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Abstract

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JEL Classification: L51, F23, G21, G28

Keywords: Complex banking groups, Resolution regimes, Restructuring

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Financing and Resolving Banking Groups*

Albert Banal-Estañol[†], Julian Kolm[‡], and Gyöngyi Lóránth[§]

May 22, 2021

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1. Introduction

The financial crisis of 2007-2008 exposed the economic, fiscal, and social costs of failing banking institutions and groups. As a policy response, Title II of the US's Dodd-Frank Act and the EU's Bank Recovery and Resolution Directive (BRRD) in the EU 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, the building blocks of the resolution frameworks will be tested by what the chairwoman of the Single Resolution Board calls "an extraordinary challenge": the economic crisis sparked by the COVID-19 outbreak (cf. König, 2020).

The new regulations require banking institutions and groups to prepare (and update) detailed resolution plans (or "living wills"), and get them approved by regulators. 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). Under SPOE, the banking group is resolved as a single entity. In order to make this possible, the bank must ensure that potential losses of individual units can be mutualized. Under MPOE, instead, the different units of the banking group are resolved separately and individual units' losses will not be shared across the banking group. Banks can choose a resolution regime subject to agreement with their supervisory authorities. Some global banks, such as BBVA and HSBC, have chosen an MPOE approach but most of them have adopted SPOE, possibly because regulators seem to have identified SPOE as the most promising approach (FDIC, 2013).[1]

Resolution regimes affect banking groups' financing capacities and investment decisions through their effects on regulators' decisions in resolution and the incentives of bankers and investors outside resolution. Despite the importance and intensity of the policy debate concerning the merits of MPOE and SPOE resolutions (see also Tucker, 2014a,b), banking theory, with the notable exception of Bolton and Oehmke (2019), provides little guidance. Which of the two regimes leads to more financing and investment, particularly in banking groups' weaker units and in times of crisis, thus remains an open question.

This paper argues, contrary to some of the widely-held views in the policy arena, that MPOE may lead to more financing and (efficient) investment than SPOE, especially

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

in times of crisis. MPOE limits the exposure of a bank's investors to negative shocks potentially hitting weak units. Although this may lead to the shut down of weak units, which is inefficient, this may increase the group's initial financing capacity, which can be crucial to fund efficient investment in weak units in the first place. In addition, because MPOE does not mutualize losses across units, MPOE groups can benefit from more complex financing structures that allow them to provide insiders with monitoring incentives at lower costs. This increases the returns that can be pledged to outside investors and consequently the banking group's financing capacity.

We show that MPOE leads to more socially efficient investment than SPOE if the stronger units' financial excess capacity is small, the weak units' expected financing deficits are large, and the group's synergies are low or SPOE banks face higher cost for providing monitoring incentives. Banking groups can create synergies by lowering the cost of incentive provision when monitoring weaker units has a larger impact on investment returns than monitoring strong units. SPOE banks' costs of providing incentives are higher than those for MPOE banks when weak and strong units face different risks and weak units are not too small relative to the strong units. In times of crises when liquidity shocks are likely and weak units' financing deficits are large, MPOE resolution is necessary to finance weaker units in the first place.

We build a model of a banking group, with two asymmetric units, that may need to go through a resolution process. As compared to the strong unit, the weak unit has access to a relatively riskier portfolio of loans, and is subject to a possible negative liquidity shock that increases its funding needs. Financing capacity falls short of the present value of the bank's assets because bankers must be incentivized to monitor loans. As a result, the weak unit may not be able to finance itself, even if its operation is ex-ante efficient and its continuation following a liquidity shock is ex-post efficient. Joining the two units together as part of a banking group centralizes decision making, which creates financing synergies that can enable the operation of the weak banking unit. Financing synergies result from (i) transferring excess financing capacity from the strong to the weak unit and (ii) reducing the cost of providing bankers with incentives to monitor both units' loans (incentive synergies), which increases the group's financing capacity as compared to the case of two stand-alone banks.

As a benchmark to compare the performance of resolution and the resolution regimes against, we first derive the constrained optimal contract between the bank's insiders and its outside investors. Our setting differs from standard analyses of a multi-unit incentive contract because we consider asymmetric units. We show that forming a banking group only reduces agency rents, and thus creates incentive synergies, when monitoring weak units has larger effects on loan returns than monitoring strong units. We show further that even banking groups that optimally finance their weak units sometimes need to liquidate them following a liquidity shock despite continuation being ex-post efficient. The reason is that continuing the weak unit following a liquidity shock would require additional funding that is not available if (i) the weak unit's financing deficit following a liquidity shock exceeds the group's incentive synergies and (ii) the group's ex-ante financing capacity is low relative to the expected investment needs.

We then ask the question whether the constrained optimum can be implemented using simple debt and outside equity financing, while bank insiders hold equity claims in the holding unit. We show that these simple contracts in combination with the holding company's limited liability can implement the constrained optimal incentive contract by issuing debt both at the holding company as well as at the operating subsidiaries. However, debt and equity financing do not allow the bank to implement the constrained optimal investment and continuation decisions. The reason is that debt and equity financing do not provide the bank with insurance against future liquidity needs or possible adjustment for the existing financing contracts following a liquidity shock.

We then introduce resolution regimes that provide a mechanism to restructure and dilute existing claims in response to negative shocks. In addition, they also determine the liability structure within a banking group, which determines the priority order of different claimholders. MPOE resolution separates banking units and maintains limited liability between the group's units. Separating the banking units prevents ex-post transfers and results in shutting down weak units that are hit by negative liquidity shocks exceeding their individual financing capacity.[2] Hence, MPOE banking groups can implement the constrained optimum if it involves a shut down of the weaker unit.

SPOE resolution, instead, mutualizes losses, which allows the transfer of resources across subsidiaries. Such transfers enable the continuation of weak units that are hit by negative liquidity shocks. These transfers are costly for outside investors when the negative shock exceeds the financing capacity a weak unit adds to the banking group. Because outside investors anticipate these costs, they reduce the banking group's ex-ante financing capacity. Moreover, loss mutualization limits the incentive contracts that the bank can implement by issuing debt and equity. This reduces the bank's financing

[2] Wells Fargo's MPOE resolution plan, for instance, calls for the liquidation of its institutional broker-dealer separately in cases 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)

capacity when weak and strong units face different risks and the weak units are not too small relative to the strong units. As a result, SPOE resolution can only implement the constrained optimum if it provides sufficient financing capacity to operate the weak unit and finance its continuation following a liquidity shock. In some of the cases in which continuation is constrained optimal, neither resolution regime can implement the optimal contract: SPOE resolution because of incentive problems and MPOE because of continuation problems.

Our paper also provides predictions about the optimal allocation of debt obligations within (MPOE) banking groups, so as to minimize the cost of providing monitoring incentives. The optimal contract rewards bankers for the success of both units and may, as well, reward the success of only the strong unit. As a result, the debt levels of the different units must be such that a holding unit's inside equity pays off when both units succeed and creates a smaller payoff when only the strong unit succeeds. This can be achieved by raising debt in the holding company and in the weak unit rather than in the strong unit.[3]

We also compare resolution regimes with costless private restructuring and show that in most cases they are equally efficient. However, when the weak unit's financing deficit exceeds the group's incentive synergies, private restructuring can fail to continue the weak unit following liquidity shocks because outside investors are unwilling to cover the unit's financing deficit. SPOE resolution does not face this problem because it can impose losses on investors as needed. Resolution is only less efficient when SPOE resolution prevents efficient incentives provision such that the bank cannot operate both units. Thus, when private restructuring is not possible due to (various) frictions, resolution can in most cases ensure an efficient outcome.

Our model also has implications for the total loss absorption capacity (TLAC) that regulators require from global systematically important banks (G-SIBs) in order to cover losses and avoid public bailouts. Funding instruments that count as TLAC need to be able to be written down or converted into (diluted) equity during resolution. We show, contrary to common wisdom, that SPOE resolution may require more TLAC than MPOE resolution. Indeed, as bankers may require larger incentive payments under SPOE, the regulator can impose smaller losses on them. This increases the losses that outside investors have to bear, and thus the TLAC.

Finally, our model provides several empirical predictions. We show that banks are

[3]A BBVA research report (Pardo et al., 2014, p. 13), suggests, indeed, that the MPOE resolution regime and the associated decentralized financing structure "provides adequate tools to account for the risks each subsidiary undertakes."

more likely to choose MPOE rather than SPOE if its stronger units' excess financial capacity is small, incentive synergies are low or their weak units are large relative to their strong units and operate in sufficiently different markets with different risks. Moreover, the bank's existing resolution regime may impact future investment decisions. Banks opting for SPOE resolution are less likely to invest in riskier units, because their investors might be less willing to finance them, in anticipation of a bail-in following a liquidity shock. Since MPOE banks are not required to provide support to risky units, they will be able to raise financing for weak units with high expected financing deficits that create small synergies. As a result, MPOE banks are also less likely to curtail investments during crises.

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; Keister and Mitkov, 2020). Despite the intense policy debate on the resolution frameworks and the virtues of SPOE versus MPOE, the academic literature has been scant, with the exception of Bolton and Oehmke (2019). In their paper, banking groups create two types of synergies: financing synergies (that result from diversification benefits due to perfect negative correlation between investment returns) and operating synergies. SPOE resolution allows banks to take advantage of both types of synergies, while MPOE resolution cannot realize the financing synergies and reduces operating synergies. The main trade-off in their paper is that, in the case of multinational banks, national regulators might be unwilling, both ex-ante and ex-post, to transfer resources from a resource abundant unit to a unit lacking resources, unless the cost from losing operating synergies is sufficiently high. Hence, the focus is on regulatory coordination and commitment problems when resolution requires transfers across jurisdictions.

Our paper analyzes a different set of trade-offs. In our framework, and contrary to Bolton and Oehmke (2019), MPOE can be more efficient than SPOE, even if (national or international) regulators can commit to and enforce SPOE resolution. The synergies or lack thereof in our model can be related to previous literature in corporate finance. First, as in Fluck and Lynch (1999), the use of excess pledgeable income of a strong unit to finance a weak unit creates financing synergies. But, as in Inderst and Müller (2003), the continuation of units suffering from negative liquidity shocks can decrease ex-ante financing capacity. We show in particular that MPOE resolution, which may force the shut down of units suffering from negative liquidity shocks, can be necessary to fund the banking group's initial investments.

