing a unit 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

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

[12] 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 ($q_i = q$). 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 ($q_H = q_L = q/2$).

[13] It is straightforward to generalize our model to different shock sizes, s_i, potentially different across units, rather than being equal to one, as long as we assume that they are smaller than their $t = 0$ expected cost of operating and continuing the unit, $(1 + q_i s_i)$. If the negative shock was larger than $(1 - q)^{-1}$, we would need to make additional assumptions on the $t = 1$ NPV following a shock, in order to make operation and continuation positive NPV decisions (and the problem interesting).

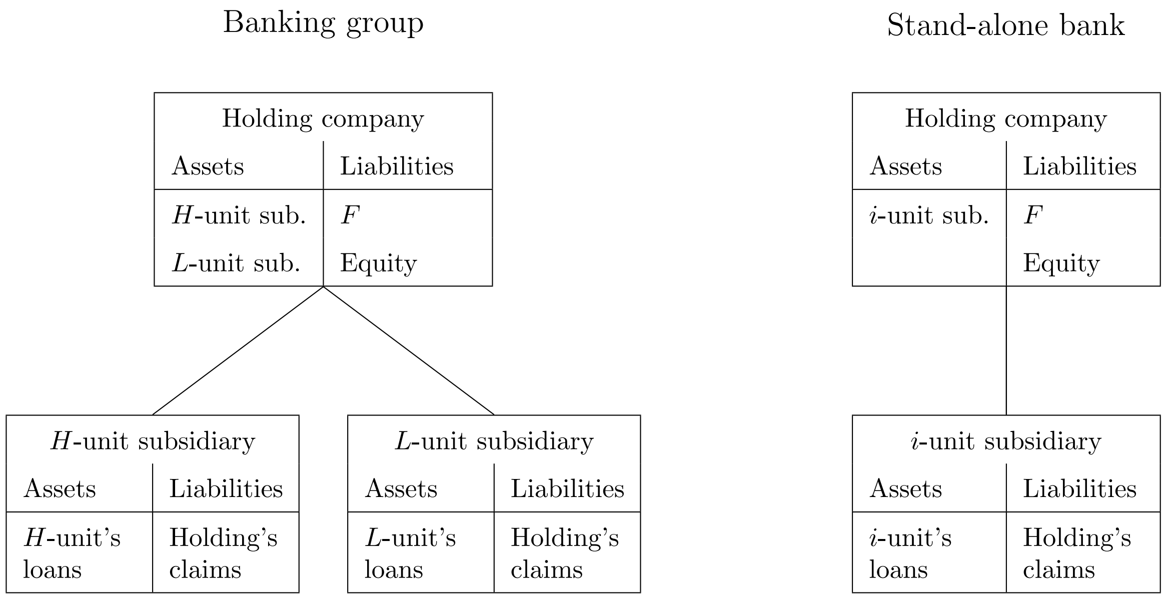

Figure 2: Group structure

never efficient. The reason is that at $t = 0$, the possibility of a $t = 1$ shock implies higher expected costs (with continuation) or a lower expected payoff (without continuation), when compared to the investment decision at $t = 1$.

2.2. Organizational structure and financing

The two banking units can operate as part of the same banking group or as two independent stand-alone banks. A banking group consists of three legal entities: the holding company and two wholly-owned subsidiaries that operate the two banking units (see Figure 2). Decision-making within a banking group is centralized in the sense that a team of bankers makes all the decisions. We abstract away from any internal agency problems within the banking group or among the team of bankers. A stand-alone bank is equivalent to a banking group that operates a single unit. Stand-alone banks make decision independent of each other.

Banks finance themselves with fairly priced debt and/or outside equity. The bank can issue debt and equity claims at $t = 0$ and $t = 1$, but all claims mature at $t = 2$. We assume that the bank cannot privately issue new claims at $t = 1$ because doing so dilutes existing investors' claims issued at $t = 0$. We are thus restricting financing to simple non-contingent contracts and do not allow the bank to write contracts with outside investors that (i) insure future financing needs or (ii) commit the bank to certain continuation decisions. This setup excludes the use of derivatives, credit lines, and insurance contracts. These assumptions make the problem interesting as fully contingent claims (complete contracts) would make any resolution regime redundant. Since we assume that the bank cannot privately dilute claims, we also exclude the option of private restructuring.[14]

For simplicity, we assume that banks only raise outside financing at the holding company level. We let F denote the face value of the debt and let e denote the outside share of equity that is held by outside investors. Bankers hold the remaining (inside) equity of the holding company. The bank's capital structure determines bankers' compensation and monitoring incentives, as well as the payoffs of outside investors.[15]

2.3. Bank resolution

Resolution, which may ensue following a negative shock at $t = 1$, provides a mechanism to restructure existing liabilities and raise additional funding by issuing new claims. A regulator who temporarily takes over control and allocates bank's losses across the various investors supervises the resolution process.

As part of its resolution planning, a banking group needs to specify which legal entities are "entry points," that is, points at which the regulator can take control. The holding company must always be an entry point, to ensure that all parts of the bank can be resolved. Further entry points can be defined at the level of the two subsidiaries. Resolution ensues at an entry point if that entity or a subsidiary that is not an entry point itself cannot finance its continued operation without diluting the existing claims or if it is undercapitalized in the sense that its capital structure does not ensure monitoring. An entry point and its subsidiaries are resolved separately (and are subsequently separated) from other parts of the banking group. When multiple entities are resolved together, their losses are mutualized, while there are no transfers between entities that are resolved separately.

Thus, the set of entry points, or the "resolution regime," determines which parts of the banking group will enter resolution together. An SPOE regime arises if the bank specifies the banking group's holding company as the sole entry point. In this case, resolution always ensues at the holding company level, and all entities are resolved

[14]We discuss private restructuring and bankruptcy in Section 8.

[15]Our results would not change if we allowed the banking group to issue outside debt at the subsidiaries, too. As we will see, issuing financing at the holding level will be enough to implement the optimal incentive contract, which consists of two different payments. In more general setups, an optimal incentive contract might consist of more payments, depending on the payoffs of the different units. Issuing securities at the subsidiaries can then help to implement the optimal contract.

jointly. An MPOE regime instead arises if the bank specifies multiple entry points and resolves different parts of a banking group separately. MPOE resolution encompasses three different entry point configurations in our setting depending on which subsidiaries are specified as entry points. The banking group can specify its L-unit subsidiary, its H-unit subsidiary, or both subsidiaries as entry points, in addition to the holding company. For stand-alone banks, the choice of a resolution regime does not make any difference because the bank operates a single unit that cannot be split up.

We assume that the regulator's objective in resolution is to maximize the NPV. In the case of a banking group, this means that the regulator aims to ensure the continuation and monitoring of both banking units. Hence, the regulator imposes sufficient losses on existing claim holders to raise additional financing and to provide sufficient inside equity to incentivize bankers to monitor. We assume that the regulator imposes losses only to the extent that such losses are necessary to maximize the NPV.

A more precise explanation of the recapitalization process is as follows. The regulator can, first, (totally or partially) wipe out the existing outside and inside equity and write down the existing debt claims (bail-in). Subsequently, it can issue new debt and/or outside equity to raise new funds. The regulator also needs to reallocate inside equity to the original bankers, who retake control of the bank following resolution.[16] If resolution separates a part of the banking group from the holding company, some members of the original team of bankers will form a new independent team to run the new bank. These bankers lose their equity stake in the remaining part of the banking group and obtain inside equity in the new bank. Note that, resolving a part of the banking group separately can make it necessary to resolve the group's remaining parts in order to ensure monitoring. If the regulator cannot raise sufficient resources to continue a unit affected by a negative shock, the unit shuts down.

We abstract away from any direct cost of resolution (or default).

3. Optimal Contracting Benchmark

As a benchmark to compare the resolution regimes against, we first derive the constrained optimal contract. We thus assume in this section that the returns at $t = 2$ are contractible as well as (i) the occurrence of a negative shock and (ii) the continuation decisions at $t = 1$, while bankers' monitoring decisions remain noncontractible.[17] We

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

[17] We also restrict ourselves to continuation decisions, which are deterministic functions of the shock.

follow Innes (1990) and require that the contract ensures that outside investors' cash flows are monotonous in each unit's cash flow. 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. As we will see, this assumption will also ensure that debt and equity financing can always provide efficient monitoring incentives in our setting.[18]

The constrained optimal contract consists of two parts. The first part is an incentive contract that specifies the distribution of cash flows between bankers and outside investors. This contract will provide monitoring incentives, while satisfying investors' participation constraints. The second part specifies the banking units' operation and continuation decisions subject to the bank's ability to raise financing at each date. We can restrict ourselves to contracts that ensure the monitoring of all units since, otherwise, their operation and continuation are inefficient.

We first analyze the case in which the two individual units are operated as stand-alone 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 contract that maximizes outside investors' cash flows. The optimal contract should also specify the number of units the bank can initially operate and the respective continuation decisions after a negative shock.