Second, incentive synergies arise from joint incentive contracts, as in Diamond (1984), Laux (2001a), and Cerasi and Daltung (2000). Our setting differs from these papers as we analyze multi-unit effort incentives in the context of asymmetric units. We show that SPOE resolution, and the resulting mutualization of losses, can prevent efficient incentive provision. This is related to the results of Kahn and Winton (2004), where separating safer loans from riskier loans by using a subsidiary structure that prevents loss mutualization reduces risk-shifting incentives in the safer subsidiary.[4]

Our results comparing the outcomes of resolution regimes to those of private restructuring add to recent contributions on this topic. Colliard and Gromb (2018) analyze the effect of resolution regimes on voluntary restructuring in a single-unit setting. They show that when resolution leads to larger bail-ins (smaller bailouts), this can slow down private restructuring and increase the probability of negotiations breaking down. Keister and Mitkov (2020) develop a model in which bail-ins are part of privately optimal contracts and show that bail-outs can delay privately optimal bail-ins. In our framework, we show that a resolution regime can improve efficiency, even when private restructuring is cost-less, because resolution can dilute investors' claims without voluntary participation.

2. Model

2.1. Banking groups and units

We present a model of two loan-making banking units, which are owned and run by bankers, also called insiders. Bankers decide which unit(s) to operate, and how to raise financing for the units, both initially as well as following the potential realization of a negative shock. Following the literature (e.g., Holmström and Tirole, 1998), we call these shocks liquidity shocks. Bankers also make decisions about whether loans are monitored, as they are assumed to have special skills in monitoring loans. Bankers do not possess any funds of their own and their outside option is set to zero. The bank needs financing from outside investors, who are competitive and, hence, break even in expectation. All parties are risk neutral, have a discount factor of one, and are protected by limited liability.

[4] Separate balance sheets can also alleviate agency problems between headquarters and unit managers as in Laux (2001b).

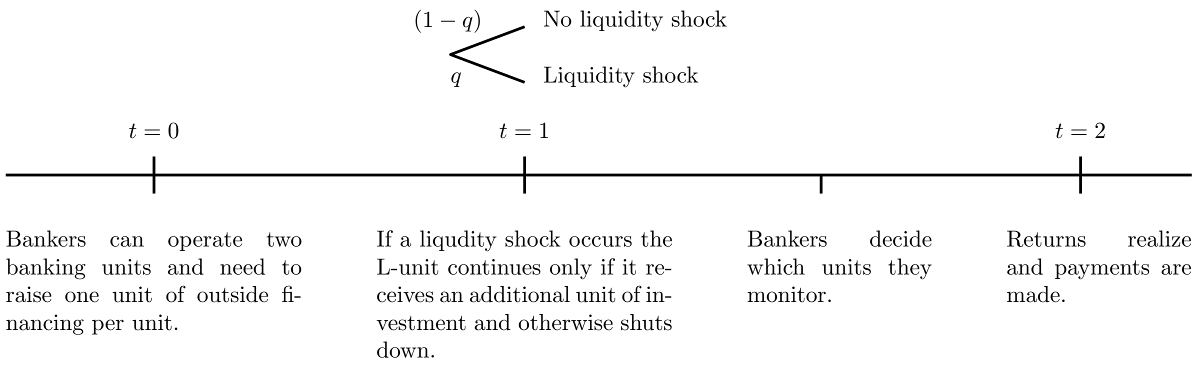

Figure 1: Time-line

In terms of organizational form, the two banking units can be operated as parts of the same banking group or as two independent stand-alone banks. A banking group consists of a holding company and the two wholly-owned subsidiary units. Decision-making within the group is centralized and there are no internal agency problems. Stand-alone banks instead are single-unit legal entities. If the banking units are operated as stand-alone banks, the decisions of each of them are made independently of each other.[5] When we write about a bank's or a unit's actions, these actions are determined by bankers unless the bank is in resolution (see Section 2.5 below).

2.2. Investments, liquidity shock, and monitoring

Our model features three dates $t = 0, 1, 2$. The model's time-line is summarized in Figure 1. At $t = 0$, each banking unit requires one unit of funding at to make loans, but otherwise the two units are asymmetric. The strong H-unit has access to a portfolio of relatively safe loans, whereas the weak L-unit has access to a portfolio of riskier loans.[6] Loan returns at $t = 2$ depend on the overall state of the world, $s \in \{G, M, X, B\}$, each occurring with a corresponding probability $p_s > 0$, and on the monitoring decision, which takes place between $t = 1$ and $t = 2$. Table 1 describes the two units' loan returns.

Monitoring improves loan returns in relatively bad states of the world (states X and B for the H-unit and states M and X for the L-unit).[7] However, it imposes a per-unit non-pecuniary cost c on the bankers. For the same monitoring decision (monitoring/no

[5] A banking group that chooses to operate only one unit is equivalent to a stand-alone bank.

[6] As we shall see below, the H-unit will have high pledgeable income whereas the L-unit will have low pledgeable income.

[7] The bank may increase its average recovery thorough monitoring by invoking protective covenants, renegotiating maturing loans, forcing foreclosure, and so forth (Winton, 1999).

state	H-unit monitoring	H-unit no monitoring	L-unit monitoring	L-unit no monitoring
G	R_H	R_H	R_L	R_L
M	R_H	R_H	R_L	0
X	R_H	0	R_L	0
B	R_H	0	0	0

Table 1: Banking units' returns

monitoring), the payoffs of the H-unit are less risky than those of the L-unit in the sense that a zero payoff is less likely. But the L-unit's payoffs are less risky than those of the H-unit if the L-unit monitors and the H-unit does not. Returns are observable but states and monitoring decisions are not. We make no assumptions on the ranking of the two units' expected returns or the success payoffs R_H and R_L.

This payoff structure uses the least number of states to capture the following features: (i) a positive payoff is a noisy signal of each unit's monitoring decision (due to state G); (ii) each unit's monitoring affects its payoffs in a state where the other unit's monitoring has no effect (state B for the H-unit and state M for the L-unit); and (iii) there exists a state in which both units' monitoring decisions affect their respective payoffs simultaneously, which allows for cross-pledging (state X).

At an interim date $t = 1$, the L-unit may suffer a liquidity shock, which is observable, and occurs with probability q. Following the shock, additional funding of one unit is needed to continue this unit.[8] If the additional investment is made, loans yield the same return at $t = 2$ as in the absence of a shock. If the investment is not made, the L-unit is shut down and generates no payoff at $t = 2$.[9] We sometimes refer to the $t = 0$ operation and the $t = 1$ continuation decisions, collectively, as the investment decisions.

Our analysis will focus on *generic* properties that hold for an open set of probabilities p_S (inside the simplex) and monitoring costs c. Throughout the paper we assume that the model parameters p_S and c are generic in this sense.

[8] Such a liquidity shock can result from higher draw-downs on the bank's precommited credit lines if firms' financing needs exhibit some correlation. If firms use these credit lines for liquidity insurance as in Holmström and Tirole (1998), but the bank does not provide these funds, then the affected firms will be liquidated, which precludes future debt repayments.

[9] The H-unit does not suffer liquidity shocks, but our main results would not change if it faced the same shock at the same time as the L-unit.

2.3. Net present value assumptions

We make a number of parameter assumptions on the net present values (NPV) of the investment decisions. These assumptions will render monitoring a necessary condition to make operation and continuation of both units optimal. We will make additional parameter assumptions in the results sections to concentrate on the most interesting and relevant cases.

We assume that the $t = 0$ operation of each unit generates a positive (expected) NPV provided that loans are monitored even if the L-unit is continued in the case of a liquidity shock. That is, we assume that each unit's expected returns, which can be obtained from Table 1, net of the monitoring costs, are higher than the (expected) investment costs:

$$R_H - c > 1 \text{ and } (1 - p_B)R_L - c > 1 + q.$$

This assumption is satisfied if the payoffs are high enough, the monitoring costs are low enough, and/or the shock probability is low enough. Notice that this assumption also implies that the continuation of the L-unit following a liquidity shock is also a positive NPV decision. This is because, while the L-unit's expected investment need at $t = 0$ is $1 + q$, at $t = 1$, once the initial investment is sunk, the additional required investment in the case of a liquidity shock is equal to 1.[10]

Conversely, we assume that, if loans are not monitored, the operation of the H-unit, as well as the operation and the continuation of the L-unit following a liquidity shock, generate negative NPV. That is, we assume

$$(p_G + p_M)R_H < 1 \text{ and } p_G R_L < 1.$$

This assumption implies that the bank should only operate the H- and the L-unit, and continue the L-unit following a liquidity shock, if it can ensure monitoring.

We also assume that the returns of the L-unit are high enough, and/or the probability of the shock is low enough, such that its operation at $t = 0$ generates positive NPV even if it is shut down in the case of a liquidity shock:

$$(1 - q)[(1 - p_B)R_L - c] > 1.$$

[10]If the liquidity shock were larger than $1 + q$, we would have needed to make additional assumptions to make continuation a positive NPV decision (and the problem interesting).

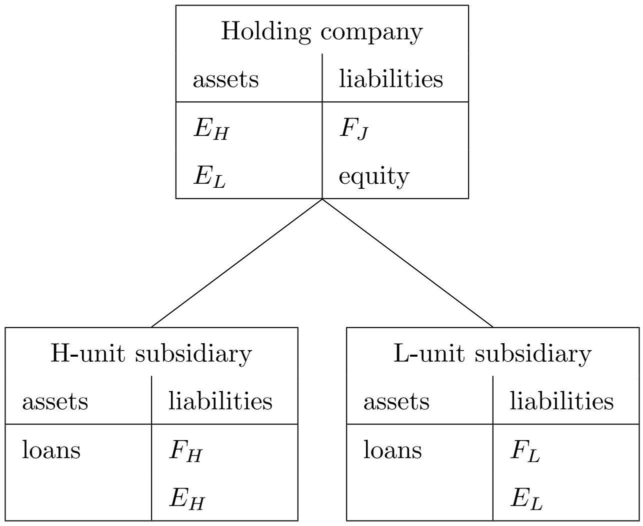

Figure 2: Group structure

2.4. Financing

We restrict financing to simple non-contingent contracts: fairly priced debt and/or outside equity. We thus do not allow the bank to write contracts with outside investors that (i) insure future liquidity needs or (ii) commit the bank to certain continuation decisions. This 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.