3.1. Stand-alone banks

Suppose that the two units are operated independently as stand-alone i-unit banks. To ensure monitoring, a stand-alone bank must provide an incentive payment, τ, to its bankers 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 banker zero.

For each i-unit bank, the incentive compatibility constraint for monitoring is as follows:

$$p_i^m \tau - c \geq p_i \tau.$$

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, as long as the bank continues at $t = 1$, bankers' (minimum) incentive payment

[18] To satisfy this assumption, we will restrict the set of parameters in what follows.

(or agency rent) does not depend on the realization of the shock at $t = 1$. As bankers' outside option is zero, their participation constraint is always satisfied.

The maximum payment that an i-unit bank can credibly promise to outside investors when it continues at $t = 1$, that is, the i-unit's $t = 1$ pledgeable income, is given by

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

The pleadgeable income at $t = 0$ depends on the bank's continuation decision following a negative shock, $\chi \in \{i, 0\}$, where $\chi = i$ denotes continuation and $\chi = 0$ denotes shut down. Taking into account the probability of a shock, q_i, and the resultant financing needs of one, the pledgeable income of an i-unit bank at $t = 0$ is given by

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

An i-unit bank can thus operate at $t = 0$ if and only if its pledgeable income exceeds the initial financing costs for some continuation policy χ, such that $P_i^0(\chi) \geq 1$.

The following lemma shows that if an i-unit bank can operate for one of the two continuation policies χ, then it can always operate for $\chi = i$. Doing so is constrained optimal because continuation generates a positive NPV.

Lemma 1. *For a stand-alone i-unit bank, the incentive contract that maximizes its financing capacity is given by the incentive payment, τ^i. Further, it is constrained optimal to operate a stand-alone i-unit bank if and only if the $t = 0$ pledegeable income is such that $P_i^0(i) \equiv P_i^1 - q_i \geq 1$, in which case it is also constrained optimal to continue the unit following a negative shock.*

Proof. See Appendix A.1. □

Our stand-alone bank model brings up two important points. First, some units may not be able to finance themselves, even if their operation is ex ante efficient and continuation following a negative shock is ex post efficient. Indeed, the financing capacity falls short of the present value of the bank's assets, $p_i^m(R_i - \tau^i) - q_i < p_i^m R_i - c - q_i$, because bankers must be incentivized to monitor loans.

Second, a stand-alone bank unit always will be continued following a shock. Indeed, to operate at $t = 0$, the bank requires one unit of financing and it might suffer a shock in the future. To continue following a negative shock at $t = 1$, the bank also requires one unit of (additional) financing but it will not suffer another shock. This means that outside investors, who are willing to finance the bank's operation at $t = 0$, also should be willing to finance its continuation following a negative shock.

Our following assumption facilitates the exposition.

Assumption 1. *Without loss of generality, we assume that the pledgeable income of a stand-alone 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 group

We now analyze the formation of a banking group that owns both units and centralizes decision-making under a single team of bankers. As we will show below, a banking group can operate units that would not have been viable as stand-alone banks. Two effects of centralized decision-making make this possible. First, a unit's excess pledgeable income can be used to provide financing to another unit that cannot finance itself. Bankers are willing to make these transfers because they will earn extra agency rents from running an additional unit.[19] As a result, the operation decision in a banking group only depends on its overall pledgeable income, not on the units' individual pledgeable incomes. Fluck and Lynch (1999) and Inderst and Müller (2003) have previously studied this advantage of group formation.

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

3.2.1. Incentive contract

With centralized decision-making, the incentive contract will (at most) consist of payments to the bankers when only the L-unit, only the H-unit, or both units generate a positive return at $t = 2$, that is, $T_G = \{\tau_L, \tau_H, \tau_2\}$ (no payment should be made in the absence of a return). Such a contract clearly presupposes that the banking group still consists of two units after $t = 1$. If it operates only one unit, the banking group and the incentive contract are equivalent to that of the stand-alone i-unit bank discussed above. The incentive compatibility constraints to ensure that the banking group is monitoring

[19] 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.

both units, not just the L-unit (IC:L), only the H-unit (IC:H), or neither unit (IC:0), are given by

$$\begin{aligned} & p_H^m p_L^m \tau_2 + p_H^m (1-p_L^m)\tau_H + (1-p_H^m)p_L^m \tau_L - 2c \\ & \geq p_H p_L^m \tau_2 + p_H(1-p_L^m)\tau_H + (1-p_H)p_L^m \tau_L - c, && \text{(IC:L)} \\ & \geq p_H^m p_L \tau_2 + p_H^m(1-p_L)\tau_H + (1-p_H^m)p_L \tau_L - c, && \text{(IC:H)} \\ & \geq p_H p_L \tau_2 + p_H(1-p_L)\tau_H + (1-p_H)p_L \tau_L. && \text{(IC:0)} \end{aligned}$$

The contract ensures monotonous payoffs for outside investors if and only if the following conditions hold:[20]

$$R_H + R_L - \tau_2 \geq \max_{i\in\{H,L\}} \{R_i - \tau_i\} \tag{1}$$
$$R_i - \tau_i \geq 0 \; \forall i \in \{H, L\}.$$

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

Deriving the minimum compensation necessary to provide monitoring incentives 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^* with $\tau_2^* > 0$ and $\tau_H^* = \tau_L^* = 0$ that maximizes financing capacity.*
2. *The banking group's resultant $t = 1$ pledgeable income P_G^1 is strictly larger than those of the stand-alone banks, $P_G^1 > P_H^1 + P_L^1$. We call the additional $t = 1$ pledgeable income, $P_J^1 \equiv P_G^1 - P_H^1 - P_L^1$, the group's "incentive synergies."*
3. *For a given level of 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 A.2. □

The proposition shows that the incentive contract, T_G^*, is simple as long as the costs of monitoring are low. Formally, the incentive payment, τ_2^*, that minimizes bankers'

[20] Because we only require monotonicity in the individual units' cash flows, we do not require that outside investors cash flows are monotonous across units' cash flows (i.e., we do not require that $R_H - \tau_H \geq R_L - \tau_L \Leftrightarrow R_H \geq R_L$).

compensation subject to the incentive compatibility constraints is proportional to the monitoring costs c (as shown in Expression (15) in Appendix A.2). The simple incentive contract, T_G^*, satisfies the monotonicity constraint (1) when the monitoring cost is not too high (i.e., $c \leq \bar{c}$). When the cost is higher, the monotonicity constraint (1) is binding, and the optimal contract will contain incentive payments for the success of the individual units, $\tau_H^*, \tau_L^* > 0$. 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 described in Proposition 1.[21]

Assumption 2. *For simplicity, we assume that the monitoring cost is below the threshold, $\bar{c}$, of Proposition 1, that is, $c \leq \bar{c}$.*

The proposition also shows that forming a banking group increases the overall pledgeable income due to incentive synergies. These synergies represent a form of cost savings that allows the bank to overcome the agency problems with lower amounts of agency rents.[22] The reason is that bankers can give up the rents they earn for monitoring each unit in case the other unit fails, which relaxes their IC-constraints.

Finally, the proposition also shows that the incentive synergies, P_J^1, are maximal when the two units are symmetric. The reason is that the sum of stand-alone 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.

3.2.2. Operation and continuation decisions

We now turn to describe the operation and continuation decisions of a banking group. We first show that if it operates both units at $t = 0$, then it will always continue the H-unit following a negative shock at $t = 1$. In contrast, it may shut down the L-unit following a negative shock.

The pledgeable income of a banking group that operates both units at $t = 0$ depends on the continuation decision $\chi \in \{2, H, L, 0\}$ at $t = 1$, where $\chi = 2$ denotes the case in which the bank continues any unit that receives a shock; $\chi = i$ describes the case in which the bank continues the i-unit if it receives a shock but shuts down the other unit if that one receives the shock; and $\chi = 0$ is the case in which the bank shuts down any

[21] For a discussion of optimal contracts in a multitask agency setting with a monotonicity constraint, see Bond and Gomes (2009).

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

unit that receives a shock. For each continuation policy, the $t = 0$ pledgeable income is given by

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

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

To understand the optimal continuation decisions, consider a banking group that can obtain financing to operate both units at $t = 0$. As before, the pleadgeable income at $t = 1$ is higher than at $t = 0$ ($P_G^1 > P_G^0(\chi)\ \forall\chi$) because there are no further shocks after $t = 1$. A necessary condition for operating both units is thus given by

$$P_G^1 = P_H^1 + P_L^1 + P_J^1 > 2. \tag{3}$$

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.