The bank can issue debt and equity claims at both dates $t = 0$ and $t = 1$, but all claims mature at $t = 2$. We assume that the bank cannot privately issue new claims at $t = 1$ that dilute exiting investors' claims issued at $t = 0$. Thus, we exclude the option of private restructuring.[11]

The banking groups' financing structure is summarized in Figure 2. Banking groups can issue debt at their subsidiaries H and L, and at the holding company level. We denote the face values of debt issued at these entities by F_H,F_L, and F_J, respectively. The holding company fully owns the subsidiaries, but its claims on the subsidiaries E_H and E_L are junior to the claims of the subsidiaries' debt holders. Banking groups can make internal transfers between the holding company and its subsidiaries. For simplicity, we assume that outside investors and bankers only hold the holding company's equity. We let e denote the ouside share of the holding company's equity that is held by investors. Bankers hold any remaining inside equity of the holding company. The banking group's

[11]We relax this assumption and discuss private restructuring in Section 6.

financial structure thus determines bankers' compensation and monitoring incentives.

2.5. Bank resolution

Resolution, and the applicable resolution regime, affect outcomes both at $t = 1$ and $t = 2$. Following a liquidity shock at $t = 1$, the bank enters resolution if it cannot finance the additional funding needs. In this case, the resolution regime provides a mechanism to restructure and dilute existing claims, in order to raise funding by issuing new claims. The bank's recapitalization is supervised by a regulator who temporarily takes over control from bankers and allocates losses among investors and bankers. The resolution regime also defines a priority order between the different claimholders at $t = 2$ and thereby also allocates eventual losses at $t = 2$.

We assume that the regulator's objective in resolution is to maximize NPV ex-post. In the case of a banking group, this means that the regulator aims to ensure (i) the continuation of the L-unit and (ii) monitoring of both subsidiaries. Hence, the regulator imposes sufficient losses on existing claim holders to raise additional financing and to provide sufficient inside equity to the bankers to ensure monitoring.[12] We further assume that the regulator imposes losses only to the extent that they are necessary to maximize NPV. In order to recapitalize the bank, the regulator can (totally or partially) wipe out 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 and allocate new inside equity to the bankers. If the regulator cannot raise sufficient funds for the L-unit's investment needs, the unit is shut down. Following resolution, control over the (remaining) bank reverts back to bankers.

2.6. Resolution regimes

We consider two different resolution regimes: Single-point-of-entry (SPOE) and Multiple-point-of entry (MPOE). The SPOE regime resolves the group as a whole and if the bank enters resolution at $t = 1$, the organizational form of the banking group is preserved. To make this possible, SPOE banks must ensure that the different units' losses are mutualized and the regulator can transfer resources between the group's units. A possible way to ensure loss mutualization is to issue debt only at the holding company level (F_J). In practice, though, SPOE banking groups often use different legal entities to issue debt

[12] As we show in Section 6, the decisions the regulator takes may be different from the ones creditors would take in a private restructuring.

(e.g. F_H or F_J) and ensure the viability of SPOE resolution through cross guarantees between these entities. Thereby, the banking groups approximate a single balance sheet where each creditor's claims are backed by the group's entire assets. We thus treat SPOE banking groups as sharing a single balance sheet. An important implication of mutualizing the unit's losses is that, at $t = 2$, equity holders (including bankers) will only be paid after all the creditors' claims are settled.

An MPOE resolution regime separately resolves the two operating subsidiaries. The different parts of the banking group are not liable for each other, and the regulator cannot transfer resources between the operating subsidiaries. If the bank enters resolution at $t = 1$, the group is split up and the two operating units become stand-alone banks. The original investors and bankers obtain claims on the new stand-alone banks and the units' monitoring decisions become independent. The group's holding company always benefits from limited liability towards its subsidiaries and a subsidiary's creditors only have claims on the respective subsidiary's cash flows. Hence, equity holders (including bankers) can receive cash flows from one subsidiary after repaying the respective subsidiary's and the holding company's debt, even when the other subsidiary defaults on its creditors.

Note, finally, that for stand-alone banks there is no difference between SPOE and MPOE resolution. We assume away any direct cost of resolution (or default).

3. Optimal Contracting Benchmark

3.1. Pledgeable income

As a benchmark to compare the resolution regimes against, we first derive the constrained optimal contract. In our model, bankers are the ex-ante residual claimants and hence, bankers' private optimum and the social optimum coincide at the initial contracting stage. An optimal contract, thus, maximizes the overall expected NPV.

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 to provide monitoring incentives, while satisfying investors' participation constraints. The second part specifies the operation and continuation decisions subject to the bank's ability to raise financing.

We assume here that (i) the occurrence of the liquidity shock, (ii) the L-unit's continuation decision at $t = 1$, and (iii) returns at $t = 2$ are contractible, but that the bankers' monitoring decisions and the state of the world are not.[13] Since both units' operation at $t = 0$ as well as the continuation of the L-unit have positive NPV, we need to determine whether these can be financed. We can restrict ourselves to contracts that ensure monitoring of all units since, otherwise, their operation and continuation are inefficient.

We analyze, in turn, the case in which the two individual units are operated as stand-alone banks and the case in which they form a banking group. In each case, we proceed backwards, in two steps. We first identify the incentive contracts that maximize the outside investors' cash flows subject to preserving the bankers' monitoring incentives between $t = 1$ and $t = 2$.[14] These contracts maximize the amount of outside financing the bank can raise and thus yield the bank's $t = 1$ pledgeable income P^1. This $t = 1$ pledgeable income will determine the continuation decision of the L-unit in the case of a liquidity shock. We then compute the $t = 0$ pledgeable income P^0 which determines the maximum financing the bank can raise for its initial operation decision. We do so separately for each continuation decision because these are contractible. The optimal contract then specifies the maximum amounts of operation and continuation that the bank can finance, given its pledgeable income P^0.

3.2. Stand-alone banks

Suppose first that the two units are operated independently, as stand-alone banks. To ensure monitoring, the incentive contract in each bank must provide an incentive payment τ to the bankers in case the bank generates a positive return. In the absence of a return, the contract that maximizes pledgeable income subject to limited liability pays the banker zero.

3.2.1. L-unit bank

The payoffs in Table 1 imply that monitoring between $t = 1$ and $t = 2$ is incentive compatible for the stand-alone L-unit bank if and only if

[13]We also restrict ourselves to continuation decisions that are deterministic functions of the liquidity shock.

[14]Because we assume a fixed investment size, several incentive contracts, including the ones that maximize financing capacity, may allow the bankers to raise sufficient financing to operate both units. But in some cases, the use of a contract that maximizes financing capacity will be necessary to raise sufficient financing and we thus concentrate on these contracts. Note that all contracts that allow the bank to raise sufficient financing satisfy the same incentive and participation constraints and result in the same amount of surplus creation.

$$(p_G + p_M + p_X)\tau - c \geq p_G\tau.$$

Hence, the incentive compatible contract that maximizes the bank's financing involves a minimal incentive payment at $t = 2$ given by

$$\tau^L \equiv \frac{c}{p_M + p_X} > 0. \tag{1}$$

As bankers' outside option is zero, their participation constraint is always satisfied. Note that the (minimum) payment to the insiders is independent of the realization of the liquidity shock at $t = 1$ (as long as the bank continues). The resulting pledgeable income to outside investors at $t = 1$ is given by

$$P_L^1 \equiv (p_G + p_M + p_X)(R_L - \tau^L).$$

The bank's pledgeable income at $t = 0$ depends on the continuation decision following a liquidity shock χ, where $\chi = L$ denotes continuation of the L-unit and $\chi = 0$ denotes shut down. Taking into account the probability of a liquidity shock q and the resulting financing needs of 1, the pledgeable income at $t = 0$ is

$$P_L^0(\chi) \equiv \begin{cases} P_L^1 - q & \text{if } \chi = L \\ (1-q)P_L^1 & \text{if } \chi = 0. \end{cases}$$

The bank can operate at $t = 0$ if and only if there exists a continuation policy χ such that the bank's pledgeable income exceeds the initial financing costs, i.e., $P_L^0(\chi) \geq 1$. The next lemma shows that if the bank can operate for any continuation policy χ, then the bank can always operate with $\chi = L$, and doing so is constrained optimal because continuation generates positive NPV.

Lemma 1. *For a stand-alone L-unit bank, the incentive contract that maximizes financing is given by the incentive payment τ^L in Expression (1). It is constrained optimal to operate a stand-alone L-unit bank if and only if $P_L^0(L) \geq 1$ (i.e., $P_L^1 \geq 1 + q$), in which case it is constrained optimal to continue it following a liquidity shock.*

Proof. See Appendix B.1. □

To make the problem interesting, we will assume in the remainder of the paper that the L-unit's pledgeable income at $t = 1$ is lower than the investment required to continue the bank following a liquidity shock.

Assumption 1. *The L-unit's pledgeable income at $t = 1$ satisfies $P_L^1 < 1$.*

The assumption also implies that the bank's $t = 0$ pledgeable income $P_L^0(\chi) < 1$ for all χ and hence, the L-unit cannot be operated as a stand-alone bank, despite having a positive NPV. This is due to agency costs. The operation and possible continuation of the L-unit will thus require an additional source of pledgeable income. In Section 3.3, we discuss the viability of the L-unit as part of a banking group that can cross pledge returns from its H-unit.

3.2.2. H-unit bank

Following the same steps as for the L-unit, monitoring is incentive compatible for the stand-alone H-unit bank if and only if

$$\tau - c \geq (p_G + p_M)\tau.$$

The incentive payment that minimizes bankers' rents at $t = 1$, and the resulting bank's pledgeable income, are given respectively by

$$\tau^H \equiv \frac{c}{p_X + p_B} \text{ and } P_H^1 \equiv R_H - \tau^H. \tag{2}$$

Since the H-unit is not affected by a liquidity shock, the stand-alone H-unit bank will always continue its operations at $t = 1$ and the bank can pledge its entire $t = 1$ pledgeable income at $t = 0$, such that $P_H^0 = P_H^1$. The bank can operate as long as $P_H^0 \geq 1$.

Lemma 2. *For a stand-alone H-unit bank, the incentive contract that maximizes financing is given by an incentive payment τ^H. It is constrained optimal to operate a stand-alone H-unit bank if and only if $P_H^0 \geq 1$ (i.e., $P_H^1 \geq 1$).*

Proof. Follows from the arguments in the text. □

In the remainder of the paper, we will assume that the H-unit's pledgeable income is high enough such that the H-unit can operate as a stand-alone bank.

Assumption 2. *The H-unit's pledgeable income at $t = 1$ satisfies $P_H^1 \geq 1$.*

3.3. Banking group

We now analyze the benefits of forming a banking group. We determine whether forming a banking group that owns and controls both units allows for the operation and possible continuation of the L-unit, which increases efficiency.

3.3.1. Incentive contract

We first derive the incentive contract that ensures monitoring of both units and maximizes the bank's financing at $t = 1$. Clearly such a contract presupposes that the bank still consists of two units after $t = 1$, because otherwise the banking group is equivalent to a stand-alone H-unit bank. The incentive contract $T_G = \{\tau_L, \tau_H, \tau_2\}$ consists of payments to the bankers when only the L-unit, only the H-unit, or both units generate a positive return at $t = 2$, respectively (no payment should be made in the absence of a return). Because monitoring does not affect the probability of a liquidity shock, the incentive contract must not depend on whether a liquidity shock, occurs or not. We denote the overall $t = 1$ pledgeable income of a banking group by

$$P_G^1 \equiv P_H^1 + P_L^1 + P_J^1,$$

where P_J^1 denotes the additional pledgeable income created by joining two units in a banking group, which we call incentive synergies.

From Table 1, the incentive compatibility constraints for monitoring both units rather than the L-unit only, the H-unit only, or neither of them are given by

$$(1 - p_B)\tau_2 + p_B\tau_H - 2c \geq (p_G + p_M)\tau_2 + p_X\tau_L - c \quad (3)$$

$$(1 - p_B)\tau_2 + p_B\tau_H - 2c \geq p_G\tau_2 + (1 - p_G)\tau_H - c \quad (4)$$

$$(1 - p_B)\tau_2 + p_B\tau_H - 2c \geq p_G\tau_2 + p_M\tau_H. \quad (5)$$

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

The pledgeable income of a banking group is determined by the minimum amount of compensation that bankers must receive in order to satisfy the above incentive compatibility constraints and all limited liability constraints. The banking group creates incentive synergies if it can reduce the compensation, or the agency rents, necessary to provide monitoring incentives in the two units, relative to the incentive payments provided in the case of two stand-alone banks.

Stand-alone banks can only base bankers' compensation on the success of individual units. A banking group can, in addition, base bankers' compensation on the joint success of both units. This additional contractual flexibility is valuable when the informativeness of the contractible outcomes about the monitoring decisions increases. This is the case if and only if the joint success of the two units is more informative about the two units' monitoring decisions than the individual success of the H-unit or the L-unit is about its respective monitoring decisions. In this case, using joint success in the bankers' compensation contract allows the bank to lower agency rents, which increases its pledgeable income.

We can measure the informativeness of an outcome by the likelihood of the outcome with monitoring relative to the likelihood of the outcome without monitoring. From Table 1, the informativeness of joint success $(R_H + R_L)$ about the two units' monitoring decisions is given by

$$\frac{p_G + p_M + p_X}{p_G}.$$

The informativeness of the L-unit's success (R_L) about the decision to monitor the L-unit is the same as that of joint success. The reason is that, due to the asymmetry of our model, the H-unit succeeds whenever the L-unit succeeds, as long as both units take the same monitoring decisions. In contrast, the H-unit can succeed when the L-unit does not. The informativeness of its success (R_H) is given by

$$\frac{p_G + p_M + p_X + p_B}{p_G + p_M}.$$

Thus, the banking group can reduce the compensation and creates incentive synergies if joint success is more informative than the individual success of the H-unit. In this case, the banking group can lower the agency rents by providing incentives to monitor the H-unit based on payments in the case of joint success. Otherwise, the banking group cannot lower the agency rents because providing incentives based on the individual units' successes already makes the most efficient use of the available information.[15]

We will now discuss the structure of the compensation contracts that maximize the bank's financing. Recall that, conditional on both units monitoring, it cannot happen that only the L-unit succeeds. If follows that rewarding the success of only the L-unit provides no monitoring incentives and hence, it is weakly optimal to set $\tau_L = 0$.[16]

[15]For the symmetric case, the positive incentive effects of combining different projects (that are not perfectly correlated) are known in the literature on optimal contracting (Diamond, 1984; Laux, 2001a) and have been discussed in a banking context by Cerasi and Daltung (2000).

[16]Note, however, that τ_L never gets paid when both units monitor and hence $\tau_L > 0$ yields the same expected compensation as $\tau_L = 0$. It follows that as long as the IC-constraint (3) does not become

If the banking group cannot reduce the agency rents, it can replicate the incentive contracts of two stand-alone units by setting $\tau_H = \tau^H$ and $\tau_2 = \tau^H + \tau^L$.[17] This contract ensures monitoring by both units and results in the same expected compensation as two stand-alone units.

If the banking group can reduce the agency rents, it must increase the reward for joint success, $\tau_2 > \tau^H + \tau^L$, and decrease it for the success of only the H-unit, $\tau_H < \tau^H$. Rewarding joint success provides stronger monitoring incentives for the L-unit than for the H-unit. This is because monitoring the L-unit affects joint success in states M and X, while monitoring the H-unit does so only in state X. If the probability of state X relative to state M is large ($p_X > p_M$), then the incentives for monitoring the H-unit are so strong that the cheapest way to provide monitoring incentives is to set $\tau_H = 0$. Conversely, if it is relatively low ($p_X < p_M$), it becomes cheaper to provide separate monitoring incentives for the success of only the H-unit, $\tau_H > 0$.

The following proposition describes the pledgeable income of a two-unit banking group and the structure of the incentive contracts that maximize the bank's financing. We derive the exact sizes of the incentive synergies and the incentive payments in the proof.

Proposition 1. *For a two-unit banking group,*

(i) *there are incentive synergies, $P_J^1 > 0$, if and only if*

$$\frac{p_M + p_X}{p_G} > \frac{p_X + p_B}{p_G + p_M}. \tag{6}$$

Otherwise $P_J^1 = 0$.

(ii) *an incentive contract $T_G^* = \{\tau_L^*, \tau_H^*, \tau_2^*\}$ that maximizes financing satisfies $\tau_2^* > \tau_H^*$, $\tau_H^* \in [0, \tau^H]$, and $\tau_L^* \in [0, \overline{\tau}_L]$, where τ_H^*, τ_2^* and $\overline{\tau}_L$ are unique.*

(iii) *the incentive payment satisfies $\tau_H^* < \tau^H$ if and only if Condition (6) holds and $\tau_H^* = 0$ if and only if additionally $p_X > p_M$.*

Proof. See Appendix B.2. □

There are two additional remarks on Condition (6) to be made. Recall that, in this asymmetric setting, joint success and the L-unit's success have the same informativeness. As a result, joint success is more informative than at least one of the unit's individual

binding, any $\tau_L \geq 0$ is optimal.

[17] Recall that the superscripts denote the incentive payments that maximize the financing of the respective stand-alone banking units, from Expressions (1) and (2).

success, and thus incentive synergies arise if the L-unit's success is more informative than the H-unit's success. Note first that, whether the L-unit's success is more informative than the H-unit's depends on the impact of monitoring for the respective units. When monitoring the L-unit has a larger impact on the likelihood of success than monitoring the H-unit, such that $p_M + p_X > p_X + p_B \Leftrightarrow p_M > p_B$, then Condition (6) is always satisfied and the banking group creates incentive synergies.[18]

Second, as the informativeness of the the L- and the H-unit's monitoring is also directly related to the agency rents of the stand-alone units, Condition (6) is equivalent to $\tau^H > (1 - p_B)\tau^L$. Thus, incentive synergies are present when the L-unit's expected agency rents are smaller than the H-unit's.

3.3.2. Operation and continuation decisions

We now turn to the operating and continuation decisions. Since the pledgeable income of the H-unit satisfies its financing needs (Assumption 2), it is always optimal to operate the H-unit. The decisions to operate and continue the L-unit as part of the banking group, instead, depend on whether the two-unit banking group's pledgeable income at $t = 0$ is high enough to make up for the insufficient stand-alone pledgeable income of the L-unit (Assumption 1).

The pledgeable income of the two-unit banking group at $t = 0$ depends on the continuation decision following a liquidity shock, as the bank can either make an additional investment in the L-unit and thus continue with both units ($\chi = 2$) or shut down the L-unit and continue with the H-unit only ($\chi = H$). Taking into account again the probability of a liquidity shock and the resulting financing needs, the pledgeable income at $t = 0$ is

$$P_G^0(\chi) \equiv \begin{cases} P_G^1 - q & \text{if } \chi = 2 \\ (1-q)P_G^1 + qP_H^1 & \text{if } \chi = H. \end{cases} \tag{7}$$

As operation and continuation are efficient, we have the following proposition.

Proposition 2. *The constrained optimal operation and continuation decisions are:*

(i) *If $P_G^0(2) \geq 2$ the bankers operate both units at $t = 0$ and continue the L-unit following a liquidity shock at $t = 1$.*

(ii) *If $P_G^0(2) \leq 2 \leq P_G^0(H)$ the bankers operate both units at $t = 0$ and do not continue the L-unit following a liquidity shock at $t = 1$.*

[18]For comparison, we consider the case of symmetric units in Appendix A.

(iii) *If* $\max\{P_G^0(2), P_G^0(H)\} < 2$ *the bankers operate only the H-unit at* $t = 0$.

Proof. Follows from the arguments in the text. □

A banking group can increase efficiency when it enables the L-unit to operate, which it cannot do as a stand-alone bank because $P_L^0 < 1$. A banking group centralizes decision-making, which creates two types of benefits. First, it allows the bank to transfer pledgeable income between the two units. Hence, as the H-unit's pledgeable income exceeds its investment costs, its excess pledgeable income $P_H^0 - 1 > 0$ can be used to finance the L-unit. Second, the banking group allows for more complex incentive schemes to ensure monitoring, which may create additional pledgeable income P_J^1.