This condition has implications for the "marginal" pledgeable income at $t = 1$ of each unit, that is, the additional pledgeable income the group obtains if it continues the unit following a negative shock. The $t = 1$ marginal pledgeable income of unit i is given by $P_i^1 + P_J^1$. This includes the incentive synergies of operating both units together.[23] Condition (3) implies that for at least one unit i of the two

$$P_i^1 + P_J^1 > 1. \tag{4}$$

Taken together, for Conditions (3) and (4), a banking group can only operate both units at $t = 0$ if the marginal $t = 1$ pledgeable income of at least one unit exceeds the cost of continuation. Because $P_H^1 \geq P_L^1$, Condition (4) at least must be satisfied for the H-unit. This in turn means that continuing the H-unit when it suffers a shock always increases the $t = 0$ bank's pledgeable income as

$$P_G^0(H) - P_G^0(0) = P_G^0(2) - P_G^0(L) = q_H(P_H^1 + P_J^1 - 1) > 0. \tag{5}$$

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

Hence, the banking group can always continue the H-unit. Since continuation is efficient, the bank will always do so, and we obtain the following lemma.

Lemma 2. *A banking group that operates both units at $t = 0$ will always continue the H-unit following a negative shock at $t = 1$.*

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

Intuitively, when the group's incentive synergies, P_J^1, are taken into account, at least one unit must be able to self-finance its continuation following a negative shock. 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 $t = 0$. Put differently, if outside investors are not willing to finance the continuation of any of the two units following a shock, they will never be willing to finance the operation of the two units in the first place.

Since a two-unit banking group will always continue the H-unit, the bank's optimal operation and continuation decisions depend on the bank's decision about its L-unit following a shock and its ability to initially finance the operation of both units.

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

$$\max\{P_G^0(2), P_G^0(H)\} \geq 2. \tag{6}$$

It shuts down the L-unit when it receives a negative shock at $t = 1$ if and only if

$$P_G^0(2) < 2 \leq P_G^0(H) \tag{7}$$

and always continues the H-unit when it receives a negative shock at $t = 1$.

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

The first part of Proposition 2 shows that the pledgeable income of a two-unit banking group that operates both units must be sufficiently high. Importantly, the operation decision depends on the group's joint pledgeable income only as bankers are willing to make transfers between units. The second part shows that shutting down the L-unit following a shock might be optimal in order to finance its operation in the first place. Shutting down the L-unit after a shock increases the banking group's $t = 0$ pledgeable income ($P_G^0(2) < P_G^0(H)$) when the L-unit is unable to self-finance its continuation:

$$P_L^1 + P_J^1 < 1. \tag{8}$$

Assumption 3. *To focus on the interesting cases, we assume from now on that the banking group's pledgeable income at* $t = 0$ *is such that it can operate both units, that is, Condition (6) holds.*

Under this condition, operating both units is constrained efficient. Notice that forming a banking group (strictly) increases efficiency when at least one unit cannot operate as a stand-alone bank, that is, when $P_L^0(L) < 1$ and/or $P_H^0(H) < 1$.

4. Debt and Equity Financing

This section considers debt and equity financing contracts in the absence of resolution. Recall that we allow the bank to issue new debt and equity claims at $t = 1$ but without dilution of the existing claims issued at $t = 0$. We assume that if a bank cannot raise new (junior) financing to continue a unit that has suffered a negative shock, the unit defaults and is shut down. We show that, in the absence of a resolution regime, the banking group may not be able to implement the constrained optimal contract, described in the previous section. The reason is that debt and equity claims do not provide sufficient state contingencies to address the banking groups' optimal continuation decisions in the presence of a negative shock.

We first consider the banking group's ability to implement the constrained optimal incentive contract, T_G^*. Cash flows that accrue to bankers' inside equity of the holding company determine bankers' payoff. For a given capital structure (F and e), bankers' payoffs as a function of the units that generate a positive payoff are

$$\begin{aligned} \tau_2 &= (1-e)\{R_H + R_L - F^+, \\ \tau_H &= (1-e)\{R_H - F\}^{+,} \\ \tau_L &= (1-e)\{R_L - F\}^+, \end{aligned} \tag{9}$$

where the $\{.\}^+$ operator denotes $max\{.,0\}$ and captures the bank's limited liability. The incentive contract, T_G^*, can be implemented with debt and equity, for instance, by setting $F = R_H + R_L - \tau_2^*$ and $e = 0$. Stand-alone banks can also implement the optimal incentive contracts, for instance, by setting $F = R_i - \tau^i$ and $e = 0$, such that $\tau_i = (1-e)\{R_i - F\}^+ = \tau^i$. The banking group's $t = 1$ pledgeable income is thus P_G^1, and the stand-alone bank's is P_i^1.

We now consider a banking group's operation and continuation decisions. First, consider the case in which the bank would like to continue either unit following a negative shock. Since the bank cannot issue new claims that dilute existing investors' claims, the bank can only continue the unit if it conserves one unit of free pledgeable income from $t = 0$. This free pledgeable income remains unpledged in the absence of a shock. The bank's $t = 0$ pledgeable income is, thus, given by

$$P_G^1 - 1. \tag{10}$$

Note that this level of pledgeable income is lower than that of the optimal contract, $P_G^0(2)$. The reason is that debt and equity claims offer no insurance against negative shocks. If the bank would like to operate and continue either unit following a shock, it has to be able to raise three units of financing against its $t = 2$ cash flows, that is, $P_G^1 \geq 3$.

Second, observe that the bank can never continue the H-unit, while shutting down the L-unit following a shock to the respective unit (which is sometimes constrained optimal, as shown in Proposition 2). If the bank preserves one unit of pledgeable income from $t = 0$ to continue the H-unit, then the bankers will also continue the L-unit since continuation is ex post efficient and bankers are the residual claimants. Conversely, if the bank does not preserve one unit of pledgeable income from $t = 0$, then the bank cannot continue the H-unit if it receives a shock.

We, thus, obtain the following proposition.

Proposition 3. *In the absence of resolution, a banking group that relies on debt and equity financing can implement the constrained optimum if and only if $P_G^1 \geq 3$, that is,*

$$P_G^0(2) \geq 3 - q, \tag{11}$$

in which case it operates and continues either unit following a negative shock.

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

The proposition shows that debt and equity may fail to implement the optimal contract for two reasons. First, the bank will be able to operate and continue either unit only if the bank has enough pledgeable income to finance the three potential units of investment. This requirement limits the set of cases in which the option of operating and continuing either unit can be implemented (Condition (11) is stronger than Condition (6) in Proposition 2). Second, the bank will always fail to implement the optimal contract when shutting down the L-unit is constrained optimal. The reason is that the bank cannot save pledgeable income by shutting down the L-unit following a shock unless it also shuts down the H-unit after a shock.

From now on we will only consider the case of a two-unit banking group that does not have enough pledgeable income to finance three potenial units of investment. This means that the bank must enter resolution following a shock because it cannot finance the unit's continuation without the dilution of existing claims. Otherwise, the bank would be able to implement the constrained optimum without entering resolution and the question of which resolution regime performs better would be mute.

Assumption 4. *To focus on the interesting cases, we assume from now on that the two-unit banking group that must enter resolution following a negative shock, that is,* $P_G^1 < 3$.

5. Resolution Regimes

This section examines the extent to which resolution regimes in combination with debt and equity financing can implement the constrained optimal contract. Both resolution regimes SPOE and MPOE can dilute and restructure bank liabilities. But they will deliver different continuation decisions and therefore pledgeable incomes (Sections 5.1 and 5.2) and result in differences in terms of efficiency (Sections 5.3 and 5.4). We also examine the extent to which a resolution regime can avoid the resolution of parts of the banking group not affected by a shock (Section 5.5).

5.1. SPOE resolution

With SPOE resolution, the bank's holding company is the sole entry point. As a result, all entities of the banking group are resolved jointly, following a shock to any of the two units. Thus, if the bank continues both units, its corporate structure does not change and its pledgeable is P_G^1. Since P_G^1 is larger than the one unit of funding required to continue a unit,[24] the regulator can and will indeed continue the unit suffering a negative shock. The regulator will be able to continue the unit by writing down existing claims and issuing new ones, backed by the cash flows of the entire banking group.

Because the regulator does not dilute outside investors' claims more than necessary, their payoff in resolution will be $P_G^1 - 1$. The allocation of losses among the different

[24] A banking group operating two units should have enough pledgeable income to cover two units of investment, $P_G^1 > 2 > 1$.

investors at $t = 1$ does not affect the bank's ability to raise funding at $t = 0$ because all claims are fairly priced. In the absence of a shock, outside investors can obtain a payoff of P_G^1. Thus, the banking group's $t = 0$ pledgeable income is given by $P_G^1 - q = P_G^0(2)$. We obtain the following lemma.

Lemma 3. *An SPOE banking group always continues with both units following a negative shock to either of its units. Its pledgeable income at $t = 0$ is equal to $P_G^0(2)$.*

Proof. See Appendix A.3. □

5.2. MPOE resolution

MPOE resolution encompasses different configurations of entry points. In our setting, an MPOE bank can specify the L-unit subsidiary, the H-unit subsidiary, or both as entry points, in addition to the one specified at the holding company level. As we will show in this subsection, these entry points determine the bank's continuation decisions and the amount of funding the banking group can raise at $t = 0$.