In case (i) of Proposition 2, the group's pledgeable income is high enough such that the optimal contract implements the first-best efficient investment decisions, namely to operate and continue both units. In case (ii) the bank can only operate both units at $t = 0$ if it commits to shut down the L-unit following a liquidity shock.[19] Importantly, shutting down the L-unit increases the bank's $t = 0$ pledgeable income such that $P_G^0(H) > P_G^0(2)$ if and only if the L-unit's financing deficit following a liquidity shock exceeds the incentive synergies

$$1 - P_L^1 > P_J^1. \tag{8}$$

In this case, continuing the L-unit requires the use of the H-unit's excess pledgeable income at $t = 1$. However, this reduces the bank's $t = 0$ pledgeable income relative to the case of shutting the L-unit down following a liquidity shock.

Since we are interested in situations where banking groups increase efficiency, the rest of the paper excludes case (iii) of Proposition 2.

Assumption 3. *The pledgeable income of the banking group satisfies*

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

4. Debt and Equity Financing

In this section, we address the question whether the constrained optimal contract can be implemented using simple financing contracts that include fairly priced debt and/or (outside) equity as described in Section 2.4. This restriction on financial contracts makes

[19] Recall that operating the L-unit at $t = 0$ has positive NPV even if it is shut down following a liquidity shock.

the problem interesting as fully contingent claims could always implement the optimal contract and would make any resolution regime redundant.

Furthermore, we assume that although the bank can issue debt and equity claims at dates $t = 0$ and $t = 1$, it cannot issue claims at $t = 1$ that dilute the claims issued at $t = 0$. Thus, for now we exclude the possibility of private restructuring or the use of a resolution regime. If a subsidiary cannot repay its maturing debt, or it cannot raise the necessary funding to continue following a liquidity shock at $t = 1$, it defaults and gets liquidated.

If no liquidity shock occurs at $t = 1$ there is no reason to issue additional claims at $t = 1$ and the bank's initial $t = 0$ capital structure does not change. In the case of a liquidity shock, the bank must either raise new (junior) financing in order to continue the L-unit, or the L-unit defaults and gets liquidated. In both cases a new capital structure arises. Since all claims mature at $t = 2$, the capital structure emerging at $t = 1$ determines bankers' monitoring incentives and the final distribution of cash flows at $t = 2$.

Investors holding debt issued at the subsidiaries F_H or F_L only have claims on the cash flows of the respective subsidiary. Debt issued by the holding company F_J gives a claim on both subsidiaries' residual cash flows after their respective debts are repaid. Outside investors also hold a share e of the holding company's equity and bankers hold the remaining equity share $1 - e$.

We first analyze how simple contracts in combination with the holding company's limited liability can implement the incentive contracts T_G^*. Second, we show that debt and equity contracts often fail to implement the constrained optimal investment and continuation decisions. The reason is that debt and equity financing do not allow the bank to insure against future liquidity needs or adjust existing financing contracts following liquidity shocks.

4.1. Incentive contracts

Bankers' monitoring incentives are determined by the cash flows that accrue to their inside equity of the holding unit. These cash flows are determined by the debt and equity claims that the banking group issues. Limited liability ensures that the bankers' payoff as well as the holding company's cash flows from any subsidiary are always weakly positive. For a two-unit banking group, the incentive payments resulting from the bank's capital structure are given by

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

where the $\{.\}^+$ operators denote $max\{., 0\}$ and capture the limited liability constraints. These limited liability constraints allow the bank to independently determine the different incentive payments τ_2, τ_H and τ_L by issuing different amounts of debt at different units. We can state the following lemma.

Lemma 3. *A banking group can implement an incentive contract T_G^* by issuing debt and equity if the monitoring costs c do not exceed an upper bound $\bar{c}$.*

Proof. See Appendix B.3. □

When the monitoring costs are sufficiently small, the bank can always implement an incentive contract T_G^*. One way to do so is to choose the debt levels $F_J = R_H - \tau_H^*$, $F_L = R_L - (\tau_2^* - \tau_H^*)$ and $F_H = 0$, and to issue no outside equity, $e = 0$. It is easy to verify that these claims implement a contract T_G^* by substituting into Expression (9).

The monitoring costs c must not exceed $\bar{c}$ because debt and equity claims limit the size of bankers' incentive payments. Debt and equity claims always yield weakly positive cash flows to outside investors, which implies that bankers' payoffs can never exceed the bank's cash flows. Moreover, the cash flows of debt and equity are weakly increasing in the cash flows of the bank's units. It follows that bankers' payoffs, going from one to two positive returns, can never grow faster than the bank's overall cash flows. The sizes of the incentive payments necessary to provide monitoring incentives depends on bankers' monitoring costs c. The upper bound $\bar{c}$ ensures that the payments in T_G^* neither exceed nor increase faster than the bank's cash flows.[20]

Debt and equity cash flows are weakly positive and increasing in the underlying cash flows of the bank, regardless of a bank's resolution regime or lack thereof. Hence, we assume in the reminder of the paper that the monitoring costs c are sufficiently small. This allows us to focus on mechanisms through which resolution regimes can improve efficiency when banks use simple financing contracts.

Assumption 4. *The monitoring cost $c \leq \bar{c}$.*

[20]This Condition is expressed formally by Expressions (18) and (19) in Appendix B.3.

Stand-alone units can also implement the incentive payments that maximize their pledgeable income τ^L and τ^H by issuing debt and equity. A stand-alone H-unit, which consists of a single entity, can do so by issuing debt with a face value F and outside equity e, such that

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

An analogous argument applies for the L-unit.

When a banking group uses debt and equity financing to implement an incentive contract T_G^* that minimizes bankers' rents, it maximizes outside investor's cash flows. It follows that a banking group's $t = 1$ pledgeable income with debt and equity financing is P_G^1. Using the same argument, the pledgeable incomes of stand-alone L- and H-unit banks with debt and equity financing are P_L^1 and P_H^1, respectively.

4.2. Operation and continuation decisions

We now turn to the investment decisions. To raise sufficient funding at $t = 0$, a banking group must issue debt and equity that yield expected cash flows of two units, taking into account the bank's future continuation decision following a liquidity shock.

4.2.1. Continuing the L-unit

Since continuation is ex-post efficient, bankers, who are the residual claimants, always have an incentive to continue the L-unit. Recall that the bank cannot issue new claims that dilute the existing investors' claims. Hence, in order to continue the L-unit following a liquidity shock, the bank must conserve one unit of free pledgeable income at $t = 0$. This free pledgeable income remains unpledged in the absence of a liquidity shock, which reduces the bank's financing capacity. Since the bank can implement a contract T_G^* with debt and equity, its $t = 0$ pledgeable income is given by $P_G^1 - 1$. It follows that its pledgeable income is smaller than $P_G^0(2)$ from Expression (7), which yields the following lemma.

Lemma 4. *The $t = 0$ pledgeable income of a banking group that continues the L-unit and issues debt and equity is strictly smaller than $P_G^0(2)$.*

Proof. Follows from the arguments in the text. □

Moreover, at $t = 0$ the bank can only operate both units if $P_G^1 \geq 3$. We are interested in cases where pledgeable income is not abundant so that a resolution regime may increase efficiency. Hence, we make the following assumption.

Assumption 5. *The pledgeable income of the banking group satisfies* $P_G^1 < 3$.

This assumption implies that in case (i) of Proposition 2 a bank can never implement the constrained optimum by issuing debt and equity as it cannot continue the L-unit following a liquidity shock.

4.2.2. Shutting down the L-unit

If the bank cannot raise financing to continue the L-unit following a liquidity shock, the L-unit defaults on F_L and gets liquidated without yielding a return. The claims on the H-unit and the holding company remain unchanged. Hence, the bankers' payment if the H-unit succeeds is given by τ_H in Expression (9). It follows that the bankers will only monitor the H-unit following a liquidity shock if τ_H is larger or equal to the minimum incentive compatible payment of a stand-alone H-unit τ^H in Expression (2).

When $\tau_H^* < \tau^H$ the bank cannot implement the contract T_G^* at $t = 0$ and ensure monitoring following a liquidity shock. When the bank implements T_G^* at $t = 0$, outside investors' cash flows following liquidity shock will be strictly smaller than P_H^1[21] which implies that the bank's $t = 0$ pledgeable income will be smaller than $P_G^0(H)$. Alternatively, the bank can issue claims at $t = 0$ such that $\tau_H \geq \tau^H$, which then do not implement the contract T_G^*. In this case, the bank cannot realize the incentive synergies P_J^1 and one can show that the bank's pledgeable income is given by

$$(1 - q)(P_H^1 + P_L^1) + qP_H^1.$$

From Proposition 1 it follows that $\tau_H^* < \tau^H$ if and only if the incentive synergies $P_J^1 > 0$. The reason is that the incentive synergies result from reducing the agency rents that are necessary to provide incentives for monitoring the H-unit as part of a banking group. But without these rents bankers do not have an incentive to monitor the H-unit once the L-unit is shut down. If follows further that for $P_J^1 = 0$ the bank can implement T_G^* at $t = 0$ and ensure monitoring following liquidity shock. Hence, we obtain the following lemma.

Lemma 5. *The $t = 0$ pledgeable income of a banking group that shuts down the L-unit and issues debt and equity is strictly smaller than $P_G^0(H)$ if and only if $P_J^1 > 0$.*

Proof. See Appendix B.4. □

[21] Recall that, without monitoring, the H-unit's expected cash flow is $(p_G + p_M)R_H < 1 < P_H^1$.

With debt and equity financing, the bank cannot condition bankers' incentive contract on whether the L-unit is shut down or not. As a result, bankers either lack monitoring incentives following a liquidity shock, which destroys value, or earn excess rents in the absence of a liquidity shock. In either case, the bank's ability to raise financing is reduced. It follows that the bank will sometimes fail to operate both units even when it is constrained optimal to shut down the L-unit following a liquidity shock (case (ii) of Proposition 2).

5. Resolution Regimes

Bank resolution regimes will improve efficiency because they allow for the restructuring and dilution of existing claims following a liquidity shock. In this section, we analyze the extent to which bank resolution regimes, in combination with simple financing contracts, can implement the constrained optimal investment and continuation decisions. A banking group always enters resolution following a liquidity shock due to Assumption 5.