We consider an MPOE banking group that specifies its L-unit subsidiary and the holding company as its entry points. We show that with this entry point configuration the banking group can achieve a maximum pledgeable income of $P_G^0(H)$ in case the L-unit cannot self-finance its continuation, that is, if $P_L^1 + P_J^1 < 1$.[25] A bank that aims to maximize its financing at $t = 0$ promises outside investors the highest possible payoff in the absence of a shock, P_G^1. In case of a negative shock to either of its units, the resolution process determines outside investors' payoffs.

Consider first the case when the L-unit receives a shock. In this case, resolution ensues at the L-unit subsidiary. Resolution turns the L-unit subsidiary into an independent stand-alone bank and the regulator cannot use the H-unit's pledgeable income to make transfers to the L-unit. As the stand-alone pledgeable income of the L-unit P_L^1 is smaller than one (as $P_L^1 + P_J^1 < 1$), the regulator cannot raise sufficient funds for its continuation even if it writes down all existing claims.[26] Thus, the regulator is forced to shut down the L-unit, even though its continuation would be ex-post efficient.

Note that the other parts of the bank will also enter resolution. The pledgeable income of the remaining H-unit, P_H^1, is lower than that of a two-unit banking group, P_G^1. As the bank promises outside investors P_G^1 in the absence of a shock, the regulator must

[25] As shown in the discussion leading up to Corollary 1, $P_G^0(H) > P_G^0(2)$ is equivalent to $P_L^1 + P_J^1 < 1$.

[26] In our model these claims are the equity claims of the holding unit. If a subsidiary were to issue external claims, they also could be written down.

partially write down outside investors' existing claims to P_H^1 in order to ensure that bankers have sufficient incentives to monitor the H-unit. The regulator will thus also resolve the remaining parts of the bank (holding company and H-unit subsidiary) when the L-unit suffers a shock. Because resolution never dilutes outside investors' claims more than necessary, their payoff will be P_H^1.[27]

Suppose now that the H-unit receives a shock. Resolution will ensue at the holding company level, and it will not split up the banking group. As explained in the previous subsection (for SPOE), the pledgeable income in this case is high enough for the regulator to finance continuation of the H-unit. Moreover, resolution preserves the incentive synergies, P_J^1, that result from the group's corporate structure. Outside investors will obtain $P_G^1 - 1$, as before.

Together, the above cases imply that the bank's $t = 0$ pledgeable income is equal to $(1 - q_L)P_G^1 + q_L P_H^1 - q_H = P_G^0(H)$. Since this is the maximum pledgeable income when the L-unit cannot self-finance its continuation, we obtain the following lemma:

Lemma 4. *Suppose that the L-unit cannot self-finance its continuation, that is, $P_L^1 + P_J^1 < 1$. If an MPOE banking group specifies its L-unit subsidiary and its holding company as its entry points, the L-unit shuts down, but the H-unit continues after a shock to the respective unit. The banking group achieves the maximum $t = 0$ pledgeable income, which is equal to $P_G^0(H)$ ($> P_G^0(2)$).*

Proof. See Appendix A.4. □

In the other case ($P_L^1 + P_J^1 > 1$), and for all other possible entry point configurations, an MPOE bank cannot achieve the maximum pledgeable income.[28] The reason is that it is never optimal to specify an i-unit as an entry point when it can self-finance its continuation ($P_i^1 + P_J^1 > 1$). Indeed, in this case, resolving the i-unit separately will either force the regulator to shut it down (when $P_i^1 < 1$) or destroy the banking group's incentives synergies, P_J^1. Either way, the payoff that outside investors can obtain is lower than when both units continue as parts of the same existing banking group. Thus, the L-unit should not be an entry point in case it can self- finance its continuation. Similarly, the H-unit should never be an entry point because it can always self finance its continuation (cf. Expression (5)). We thus obtain the following lemma.

[27] Resolving the holding company and the H-unit subsidiary is necessary when the bank maximizes its financing at $t = 0$. In Section 5.5 (Proposition 5), we analyze the case when the banking group may avoid resolving these parts in case the L-unit receives a shock.

[28] For the sake of exposition, we gloss over the nongeneric case of $P_L^1 + P_J^1 = 1$. In this case, analogue result to Lemma 4 holds.

Lemma 5. *If $P_L^1 + P_J^1 > 1$, or if a banking group specifies an entry point configuration other than the L-unit and the holding company, the banking group's $t = 0$ pledgeable income under MPOE resolution will be lower than the maximum attainable,* $\max\{P_G^0(2), P_G^0(H)\}$.

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

5.3. Resolution efficiency

The previous sections allow us to draw conclusions about which of the two resolution regimes, if any, can implement the constrained optimal operation and continuation decisions for each parameter constellation.

Proposition 4. *The constrained optimal operation and continuation decisions always can be implemented by one of the two resolution regimes: SPOE resolution when $P_G^0(2) \geq 2$ and MPOE resolution when $P_G^0(2) < 2 \leq P_G^0(H)$.*

Proof. It follows from Proposition 2 and Lemmas 3 and 4. □

SPOE resolution ensures that the regulator will continue both units together, which is ex post efficient, and achieves a pledgeable income of $P_G^0(2)$. Hence, SPOE resolution can implement the constrained optimum when the constrained optium involves the continuation of the L-unit ($P_G^0(2) \geq 2$). But when shutting it down is constrained optimal ($P_G^0(2) < 2 \leq P_G^0(H)$), SPOE resolution will prevent financing of the L-unit at $t = 0$ because covering the L-unit's funding shortfall exceeds the banking group's pledgeable income ex ante.

As shown in Sction 3.2, shutting down the L-unit can be constrained optimal when the continuation of the L-unit is not self-financing ($P_L^1 + P_J^1 < 1$). In this case, MPOE resolution can force the regulator to shut down the L-unit following a shock by specifying the unit as an entry point. At the same time, MPOE resolution will be able to continue the H-unit and preserve the group's incentive synergies, as long as the H-unit is *not* specified as an entry point. Thus, MPOE resolution can achieve a pledgeable income of $P_G^0(H)$ and implement the constrained optimum when the constrained optimum involves shutting down the L-unit ($P_G^0(2) < 2 \leq P_G^0(H)$).

Conversely, MPOE resolution fails to implement the constrained optimum when the constrained optimum involves the continuation of the L-unit, for two reasons. First, it forces the regulator to shut down the L-unit following a negative shock, an action that is not constrained optimal. Second, it destroys the incentive synergies, P_J^1, by separating the two units, which may prevent financing at $t = 0$.

5.4. MPOE is optimal for which banking groups?

Proposition 4 allows us to derive comparative static results on the optimality of MPOE resolution. We show that MPOE resolution is optimal for banking groups that operate sufficiently asymmetric units that have diverse operations, and include weaker units facing sizeable negative shocks, which might call for their closure.

To gain some intuition, let us revisit and rewrite the inequalities that make MPOE resolution optimal in Proposition 4. First, continuing the L-unit after a shock should not be feasibe (the H-unit always must operated and continued) ($P_G^0(2) < 2$). This is the case if the probability of a negative shock is high enough, so that the expected cost of continuation exceeds the pledgeable income net of the initial investment costs:

$$q > P_G^1 - 2. \tag{12}$$

As discussed in Section 3.2.2, shutting down the L-unit after a shock increases the banking group's $t = 0$ pledgeable income ($P_G^0(2) < P_G^0(H)$) when the L-unit is unable to self-finance its continuation: $P_L^1 + P_J^1 < 1$. Freeing up pledgeable income by shutting down the L-unit allows the $t = 0$ operation of both units ($P_G^0(H) \geq 2$) when the increase in the bank's $t = 0$ pledgeable income by shutting down the L-unit (as compared to refinancing it) is higher than the banking group's $t = 0$ funding shortfall when it continues both units:

$$P_G^0(H) - P_G^0(2) = q_L(1 - P_L^1 - P_J^1) \geq 2 + q - P_G^1 = 2 - P_G^0(2). \tag{13}$$

Condition (13) shows that, for a given shock probability q, shutting down the L-unit after a shock only frees up enough pledgeable income when the probability of the shock affecting the L-unit q_L and the resultant financing deficit $(1 - P_L^1 - P_J^1)$ are high enough. We summarize this discussion in the following corollary.

Corollary 1. *MPOE resolution is constrained optimal if and only if the risk of a shock q, the risk that the L-unit receives the shock q_L for a given q, and the L-unit's $t = 1$ financing deficit when it receives a shock $1 - P_L^1 - P_J^1$ are high enough such that Conditions (12–13) are satisfied.*

Proof. This proof follows from Propositions 2 and 4. □

Another important implication of Propositions 2 and 4 is that shutting down the L-unit, and thus MPOE resolution, is optimal only if the two units are asymmetric. To see this, consider the case of two symmetric units, which implies that $P_H^1 = P_L^1$. In this case, continuing either unit is self-financing because a bank can operate both units only when Condition (4) is satisfied for both units. Continuing the L-unit also increases the banking group's pledgeable income at $t = 0$, such that $P_G^0(2) > P_G^0(H)$. We obtain the following corollary.

Corollary 2. *Symmetric banking groups should always choose SPOE. A necessary condition for MPOE is that the two banking units are asymmetric.*

Proof. Follows from the discussion in the text. □

Our model has several dimensions of asymmetry: the risk that the L-unit receives the shock q_L for a given q, and the units' differing self-financing capacities, 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_J^1, and thus a banking group's overall financing capacity (cf. Proposition 1, Part 3). Since MPOE resolution is efficient when the banking group cannot finance its operations as an SPOE bank, this effect further strengthens the association between asymmetric banking units and MPOE resolution.

5.5. Reach and scope of resolution

In our framework, resolution has no direct cost. More generally though, resolution can be costly, in which case whether a part of the banking group can avoid resolution is a relevant question. This subsection shows that MPOE resolution can in some cases avoid the restructuring of the remaining parts of the banking group (namely the holding company and H-unit subsidiary) if the L-unit receives a shock.[29]

A banking group maximizes its $t = 0$ financing when it promises outside investors a payoff, P_G^1, in the absence of resolution. In Section 5.1, we explained that fulfilling this promise requires the resolution of an MPOE bank's holding company and H-unit subsidiary in case the L-unit receives a negative shock. However, this requirement could be avoided if the payoff promised is less than or equal to the H-unit's pledgeable income, P_H^1. Since $P_H^1 < P_G^1$, pledging only the H-unit's income reduces the amount of financing that outside investors are willing to provide at $t = 0$. But, if the H-unit's pledgeable income is high enough, the bank can still finance its operations at $t = 0$.

[29]Recall that resolution can be avoided altogether if the promised payoffs to inverstors allow to raise three units of finance ($P_G^1 > 3$) independent of the resolution regime. If not (as assumed in Assumption 3), the banking group is forced to enter resolution.

Proposition 5. *An MPOE bank (that specifies its L-unit subsidiary and its holding company as its entry points) can avoid resolution of its holding company and H-unit subsidiary in case the L-unit receives a shock if and only if*

$$P_H^1 + q_H(P_L^1 + P_J^1) \geq 2 + q_H. \tag{14}$$

Proof. See Appendix A.5. □

The P_H^1 term in Condition (14) results from the fact that outside investors will always receive the H-unit's pledgeable income independent of the occurance of the shock. In case the H-unit receives a shock the regulator will also use the free pledgeable income of the L-unit, $P_L^1 + P_J^1$, to continue the H-unit, which yields the condition's second term. The right-hand side of the condition describes the cost of operating the two units at $t = 0$ plus the expected cost of continuing the H-unit following a shock, q_H.

6. Policy Implications

We now derive a series of implications from our results that are relevant for policy.

6.1. MPOE as a valid resolution regime

Proposition 4 shows that implementing the constrained optimum relies on each bank choosing an appropriate resolution regime. A trade-off between the two resolution regimes depends on the level of pledgeable income of the banking group, as well as the likelihood of adverse shocks that increase the future financing need of the different parts of the group. As the level of pledgeable income is bank specific, we have the following implication.

Implication. *A bank-specific choice between SPOE and MPOE resolution increases efficiency relative to the adoption of a uniform resolution regime for all banks. In some cases, banking groups can strictly increase efficiency and reduce the extent of resolution by choosing MPOE resolution over SPOE resolution.*

SPOE and MPOE resolutions do coexist in practice, although regulators appear to prefer SPOE. One reason for this preference could be differences in efficiency between the two types. SPOE resolution is considered to be ex-post efficient. We argue, however, that both SPOE and MPOE resolutions should remain part of the regulatory toolbox.

As shown by Proposition 4, MPOE can strictly increase efficiency, and, as shown in Proposition 5, MPOE can reduce the reach and scope of resolution in banking groups,

6.2. 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 forces the shut down of the L-unit, even though the shut down is inefficient ex post. In reality, regulators may not be easily able to rule out transfers and commit to shutting down units under their responsibility.[30] 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 to shutting down 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).

Our argument differs from that of Bolton and Oehmke (2019), 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 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 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.

6.3. TLAC

Global systemically important banks (G-SIBs) are required to have certain financial claims available to absorb potential losses during resolution, the so-called "total loss-absorbing capacity" (TLAC). 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). The purpose of TLAC

[30]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).

(and MREL) is to ensure that bank losses can be absorbed by debt and equity holders as part of a bail-in. The aim of boths 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 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. Since funding is only raised at the holding company level, we account for losses at the group level and do not separately account for the banking units' losses.

Since the required loss absorption depends on the size of the shock, we introduce in this section a parameter that captures varying shock sizes for each of the two units, s_L and s_H, respectively (rather than one for both units, as in the rest of the paper). In this setup, the relevant distinction between the strong and weak units is the $t = 1$'s excess pledgeable incomes $P_H^1 - s_H \geq P_L^1 - s_L$ rather than $P_H^1 \geq P_L^1$ (cf. Assumption 1). As explained before (cf. Footnote 13 on page 9), it is straightforward to generalize our model and the results in this way as long as we assume that the size of the unit's shock, s_i, is smaller than the $t = 0$ expected cost of operating and continuing the unit, $(1 + q_i s_i)$.[31]

Outside investors' losses depend on the continuation decisions. If an i-unit continues after a shock, their expected payoff is given by $P_G^1 - s_i$. If instead the unit shuts down, their expected payoff is P_k^1, where $k \neq i$ denotes the remaining unit. Since outside investors provide two units of financing at $t = 0$, their losses are given by $2 - (P_G^1 - s_i)$ and $(2 - P_k^1)$, respectively.

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

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

Instead, MPOE resolution may or may not continue the L-unit following a shock. If it continues, the maximum losses to investors are the same as under SPOE. If it does not

[31] This assumption ensures that when a unit's operation at $t = 0$ creates positive NPV, so does continuation when the unit suffers a shock. It also ensures that it will always be constrained optimal to continue the H-unit following a shock.

continue, the maximum losses outside investors must be ready to absorb are

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

where the first term refers to the losses if the H-unit gets a shock, and the second term refers to the losses if the L-unit gets a shock and is shut down. Comparing these two expressions, we obtain the following result.

Proposition 6. *MPOE resolution requires less loss absorption capacity than SPOE resolution if and only if $P_L^1 + P_J^1 \leq s_L$ and $s_H < s_L$. Otherwise, both resolution regimes require the same amount of loss absorption capacity.*

Proof. See Appendix A.6. □

Investors' maximum losses under the two resolution regimes are different if the continuation decision for the L-unit under the two resolution regimes is different. This is the case if, under MPOE, the L-unit cannot self-finance its continuation ($P_L^1 + P_J^1 \leq s_L$). In this case, shutting down the L-unit limits losses to outside investors. As TLAC is determined by the maxium losses outside investors have to bear upon the realization of a shock to any of the units, MPOE only requires less TLAC if the shock to the L-unit is larger that the one to the H-unit ($s_H < s_L$). Otherwise, both resolution regimes require the same amount of loss absorption capacity as the potential losses to the H-unit (which is continued for both resolution regimes) dominate and determine the required loss absorption capacity.

Note that shutting down the L-unit destroys the (positive) NPV of continuation and, thus, increases overall losses. However, part of these losses is borne by the bankers, who lose the agency rents. In SPOE resolution, bankers do not lose their agency rents as units are always continued 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. In our model, however, both SPOE and MPOE banks share their loss absorption capacity across units because the individual units' TLAC is provided by the holding company in the form of so-called "internal TLAC" (cf. FSB, 2015). 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. Empirical Implications

This section delivers a number of empirical implications for our model. First, the 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 resolution regimes in national and cross-border contexts.

7.1. Choice of resolution regimes

Our model predicts which banking groups should favor SPOE and MPOE, respectively, based on Corollaries 1 and 2. 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, with different scopes, and with 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.*

7.2. Choice of entry points

The efficiency of MPOE resolution depends on the configuration of the banking group's entry points. Lemmas 4 and 5 show that to achieve efficiency, an MPOE banking group must specify its entry points in such a way that (i) the weak units can be resolved separately and shut down in case they suffer a negative shock, and (ii) resolution following a shock to the strong units preserves the structure of the banking group. To do so, a banking group must specify an entry point at its holding company and additional entry points at those subsidiaries that will be resolved separately in case of a shock. Shocks to subsidiaries which are not entry points will then trigger resolution at the holding company and will not lead to the breakup of the banking group.

Prediction 2. *An MPOE bank should designate its weak units as separate entry points. Strong units should not be separate entry points.*

In Europe, many banking groups do not operate a holding company-subsidiary structure, as in our model, but a parent bank-subsidiary structure, where the parent bank itself is an operating unit that owns further operating subsidiaries. In the latter case, a negative shock to the parent will always trigger the resolution of the entire group. If instead an operating subsidiary receives a shock, it will be resolved separately if it is specified as an entry point.[32] Otherwise, the entire banking group will be resolved.