5.1. MPOE Resolution

MPOE resolution separates the two units when the banking group enters resolution. Units become stand-alone banks and the regulator can no longer transfer funds between them. Separate resolution of the different units preserves the limited liability of a banking group's holding company.

The holding company's limited liability vis-a-vis debtholders of the subsidiaries allows the banking group to implement the incentive contracts T_G^* using debt and equity (cf. Lemma 3). Hence the bank's $t = 1$ pledgeable income in the absence of a liquidity shock is P_G^1.

When the bank enters resolution following a liquidity shock, the regulator will be forced to shut down the L-unit. The reason is that the L-unit's pledgeable income $P_L^1 < 1$ falls short of its investment needs (cf. Assumption 1), even if the regulator writes down all its existing claims. As a result, claims on the L-unit become worthless.

The regulator will write down existing claims on the H-unit (issued by the H-unit subsidiary or the holding company) if necessary to ensure monitoring. Thus, it follows from Section 4.2.2 that the regulator will write down claims if and only if the initial claims are such that $\tau_H < \tau^H$. In the case of a write-down, outside investors' claims will be worth $R_H - \tau^H = P_H^1$, because the regulator chooses the smallest write-down necessary to ensure monitoring. In the absence of a write-down, outside investor's claims are worth $R_H - \tau_H$.

A bank maximizes outside investors' cash flows if it issues initial claims that are worth P_G^1 in the absence of a liquidity shock. In the case of a liquidity shock outside investors' cash flows are worth $P_H^1 - 1$, because $\tau_H^* \leq \tau^H$ (cf. Proposition 1). It follows that the bank's $t = 0$ pledgeable income is given by $(1-q)P_G^1 + qP_H^1 = P_G^1(H)$. We obtain the following lemma.

Lemma 6. *An MPOE banking group always shuts down the L-unit following liquidity shock. The banking group's pledgeable income equals $P_G^0(H)$.*

Proof. Follows from the preceding discussion. □

MPOE resolution increases the bank's pledgeable income relative to debt and equity financing without resolution because it restructures outside investors' claims when it shuts down the L-unit. This restructuring ensures that bankers will monitor the H-unit following a liquidity shock regardless of the claims the bank issues at $t = 0$. Hence, the banks can issue claims at $t = 0$ that implement T_G^* in the absence of a liquidity shock and take full advantage of any incentive synergies P_J^1 even though $\tau_H^* < \tau^H$.

Note that the increase in pledgeable income relative to the case without resolution relies on resolving the holding company and the H-unit subsidiary in order to restructure claims, even though only the L-unit subsidiary experiences a liquidity shock. Resolving all parts of the banks could only be avoided if the bank issues claims at $t = 0$ that ensure that bankers monitor the H-unit after shutting down the L-unit. But, as we have argued in Section 4.2.2, such claims imply that the bank cannot implement T_G^* when $P_J^1 > 0$, which reduces its pledgeable income.

5.2. SPOE resolution

SPOE resolution preserves the structure of the banking group. In order to continue units in difficulty, SPOE mutualizes the different units' losses, which allows the regulator to transfer funding resources within the group. Loss mutualization approximates a single balance sheet where each creditor's claims are backed by the group's entire assets. The simplest way to implement loss mutualization is to issue debt only at the holding company. Our results, however, do not depend on the specific implementation of loss mutualization.

Because SPOE resolution mutualizes losses, equity holders (including bankers) will only be paid, at $t = 2$, after all the group's creditors' claims are settled. It follows that the bankers' incentive contract depends only on the sum of all the face values of the banking group's debts, which we denote by F_G, and the share of outside equity e. The incentive contract is given by

$$\begin{aligned} \tau_L &= (1-e)\{R_L - F_G\}^+ \\ \tau_H &= (1-e)\{R_H - F_G\}^+ \\ \tau_2 &= (1-e)\{R_L + R_H - F_G\}^+, \end{aligned} \tag{10}$$

where the $\{.\}^+$ operators capture equity holders' limited liability. Loss mutualization restricts the contracting space and reduces the set of contracts that can be implemented by issuing debt and equity because it eliminates the holding company's limited liability towards its subsidiaries.

The bank can implement an incentive contract that maximizes its financing when it can issue debt and equity such that Expression (10) yields $T_G^* = \{\tau_L^*, \tau_H^*, \tau_2^*\}$. This will not always be feasible. When $\tau_H^* > 0$, then implementing τ_H^* and τ_2^* uniquely determines the debt and equity claims F_G and e, which, in turn, uniquely determine τ_L. If τ_L is larger than $\bar{\tau}_L$, it violates the IC-constraint (3), which ensures monitoring of the H-unit conditional on the L-unit monitoring. As a result, the bank cannot implement the incentive contract T_G^*.

Conversely, when $\tau_H^* = 0$, the bank needs to implement a contract that consists of a single payment τ_2^* in case both units succeed. This can be achieved by issuing a single debt claim at the holding company such that $F_G = R_L + R_H - \tau_2^*$ and not issuing any outside equity.[22]

We let P_S^1 denote an SPOE bank's pledgeable income at $t = 1$. If the bank can implement a contract T_G^* then $P_S^1 = P_G^1$. If it cannot, banker's monitoring rents are higher and $P_S^1 < P_G^1$. We obtain the following lemma.

Lemma 7. *An SPOE bank cannot implement an incentive contract that maximizes its financing by issuing debt and equity, and its $t = 1$ pledgeable income P_S^1 is strictly smaller than P_G^1, if and only if $\tau_H^* > 0$ and*

$$\frac{\tau_2^* - \bar{\tau}_L}{\tau_2^* - \tau_H^*} > \frac{R_H}{R_L}. \tag{11}$$

Proof. See Appendix B.5. □

[22]The incentive payment $\tau_H = \tau_L = 0$ because the debt claim satisfies $F_G > R_L$ and $F_G > R_H$ due to Assumption 4 and the associated Condition (19) in Appendix B.3.

The incentive contract T_G^* determines the minimum increase in bankers' pay going from the success of only the L-unit to the success of both units $\tau_2^* - \bar{\tau}_L$ relative to the increase going from the success of only the H-unit to the success of both units $\tau_2^* - \tau_H^*$. However, loss mutualization implies that the bankers' (inside equity) payoff must increase proportionally to the bank's overall cash flows. Thus an SPOE bank cannot implement T_G^* when the increases in the bank's cash flows going from the success of only the L-unit to the success of both units R_H is too small relative to the increase going from the success of only the H-unit to the success of both units R_L, which yields Expression (11).

When the bank enters resolution following a liquidity shock, SPOE resolution maintains the structure of the banking group. Hence, a regulator can raise one unit of additional financing to continue the L-unit by writing down existing investors' claims if and only if $P_S^1 \geq 1$. If possible, the regulator will always do so because continuation maximizes ex-post efficiency (NPV). A banking group's $t = 0$ pledgeable income is smaller than its $t = 1$ pledgeable income in the absence of a liquidity shock. It follows that an SPOE banking group can only raise financing to operate both units if the $t = 1$ pledgeable income $P_S^1 \geq 2$. As argued above, this implies that the regulator will always continues the L-unit of an SPOE bank following a liquidity shock.

The bank maximizes outside investors' claims if it issues initial claims such that their expected cash flows in the absence of a liquidity shock is P_S^1. Because the regulator never dilutes outside investors' claims more than necessary, their payoff following a liquidity shock will be $P_S^1 - 1$. Note that some of the losses must be borne by outside investors that hold claims of the holding company or the H-unit subsidiary. Such loss mutualization is necessary to raise funding against the H-unit's cash flows in order to cover the L-unit's financing deficit $P_L^1 - 1$ following a liquidity shock. The precise allocation of losses among the existing outside investors at $t = 1$ does not affect the bank's overall pledgeable income at $t = 0$ because all claims are fairly priced.Thus, an SPOE bank's $t = 0$ pledgeable income is

$$P_S^0 \equiv (1 - q)P_S^1 + q(P_S^1 - 1) = P_S^1 - q.$$

It follows that when the bank can implement the incentive contract T_G^*, $P_S^0 = P_G^0(2)$, and otherwise $P_S^0 < P_G^0(2)$. We obtain the following lemma.

Lemma 8. *An SPOE banking group always continues the L-unit following a liquidity shock. The banking group's pledgeable income* $P_S^0 < P_G^0(2)$ *if* $\tau_H^* > 0$ *and Condition (11) hold. Otherwise* $P_S^0 = P_G^0(2)$.

SPOE resolution can increase efficiency because the regulator can restructure claims to raise funds for continuing the L-unit. Because the regulator only restructures claims in the case of a liquidity shock, the bank does not need to conserve pledgeable income in the absence of a liquidity shock, which increases the bank's $t = 0$ pledgeable income. Loss mutualization is necessary to raise sufficient financing to cover the L-unit's financing deficit following a liquidity shock.

But, loss mutualization can also prevent a banking group from implementing an incentive contract T_G^*, which reduces its pledgeable income. The next remark provides sufficient conditions for this to be the case:

Remark 1. An SPOE bank cannot implement T_G^* when $R_L > R_H$, $p_M > p_X$, and $P_J^1 > 0$.

Proof. See Appendix B.6. □

The condition $R_L > R_H$ describes a situation where the L-unit's success payoff exceeds the H-unit's. This will be the case when the units create similar expected returns because the L-unit's success probability is lower than the H-unit's when both units are monitored. The conditions $p_M > p_X$ and $P_J^1 > 0$ describe a situation in which monitoring the L-unit primarily addresses risks that do not affect the H-unit and a banking group creates incentive synergies. Intuitively, different risk characteristics require more complex incentive schemes in order to realize incentives synergies, which are not compatible with the loss-mutualization of SPOE banks. This will likely be the case for banks that operate weak units whose risk characteristics differ from those of their strong units. Possible examples are OECD banks with large operations in developing countries or commercial banks with investment bank operations.

5.3. Resolution efficiency

First, consider case (i) of Proposition 2, in which it is constrained optimal to operate and continue both units, and $P_G^0(2) \geq 2$. In this case, an SPOE bank, which always continues the L-unit, can implement the constrained optimum if and only if $P_S^0 \geq 2$. The bank may fail to implement the constrained optimum, however, when loss mutualization prevents efficient incentive provision such that the bank's $t = 0$ pledgeable income $P_S^0 < 2 \leq P_G^0(2)$. In this case an SPOE bank cannot operate the L-unit at $t = 0$.