HSBC and Santander provide examples of entry point configurations where some units can be resolved separately, while shocks to other units will trigger the resolution of the entire banking group (HSBC, 2021; Santander, 2021). HSBC 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. Santander consists of a parent bank, which includes its Spanish operations, and specifies its large international operations as separate individual entry points.

7.3. 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

[32] 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.

will more likely be bailed-in to continue 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 to shut down failing units, they will be more capable of financing such large, risky units.

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.*

Naturally, these effects 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.

7.4. Cross-border banking

We have argued, in Section 6.2, that cross-border banks may find it easier to implement a credible MPOE resolution strategy than national banks. Regulators might find committing to shutting down units for which they are responsible difficult to do. 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 7.1, such banking groups will typically prefer MPOE resolution. Thus, we obtain the following prediction.

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.[33] 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.*

8. Restructuring in the Absence of a Resolution

In our setup, the bank must dilute the claims of its outside investors to raise new financing and be able to continue a unit that suffers a shock (Assumption 4). So far we have assumed that resolution is the only mechanism by which to do so. In this section, we examine the feasibility of a voluntary restructuring mechanism in the absence of resolution, whereby bankers and outside investors can renegotiate the bank's existing liabilities. In reality, this renegotiation may be either a private out-of-court restructuring or a part of a bankruptcy proceeding in which the outside investors (i.e., creditors) have to approve the reorganization plan. We show that voluntary restructuring in the absence of resolution, even if it is frictionless, can sometimes fail to implement the constrained optimum.

Consider debt and equity financing without resolution, as in Section 4, but with the possibility of voluntarily restructuring, as depicted in Figure 3. Following a negative shock at $t = 1$, bankers and outside investors can renegotiate the bank's liabilities to raise new funds for the continuation of the affected unit. If the renegotiation fails, the unit shuts down. Another possible round of renegotiation of the bank's liabilities ensures that bankers have sufficient incentives to monitor the remaining unit.

We assume that there are no frictions between the different (classes of) outside investors and restructuring without resolution entails no direct costs (as we assume for resolution). Making these assumptions abstracts from differences between out-of-court restructuring and bankruptcy proceedings that result from disagreements between different creditor classes or from the direct costs of the bankruptcy proceedings. However,

[33] Faia and Weder di Mauro (2016) make a similar argument. Bebchuk and Guzman (1999) make related arguments in the context of cross-border bankruptcies.

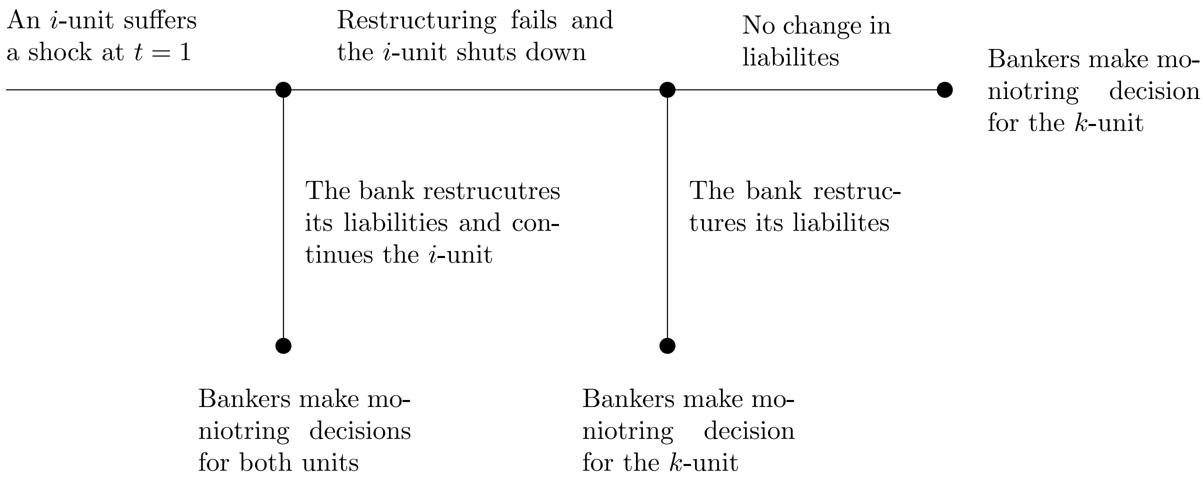

Figure 3: Restructuring by investors

the parties engaged in restructuring are still affected by the general frictions of the model: the need to provide bankers with monitoring incentives, bankers' financial constraints, and limited liability. We also assume that the initial outside investors have all the bargaining power.[34]

Bankers always have an incentive to continue a unit that receives a shock because this increases the NPV and the compensation they may receive. Things are different for outside investors, who cannot obtain more than the bank's pledgeable income (because of the aforementioned agency frictions). Outside investors are willing to renegotiate claims in order to continue an i-unit if the pledgeable income that the unit adds to the banking group is larger than the investment cost $P_i^1 + P_J^1 \geq 1$. This condition is always satisfied for the H-unit but may be violated for the L-unit. In case $P_L^1 + P_J^1 < 1$, outside investors are only willing to continue the L-unit after a shock if the bank conserves enough free pledgeable income at $t = 0$, so that the bankers can compensate the outside investors for the L-unit's financing deficit $(1 - P_L^1 - P_J^1)$.However, conserving free pledgeable income, which remains unpledged in the absence of a shock, reduces the bank's $t = 0$ pledgeable income. This in turn means that there will be cases in which private restructuring fails to continue the L-unit, while the same unit would have got continued if the bank had opted for SPOE resolution.

If the L-unit shuts down, bankers and outside investors can opt to restructure the (remaining) claims on the H-unit to ensure that bankers monitor. It is both in the interests of the bankers and investors to ensure monitoring, because doing so maximizes NPV,

[34]Otherwise, restructuring would unnecessarily expropriate outside investors and thus, reduce the bank's pledgeable income at $t = 0$.

as well as the income that the bank can pledge to outside investors. Because outside investors have all the bargaining power, restructuring will maximize outside investors' payoff subject to the bankers' IC constraints. It follows that the bank's pledgeable income equals $P^0_G(H)$. We obtain the following Proposition.

Proposition 7. *The banking group's continuation decisions and pledgeable income with voluntary restructuring in the absence of resolution, $P^0_R(\chi)$, are as follows. The bank always continues the H-unit when it receives a shock. When the L-unit receives a shock, there are three possible cases:*

1. *When $P^1_L + P^1_J \geq 1$, the bank continues the L-unit and $P^0_R(2) = P^0_G(2)$.*
2. *When $P^1_L + P^1_J < 1$ and the bank conserves sufficient free pledgeable income at $t = 0$, it continues the L-unit and $P^0_R(2) < P^0_G(2)$.*
3. *When $P^1_L + P^1_J < 1$ and the bank does not conserve pledgeable income at $t = 0$, it shuts down the L-unit and $P^0_R(H) = P^0_G(H)$.*

Proof. See Appendix A.7. □

The bank will operate and continue both units whenever its pledgeable income $P^0_R(2)$ allows it to do so. If it is constrained optimal to shut down the L-unit when it suffers a shock, restructuring implements this constrained optimum. Comparing restructuring and resolution yields the following corollary.

Corollary 3. *Restructuring (in the absence of resolution) is less efficient than resolution if and only if $P^0_R(2) < 2 < P^0_G(2)$. Otherwise, restructuring can implement the constrained optimum.*

Proof. It follows from Propositions 4 and 7. □

The above corollary shows that even frictionless restructuring (without resolution) can fail to implement the constrained optimum. The reason is that private restructuring and bankruptcy proceedings only continue the L-unit when its continuation benefits outside investors. This problem does not arise with resolution, where a regulator can force the restructuring of the bank's liabilities. Under SPOE, the regulator uses its powers to continue banking units that receive negative shocks, at the expense of outside investors, when doing so increases the NPV. This constitutes an important difference between bank resolution and bankruptcy procedures, the latter of which typically are more creditor friendly.[35]

9. Conclusions

This paper analyzes how the choice of resolution regimes affects banking groups' financing and investment decisions. Resolution is valuable because it allows regulators to write down existing liabilities and raise new funding. SPOE resolution mutualizes banking groups' losses, which allow for ex post efficient continuation of weak units that have experienced negative shocks. However, loss mutualization increases the losses outside investors must bear in the case of shocks. 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 force weaker units to be shut down after a negative shock. This in turn limits outside investors' losses and can increase ex ante (efficient) investment.

Our model suggests that the coexistence of both resolution regimes in the regulatory tool kit increases economywide efficiency relative to the adoption of a uniform resolution regime for all banks. We show that, contrary to common wisdom, MPOE resolution can strictly increase efficiency. In particular, MPOE resolution can be optimal for banking groups with sufficiently asymmetric units. Asymmetry in our model can arise because units differ in their exposure to adverse shocks, or because they may have different capacities to raise financing. Differences in financing capacities also lower (incentive) synergies and, thus, the banking group's overall financing capacity. This consideration further strenghtens the optimality of MPOE for this type of banking groups. We also show that MPOE resolution can require less TLAC than might SPOE resolution, because MPOE resolution limits outside investors' losses from investments in weaker units.

Several empirical predictions follow from our model. First, MPOE resolution should be chosen by banking groups with heterogenous business lines and/or a diverse geographic footprint. Second, 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. Third, we argue that the choice of resolution regimes will affect banking groups' future investment decisions: MPOE banks will be more likely to make large and risky investments, and they will be less likely to curtail investments in future crises.

[35]For a comparison of resolution and bankruptcy in the United States, see Jackson and Skeel Jr (2012); Skeel Jr (2014).

Our framework assumes that regulators maximize net present value, ex ante and ex post (in resolution). In practice, regulators may have a strict preference for continuation, even when continuation is inefficient, because they take into account other costs of failure. In such a framework, MPOE would have the additional benefit of preventing the regulator from using resources from the strong units to finance the inefficient continuation of the weak units.

Our model also assumes that resolution is costless. In reality, resolution can involve both direct and indirect costs. Thus, minimizing these costs could be a key consideration when choosing a resolution regime. We show that MPOE resolution, by separating the weak unit hit by a shock from the rest of the group, may avoid restructuring the liabilities of the entire banking group and, thus, reduce the reach and scope of resolution. Indeed, MPOE resolution strategies create natural firewalls and built-in limits to contagion. This argument provides another potential benefit for MPOE resolution.

Finally, the choice of a resolution regime may also affect the probability of entering resolution. Our analysis focuses on a case when a bank always needs to enter resolution upon the realization of a negative shock. More generally, one could consider shocks of different sizes, potentially differing across units. In this framework, SPOE banks, as compared to MPOE banks, may have a lower probability of entering resolution because of the mutualization of losses within the banking group. However, conditional on entering resolution, resolution of SPOE banks would be more costly because it would involve the entire group, rather than just the parts that have experienced a negative shock. Analyzing these trade-offs is a promising avenue for further research.

A. Proofs

A.1. Lemma 1

The incentive contract that maximizes the financing of an i-unit bank follows from the discussion in Section 3.1. The bank can operate the i-unit as a stand-alone bank if and only if there exists a continuation policy $\chi \in \{i, 0\}$ such that $P_i^0(\chi) \geq 1$.

It is easy to see that $P_i^0(\chi) < P_i^1$ for any continuation policy. Hence, the bank can only operate at $t = 0$ if its pledgeable income at $t = 1$ exceeds the reinvestment need following a liquidity shock, such that $P_i^1 > 1$. In this case, continuation maximizes the bank's pledgeable income such that $P_i^0(i) \geq P_i^0(0)$. It follows that an i-unit bank can operate at $t = 0$ if and only if $P_i^0(i) \geq 1$, which is equivalent to $P_i^1 \geq 1 + q_i$. It also follows that an i-unit bank that can operate at $t = 0$, can also continue following a liquidity shock. When possible, continuation is constrained optimal because it creates positive NPV.

A.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 show that for any incentive contract $\{\tau_L, \tau_H, \tau_2\}$ 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 yields the same expected compensation when τ_2' 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 $\{\tau_L, \tau_H, \tau_2\}$ into the IC constraints (IC:L,IC:H,IC:0) shows that their respective right-hand-sides decrease:

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

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. Because of the units' asymmetry it is possible that one of the IC constraints for monitoring a single unit (IC:L,IC:H) is binding (unlike in Laux, 2001). First, suppose that the (IC:L) constraint is satisfied with equality which yields

$$p_H^m p_L^m \tau_2^* - 2c = p_H p_L^m \tau_2^* - c$$

It is easy to show that this compensation contract satisfies the other IC constraints if and only if $\Delta p_H p_L^m \leq p_H \Delta p_L$. Second, when the (IC:H) constraint is binding

$$p_H^m p_L^m \tau_2^* - 2c = p_H^m p_L \tau_2^* - c$$

and the other IC constraints are satisfied if and only if $\Delta p_L p_H^m \leq p_L \Delta p_H$. Third when the (IC:0) constraint is binding

$$p_H^m p_L^m \tau_2^* - 2c = p_H p_L \tau_2^*$$

and the other IC constraints are satisfied if and only if $\Delta p_H p_L^m \geq p_H \Delta p_L$ and $\Delta p_L p_H^m \geq p_L \Delta p_H$. Together these three cases describe the entire parameter space. Solving the equations of the different cases yields

$$\tau_2^* = c \begin{cases} (\Delta p_H p_L^m)^{-1} & \Delta p_H p_L^m \leq p_H \Delta p_L \\ (\Delta p_L p_H^m)^{-1} & \Delta p_L p_H^m \leq p_L \Delta p_H \\ 2(p_H^m p_L^m - p_H p_L)^{-1} & \text{otherwise.} \end{cases} \tag{15}$$

Since $\tau_H^* = \tau_L^* = 0$, it follows that the incentive contract T_G^* satisfies the monotonicity constraint (1) when

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

□

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

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

Substituting for τ^H, τ^L, and τ^* (Expression (15)) yields the incentive synergies

$$P_J^1 = c \left(\frac{p_H^m}{\Delta p_H} + \frac{p_L^m}{\Delta p_L} - \begin{cases} \frac{p_H^m}{\Delta p_H} & \Delta p_H p_L^m \leq p_H \Delta p_L \\ \frac{p_L^m}{\Delta p_L} & \Delta p_L p_H^m \leq p_L \Delta p_H \\ \frac{2 p_H^m p_L^m}{p_H^m p_L^m - p_H p_L} & \text{otherwise} \end{cases} \right) \tag{16}$$

Inspection of the three cases shows that the pledgeable income increases in all cases. □

Proof of Part 3. We let $\bar{p} \equiv \frac{p_L+p_H}{2}$ and $\Delta\bar{p} \equiv \frac{\Delta p_H+\Delta p_L}{2}$. 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 $\bar{\mathbf{p}}$:

$$\max_{\mathbf{p}} P_J^1 \tag{17}$$

subject to

$$p_L + p_H = 2\bar{p} \tag{18}$$

$$\Delta p_H + \Delta p_L = 2\Delta\bar{p} \tag{19}$$

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 (16) implies that $P_J^1 = c(\frac{p_H^m}{\Delta p_H} + \frac{p_L^m}{\Delta p_L} - \frac{2p_H^m p_L^m}{p_H^m p_L^m - p_H p_L})$. Checking the first and second order conditions (after substituting for p_H^m and p_L^m) it is easy to show that the solution of the maximization program (17-19) within the parameter range is given by $\mathbf{p} = \bar{\mathbf{p}}$.

Second, consider the parameter range $\Delta p_H p_L^m \leq p_H \Delta p_L$. Expression (16) implies that $P_J^1 = c\frac{p_L^m}{\Delta p_L}$. The directional derivative toward $\bar{\mathbf{p}}$,

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

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 (17-19) 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_J^1 is continuous, the three cases above imply that $\mathbf{p} = \bar{\mathbf{p}}$ is the solution to the maximization program (17-19). □

A.3. Lemma 3

Proof. Suppose the bank issues initial claims that implement the incentive contract T_G^*. In this case outside investors' expected cash flows in the absence of a shock are given by P_G^1.

Resolution ensues following a negative shock due to Assumption 4. Because SPOE resolution resolves the entire banking group the bank's pledgeable income when it continues both units is given by $P_G^1 > \max\{P_G^0(2), P_G^0(H)\} \geq 2$. It follows that the regulators can and will always continue both banking units. The regulator does not dilute the outside investors' claims more than necessary subject to the costs of continuation and ensuring the units' monitoring. Hence, the initial outside investors' payoff in case of a shock will be $P_G^1 - 1$.

Given the probability of a shock, outside investors' payoff is given by $(1-q)P_G^1 + q(P_G^1 - 1) = P_G^0(2)$. Because $P_G^0(\chi)$ results from an optimal contracting problem outside investors' payoff, and the bank's pledgeable income, can never be higher for the same continuation decision. $\square$

A.4. Lemma 4

Proof. Suppose the bank issues initial claims that implement the incentive contract T_G^*. In this case outside investors' expected cash flows in the absence of a shock are given by P_G^1.

Resolution ensues following a negative shock due to Assumption 4. Because the L-unit subsidiary is an entry point, the L-unit gets resolved separately when it suffers a shock. Because the L-unit's pledgeable income $P_L^1 < P_L^1 + P_J^1 < 1$ the regulator cannot raise funding to continue the L-unit and it shuts down. Given the holding unit's existing liabilities the bankers' payoff in case the remaining H-unit obtains a positive payoff is given by

$$(1-e)\{R_H - F\}^+ = \tau_H^* = 0 < \tau^H.$$

Thus the regulator must resolve the remaining parts of the banking group to ensure monitoring. Since the regulator does not dilute outside investors' payoffs more than necessary, their payoff is P_H^1.