An MPOE bank fails to implement the constrained optimum because it always shuts down the L-unit following a liquidity shock. The MPOE bank is able to operate both units at $t = 0$ if and only if $P_G^0(H) \geq 2$. Because operating the L-unit creates positive

NPV even when it is shut down following a liquidity shock, an MPOE bank will be more efficient than an SPOE bank that can only operate the H-unit.

Second, consider case (ii) of Proposition 2, in which it is constrained optimal to operate both units and shut down the L-unit following a liquidity shock. In this case, an SPOE bank fails to implement the constrained optimum because it always continues the L-unit. Continuing the L-unit is costly for outside investors because the incentive synergies do not cover the L-unit's financing deficit ($1 - P_L^1 > P_J^1$). Hence, continuation requires the use of the H-unit's excess pledgeable income, which decreases the bank's $t = 0$ pledgeable income. It follows that an SPOE bank cannot operate both units at $t = 0$.

An MPOE bank can implement the constrained optimum, because MPOE resolution forces the regulator to shut down the L-unit following a liquidity shock, even though continuation would be ex-post efficient. As a result, the bank conserves pledgeable income following a liquidity shock and can operate both units at $t = 0$. We thus obtain the following proposition.

Proposition 3. *The constrained optimal investment decisions can be implemented by the following resolution regimes:*

(i) *If* $P_G^0(2) \geq 2$ *and* $P_S^0 \geq 2$ *by SPOE resolution.*

(ii) *If* $P_G^0(2) \geq 2$ *and* $P_S^0 < 2$ *by no resolution regime.*

(iii) *If* $P_G^0(2) < 2 < P_G^0(H)$ *by MPOE resolution.*

In case (ii)*, an MPOE bank can operate both units if and only if* $P_G^0(H) \geq 2$*. Otherwise the bank can operate only the H-unit regardless of the resolution regime.*

Proof. Follows from the preceding discussions. □

Proposition 3 shows that an appropriate resolution regime in many cases can implement the constrained optimal outcome. This is only possible when different resolution regimes are used for different banks, such that the different constrained efficient continuation decisions are implemented. We can thus rationalize the coexistence of SPOE and MPOE resolution in practice. In some cases, both resolution regimes may fail to implement the constrained optimum, because loss mutualization restricts the contracting space of an SPOE bank.

To visualize the trade-off between the resolution regimes, Figure 3 depicts the areas in which the resolution regimes can and cannot implement the constrained optimum.

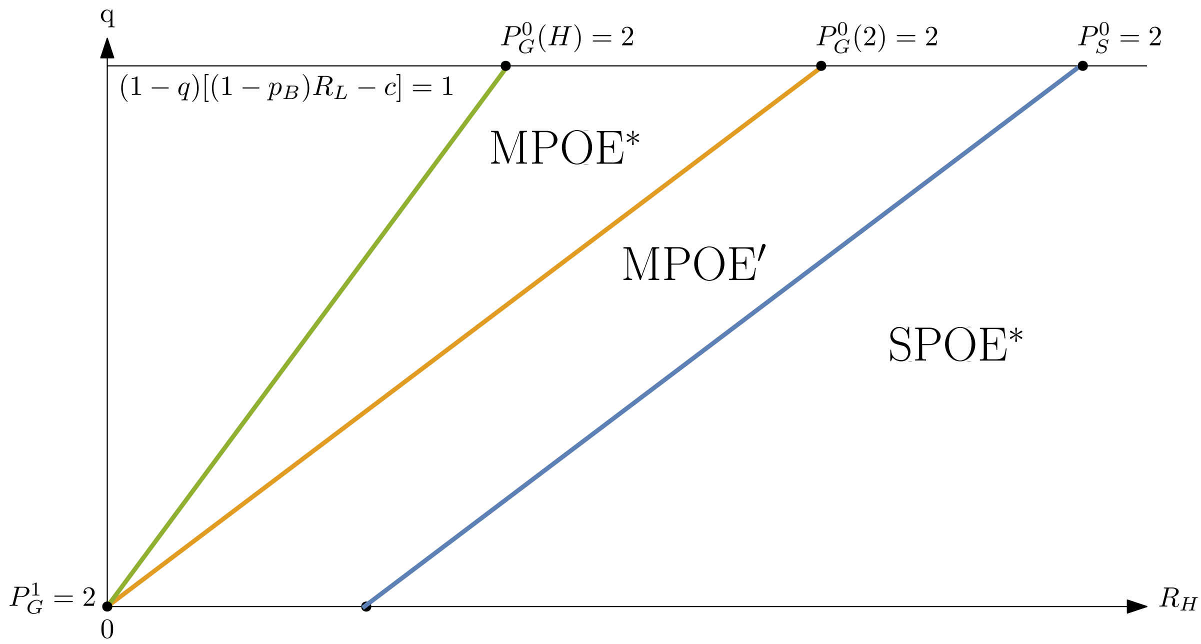

Figure 3: Operation and continuation decisions with sub-optimal incentives.
This figure depicts parameter ranges in which the different resolution regimes implement the constrained optimal operation and continuation decisions when $P_G^0(H) > P_G^0(2)$ and $P_S^0 < P_G^0(2)$. The regions SPOE*, MPOE′, and MPOE* correspond to cases (i), (ii) and (iii) of Proposition 3, respectively. In the unlabeled area, it is impossible to operate both units and hence, the choice of a resolution regime is irrelevant. The upper boundary of the figure ensures that it is optimal to operate the L-unit even when it gets shut down following a liquidity shock.

To cover all cases of Proposition 3, the figure depicts the case when the financing synergies P_J^1 do not cover the L-unit's financing deficit following a liquidity shock such that $P_G^0(H) > P_G^0(2)$, and an SPOE bank cannot implement T_G^* such that $P_S^0 < P_G^0(2)$.

First, when the probability of a liquidity shock q is sufficiently low and the return of the H-unit R_H is sufficiently high, an SPOE can operate and continue both units, which is constrained efficient (region SPOE*).

Second, because the SPOE bank cannot implement T_G^*, there exists a region of intermediate values of R_H and q in which operating and continuing the L-unit would be constrained optimal but an SPOE bank cannot operate the L-unit (region MPOE′). In this region, an MPOE bank can operate both units but shuts down the L-unit as long as $P_G^0(H) > P_G^0(2)$. This region does not exist when the SPOE bank can implement T_G^* such that $P_S^0 = P_G^0(2)$.

Third, when the probability of liquidity shock q is sufficiently high and the return of the H-unit R_H is sufficiently low, it is constrained optimal to shut down the L-unit following a liquidity shock (region MPOE*). In this region, an MPOE bank can implement the constrained optimum. The region does not exist when the financing synergies P_J^1 cover the L-unit's financing deficit, such that $P_G^0(H) \leq P_G^0(2)$.

Finally, when the probability of liquidity shock q is too high and the return of the H-unit R_H is too low, it is never feasible to operate both units and the choice of a resolution regime is moot.

6. Private Restructuring

In our setup, the bank must dilute the claims of its outside investors in order to continue the L-unit following a liquidity shock (Assumption 5). So far, we have assumed that resolution is the only mechanism to do so. In this section, we compare resolution with private restructuring, whereby private renegotiation between bankers and outside investors can reduce the bank's outside claims by mutual agreement.

Consider debt and equity financing as in Section 4. We assume that following a liquidity shock, the bank now has the possibility to privately restructure existing claims and subsequently raise new funds to continue the L-unit. If this fails, the L-unit shuts down and defaults on the unit's creditors. Following the L-unit's shut down, the bank has another possibility to privately restructure the remaining claims to ensure that its capital structure supports the bankers' monitoring. We assume further that private restructuring has no direct costs (as we assume for resolution), and assign all the bargaining power to the existing outside investors (to evaluate the maximum potential of private restructuring). However, the parties that engage in private restructuring are still affected by the general frictions of the model: the necessity to provide the bankers with monitoring incentives, bankers' financial constraints, and limited liability.

We proceed by backwards induction. Suppose that the L-unit has shut down following a liquidity shock. In this case, the remaining outside claims determine bankers' payment, which is given by τ_H in Expression (9). If the outside claims are such that $\tau_H < \tau^H$, private restructuring is necessary to ensure that bankers monitor. Bankers and investors have incentives to restructure because monitoring is efficient. Because outside investors have all the bargaining power, bankers will obtain the minimum compensation that ensures monitoring τ^H and outside investors' claims will be worth $R_H - \tau^H = P_H^1$. Note that both parties benefit as bankers' claims increase and the pledgeable income P_H^1 exceeds the value of the H-unit without monitoring. Otherwise, when the existing claims ensure monitoring ($\tau_H \geq \tau^H$), there are no incentives to restructure, because the overall surplus cannot be increased. In this case, bankers' and outside investors' payoffs are given by τ_H and $R_H - \tau_H$, respectively.

Now, consider the situation immediately following liquidity shock. The bank can only continue the L-unit if it restructures its claims (Assumption 5) There are incentives to restructure because continuing the L-unit is ex-post efficient. Still, private restructuring does not always occur. Indeed, even though outside investors have all the bargaining power, bankers' claims must remain large enough to provide them with monitoring incentives. This limits the feasible distributions of surplus between bankers and outside investors.

Since private restructuring maintains the group structure of an MPOE bank, the minimum compensation that bankers must receive is given by the incentive contract T_G^*. Hence, when private restructuring avoids resolution and continues the L-unit, the maximum payoff that the bank can pledge to outside investors, net of the required investment to continue the L-unit, is given by $P_G^1 - 1$. If instead the bank does not restructure and shuts down the L-unit, the preceding discussion implies that outside investors' payoff is given by $\min\{R_H - \tau_H, P_H^1\}$. Clearly, outside investors will only participate in private restructuring to continue the L-unit if this allows them to increase their payoff relative to shutting down the L-unit. Bankers will always be willing to restructure because it is ex-post efficient and there is no friction that limits their surplus share. Hence, we obtain the following lemma.

Lemma 9. *Private restructuring will continue the L-unit if and only if*

$$P_G^1 - 1 \geq \min\{R_H - \tau_H, P_H^1\}. \tag{12}$$

If the L-unit shuts down, private restructuring will ensure monitoring of the H-unit.