If the H-unit receives a shock, resolution will ensue at the holding company and does not split up the banking group. The regulator will continue the H-unit because the resultant pledgeable income $P_G^1 > \max\{P_G^0(2), P_G^0(H)\} \geq 2$ is large enough to do so. Outside investors payoff is given by $P_G^1 - 1$ because the regulator does not dilute the outside investors' claims more than necessary subject to the costs of continuation and ensuring the units' monitoring.

Given the shock probabilities, outside investors' payoff is given by $(1-q)P_G^1 + q_H(P_G^1 - 1) + q_L P_H^1 = P_G^0(H)$. Because $P_G^0(\chi)$ results from an optimal contracting problem outside investors' payoff, and the bank's pledgeable income, can never be higher for the same continuation decision. Since, $P_L^1 + P_J^1 < 1$, $P_G^0(H) = \max_\chi P_G^0(\chi)$. $\square$

A.5. Proposition 5

Proof. The maximum payoff the bank can promise to outside investors such that bankers will monitor the H-unit once the L-unit shuts down is given by P_H^1. Hence, outside investors' payoff in the absence of a shock, and when the L-unit receives a shock and shuts down is given by P_H^1.

When the H-unit suffers a shock the whole banking group will be resolved and the regulator will continue the H-unit. Because resolution never dilutes outside investors' claims more than necessary the regulator will use the free pledgeable income when it recapitalizes the banks and outside investors' payoff is $P_G^1 - 1$.

Together these cases imply that the banking group can finance its $t = 0$ investment if and only if

$$(1 - q_H)P_H^1 + q_H(P_G^1 - 1) \geq 2$$

Substituting for P_G^1 and rearranging the terms then yields the proposition. $\square$

A.6. Proposition 6

Proof. First consider the *if* part. The Conditions $P_G^1 - s_L \leq P_H^1$ and $s_H < s_L$ imply that that $2 - (P_G^1 - s_L) > 2 - (P_G^1 - s_H)$ and $2 - (P_G^1 - s_L) > 2 - P_H^1$. It follows that

$$\max\{2 - (P_G^1 - s_H), 2 - (P_G^1 - s_L)\} = 2 - (P_G^1 - s_L) \geq \max\{2 - (P_G^1 - s_H), 2 - P_H^1\}$$

Second, consider the *only if* part. When $s_H \geq s_L$,

$$\max\{2 - (P_G^1 - s_H), 2 - (P_G^1 - s_L)\} = 2 - (P_G^1 - s_H) \leq \max\{2 - (P_G^1 - s_H), 2 - P_H^1\}.$$

And when $P_G^1 - s_L > P_H^1$, $2 - P_H^1 \leq 2 - (P_G^1 - s_L)$, which implies

$$\max\{2 - (P_G^1 - s_H), 2 - P_H^1\} \leq \max\{2 - (P_G^1 - s_H), 2 - (P_G^1 - s_L)\}$$

because the first parts of the maximum terms are identical. $\square$

A.7. Proposition 7

We first establish the following lemma, which describes the continuation decision that results from restructuring in the absence of resolution. We denote a different unit $k \neq i$ rather than j in order to distinguish P_k^1 and P_J^1 more clearly.

Lemma 6. *Restructuring by investors will continue an i-unit when it suffers a liquidity shock if and only if for $k \neq i$*

$$P_G^1 - 1 \geq \min\{P_k^1, p_k^m(R_k - \tau_k)\}. \tag{20}$$

If an i-unit shuts down, restructuring by investors will ensure monitoring of the remaining k-unit.

Proof. We proceed by backward induction. Suppose that the first round of renegotiation fails and the bank shuts down an i-unit suffering from a shock. If the bank does not restructure its existing liabilities, bankers will monitor the remaining k-unit ($k \neq i$) if and only if $\tau_k \geq \tau^k$.[36] In this case there is no incentive to restructure, because bankers' monitoring maximizes NPV. Outside investors claims will be worth $p_k^m(R_k - \tau_k)$. Otherwise bankers and outside investors will restructure the banks liabilities in order to ensure monitoring. Because banker have all the bargaining power in restructuring, their claims will be worth P_k^1.

Now consider the decision to restructure existing claims and continue an i-unit suffering a shock.[37] If the bank restructures its claims and outside investors finance the continuation of the i-unit, the maximum payoff outside investors can obtain is $P_G^1 - 1$. Outside investors are willing to restructure and continue the i-unit if and only if their, payoff is higher than in case the i-unit shuts down, which yields Condition (20). Bankers are always willing to restructure and continue the i-unit, which increases the NPV and there is no friction that limits their surplus share. □

We can now proceed with the proof of Proposition 7.

Proof. First, consider the continuation of the H-unit. Assumption 3 implies that $P_H^1 + P_J^1 \geq 1$ which is equivalent to $P_G^1 - 1 \geq P_L^1$. It follows from Lemma 6 that the bank will always continue the H-unit when it suffers a shock. If the bank issues claims that implement an incentive contract T_G^*, outside investors expected payoff at $t = 1$ is given by P_G^1 in the absence of a shock, and $P_G^1 - 1$ when the H-unit suffers a negative shock, because outside investors have all the bargaining power.

Second, consider the continuation of the H-unit and recall that $P_L^1 + P_J^1 \geq 1 \Leftrightarrow P_G^0(2) \geq P_G^0(H) \Leftrightarrow P_G^1 - 1 \geq P_H^1$. We distinguish three cases.

[36] Recall that τ^k denotes the minimum incentive payment to induce monitoring in a stand-alone k-unit bank.

[37] Because of Assumption 4, restructuring is neccesary to continue the unit.

Case 1: $P_G^1 - 1 \geq P_H^1$**.** Lemma 6 implies that when the L-unit suffer a shock, it will continue and outside investors' payoff is $P_G^1 - 1$. If the bank issues claims that implement an incentive contract, T_G^*, the bank's $t = 0$ pledgeable income is given by $(1 - q)P_G^1 + q(P_G^1 - 1) = P_G^0(2)$.

Case 2: $P_G^1 - 1 < P_H^1$ **and the bank issues claims such that restructuring in the absence of resolution continues the** L**-unit.** Lemma 6 implies that private restructuring will continue the L-unit if and only if the bank issues claims such that $R_H - \tau_H \leq P_G^1 - 1$. Since $P_G^1 - 1 < P_H^1$, it follows that the bank issues claims such that $\tau_H > \tau^H$.

Analogously to the Proof of Lemma 1 one can show that for any incentive contract $\{\tau_L, \tau_H, \tau_2\}$ that satisfies the three IC constraints (IC:L,IC:H,IC:0) there exists another incentive contract $\{0, \tau_H, \tau_2'\}$ that yields the same expected compensation and satisfies the three IC constraints, as well as the monotonicity constraint (1). Thus, we can restrict the following argument to contracts with $\tau_L = 0$.

We will now derive an upper bound on the bank's pledgeable income.[38] The bank must issue claims that satisfy the IC constraint for monitoring both units rather than only the H-unit (IC:H). For a given $\tau_H > \tau^H$ and $\tau_L = 0$ the (IC:H) constraint implies that $\tau_2 \geq \tau_H + \frac{c}{p_H^m \Delta p_L}$. Thus, the expected compensation $p_H^m p_L^m \tau_2 + p_H^m (1 - p_L^m)\tau_H$ is larger or equal to

$$p_H^m \tau_H + p_L \frac{c}{\Delta p_L} > p_H^m \tau^H + p_L^m \tau^L.$$

It follows that the bank's $t = 1$ pledgeable income in the absence of shock is smaller or equal to

$$p_H^m R_L + p_L^m R_L - (p_H^m \tau_H + p_L \frac{c}{\Delta p_L}) < P_H^1 + P_L^1 \tag{21}$$

which implies that the bank's $t = 0$ pledgeable income is strictly smaller than $P_G^0(2)$.

Case 3: $P_G^1 - 1 < P_H^1$ **and the bank issues claims such that private restructuring shuts down the** L**-unit.** When the bank issues claims that implement the incentive contract T_G^* and the L-unit suffers a shock, Lemma 6 implies that the L-unit will shut down. The bank will then restructure its claims to ensure monitoring of the remaining

[38] Because we derive an upper bound on the bank's pledgeable we can rely on the following necessary condition at this point. The upper bound will not be tight, however, the bank only issues debt and equity at the holding company level which limits the set of incentive contracts $\{\tau_L, \tau_H, \tau_2\}$ the bank can implement to those contracts that satisfy Expression (9). This additional constraint is not necessary to derive our result, though.

H-unit, and the outside investors payoff is P_H^1, because the have all the bargaining power. Hence, the bank's $t = 0$ pledgeable income is given by $(1-q)P_G^1 + q_H(P_G^1 - 1) + q_L P_H^1 = P_G^0(H)$. $\square$

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