Proof. Follows from the preceding discussion. □

If $P_G^1 - 1 \geq P_H^1$, the incentive synergies exceed the L-unit's financing deficit following a liquidity shock ($1 - P_L^1 \leq P_J^1$). Hence, outside investors will always be able to benefit from continuing the L-unit, independently of the claims issued at $t = 0$. Since the bank always continues the L-unit, the bank can issue claims at $t = 0$ that implement a contract T_G^* . It follows that the $t = 0$ pledgeable income of the MPOE bank is $P_G^0(2)$.

If instead $P_G^1 - 1 < P_H^1$, the L-unit's financing deficit exceeds the incentive synergies and thus, the pledgeable income from continuing the L-unit is not large enough to compensate outside investors for the associated losses. Hence, outside investors will only agree to restructure their claims if the bankers compensate them by reducing their claims τ_H without destroying their monitoring incentives. Bankers can and will do so if the claims the bank issues to outside investors at $t = 0$ are sufficiently small such that $R_H - \tau_H < P^1_G - 1$. If the bank issues such claims, its pledgeable income is smaller than $P^0_G(2)$ because bankers hold on to their larger claims in the absence of a liquidity shock.

Finally, suppose that $P^1_G - 1 < P^1_H$ and the bank issues claims that implement a contract T^*_G. In this case $\tau^*_H \leq \tau^H$ and Lemma 9 imply that the bank shuts down the L-unit following a liquidity shock. Due to private restructuring, investors' payoff following liquidity shock is P^1_H. In the absence of a liquidity shock, investors' claims yield an expected payoff of P^1_G. It follows that the bank's $t = 0$ pledgeable income is given by $P^0_G(H)$. Combining the above cases yields the following lemma.

Lemma 10. *With private restructuring, a bank's $t = 0$ pledgeable income is*

$$P^0_R(2) = \begin{cases} P^0_G(2) & P^1_G - 1 \geq P^1_H \\ P^0_G(2) - (1-q)(1-P^1_L) & \textit{otherwise.} \end{cases} \tag{13}$$

if it continues the L-unit and $P^0_G(H)$ if it shuts down the L-unit.

Proof. See Appendix B.7. □

The bank will operate and continue the L-unit whenever its pledgeable income allows it to do so. When it is constrained optimal to operate and shut down the L-unit private restructuring allows the bank to implement this outcome. The following proposition compares the outcomes of private restructuring with the outcomes of the different resolution resolution regimes.

Proposition 4. *Consider the relative efficiency of private restructuring and the two resolution regimes.*

(i) *If $P^0_R(2) > 2 > P^0_S$ then private restructuring can implement the constrained optimum and is more efficient than resolution.*

(ii) *If $P^0_R(2) < 2 < P^0_S$ then private restructuring is less efficient than SPOE resolution, which can implement the constrained optimum.*

(iii) *Otherwise, private restructuring and MPOE resolution result in the same outcomes and are more efficient than SPOE resolution.*

Proof. Follows from Lemmata 6, 8, and 10. □

The above proposition shows that in most cases resolution and costless private restructuring are equally efficient. However, private restructuring can fail to continue the L-unit when its financing deficit exceeds the banking group's incentive synergies. In this case, outside investors only agree to continuing the L-unit at $t = 1$ when the bank can conserve free pledgeable income at $t = 0$ to compensate these investors. In contrast, SPOE resolution can impose losses on outside investors if needed and is not constrained by fulfilling their participation constraint at $t = 1$. Hence, SPOE resolution allows the bank to use its entire pledgeable income at $t = 0$. It thus ensures an efficient outcome in cases where private restructuring cannot. Resolution is only less efficient than private restructuring when SPOE resolution prevents efficient incentives provision and and as a result, the banking group cannot raise sufficient financing to operate both units. Thus, when private restructuring is not possible due to (various) frictions, resolution can in most cases ensure an efficient outcome.

7. Empirical Implications

Our model derives a number of empirical implications. First, the model predicts which banking groups should prefer MPOE over SPOE, and vice-versa. This trade off depends in particular on the level of the group's synergies, for which our model also has predictions. Second, the model predicts how resolution and a given resolution regime may affect the financing and investment decisions of banking groups. Third, the model has predictions about the consequences of a (sudden) change in the economic conditions, for instance as a result of a crisis.

7.1. MPOE vs. SPOE

Prediction 1. *A banking group is more likely to choose MPOE rather than SPOE if (i) its stronger units' excess financing capacity is small, (ii) its weak units' expected financing deficits are large, and (iii) the group's synergies are low or SPOE cannot realize the incentives synergies.*

This prediction follows from Proposition 3. A bank whose stronger units have large financial excess capacity, and which generates large synergies, does not need to ensure that it can shut down its weaker units in the future. Rather, the bank has an incentive to choose SPOE resolution that will preserve the integrity of the banking group following liquidity shocks. If, however, the bank creates small synergies, then continuing weak units with high financing deficits increases investors' losses. If the stronger units have small excess capacity, the bank cannot compensate investors for these losses. Instead, it must adopt an MPOE resolution regime that shuts down weak units when they experience negative shocks, even if they generate positive NPV.

Several parameters of our model directly affect expected financing deficits and excess financing capacity of the strong unit. First, the weak unit's expected financing deficit is high when its success revenue R_L is low relative to the investment needs of 1, the probability of liquidity shocks q is high, and the monitoring costs c are high. The strong unit's excess financial capacity is low when its success revenue R_H is low. Finally, the size of the weak relative to the strong units in practice likely increases expected financing deficits, although in our model, the (investment) sizes of the two units are fixed. Hence, banking groups with low profitability, and large units that are susceptible to negative shocks, are more likely to be financially constrained and thus choose MPOE rather than SPOE.

The synergies in Prediction 1 could be of any kind (operational, managerial, etc.). Our model makes predictions on which banking groups should enjoy higher incentive synergies, which represent a form of cost savings that allow the bank to overcome its agency problems with lower amounts of agency rents. In practice, these synergies could correspond to overall lower bonus pools and less generous incentive payment schemes.

Prediction 2. *The banking group can create incentive synergies when monitoring has a larger impact on weak units than on strong units.*

Proposition 1 shows that incentive synergies arise because a banking group can provide incentives based on the performance of the two units. Monitoring is more important for a weak unit when $p_M > p_B$, in which case the weak unit requires lower incentives for monitoring than the strong unit. In this case, incentive synergies will always be strictly positive because a bank that provides incentives for monitoring the strong unit automatically provides incentives for monitoring the weak unit, which lowers the agency rents. Thus, incentive synergies are likely to occur for banking groups where managerial oversight is more important for weak than for strong units.

To realize the incentive synergies, the banking group must choose an appropriate financial structure. The loss mutualization of SPOE banks may impede incentive provision. In contrast, the flexibility of financial arrangements under MPOE always makes efficient incentive provision possible.

Prediction 3. *An SPOE bank cannot realize the incentive synergies if (i) the weak and strong units face different risks and (ii) the weak units are not too small relative to the strong units.*

Lemma 7 and Remark 1 show that SPOE banks are likely to be unable to implement incentive contracts that fully exploit banking groups' incentive synergies P_J^1 when (i) weak units' monitoring primarily reduces risks that do not affect strong units such that $p_M > p_X$ and (ii) the weak units' success payoffs exceed those of strong units such that $R_L > R_H$. The reason is that different risk characteristics require more complex incentive schemes that separately reward strong units' success, which is not compatible with loss-mutualization when the weak units' potential losses are sufficiently large. Proposition 3 shows that banks are more likely to choose MPOE when SPOE resolution reduces banks' financing capacity because imposing loss-mutualization prevents the realization of incentive synergies.

Weak units' payoffs will in practice be large relative to strong units' payoffs if the weak units' risky operations are not too small relative to strong units' operations. Monitoring will affect different risks when a banking group operates units with different scopes and competencies (such as investment and commercial banks) or in developed and developing countries, where they face different risks.[23] It follows that banking groups which have large operations with very different risk characteristics are more likely to choose MPOE. Thus, our model can for example explain why BBVA and HSBC, who have large operations outside the OECD, may have chosen MPOE, while Santander may have chosen SPOE due to its large presence in the UK.

7.2. Financing and investment decisions

SPOE resolution can (most easily) achieve loss mutualization by concentrating the entire group's funding at the holding unit. Conversely, MPOE banking groups that exploit the incentive synergies P_J^1 must raise funding at multiple units to reward the performance of the individual units. Hence, we expect a correlation between banks' funding models and their resolution regimes.

Prediction 4. *Banks with a centralized funding structure, who mainly raise funding at their holding company, are more likely to choose SPOE.*

[23] Suppose for example that a unit's monitoring reduces its non-performing loans during a business cycle downturn. If different units operate in different areas or sectors with different business cycles, monitoring different units will affect different risks.

Once a bank has a resolution regime in place and gets it approved by the regulator, it cannot change it immediately. Thus, the resolution regime can impact the banks' investment decisions, including their M&A activities. Banks opting for SPOE resolution are less likely to acquire riskier units (measured by the probability of receiving a liquidity shock, for example), because their investors might be less willing to finance them, in anticipation of a bail-in following a liquidity shock. Since MPOE banks are not required to support risky units, they will be able to raise financing for weak units with high expected financing deficits that create small synergies.

Prediction 5. *MPOE banks are more likely to finance riskier investments than SPOE banks.*

7.3. Crisis

Our model also provides predictions on what may happen to an existing bank if economic conditions change, for instance due to an economic crisis. In a crisis, the profitability of the banking units is likely to decrease and the probability of receiving negative shocks is likely to increase, which increases the potential financing deficits of its weak units. As a result, following the arguments behind Prediction 1, MPOE resolution becomes more attractive relative to SPOE resolution.

Prediction 6. *In a crisis, when profitability is low and the probability of negative shocks is high, banking groups are more likely to choose MPOE rather than SPOE.*

Maybe more importantly, when a bank already has a resolution regime in place and it cannot change it, the resolution regime affects how a crisis impacts the bank's investment decisions.

Prediction 7. *In a crisis, when expected returns decrease and the probability of receiving negative liquidity shocks increases, MPOE banks are less likely to curtail investment into weak units than SPOE banks.*

SPOE banks are likely to curtail their investments into weak units in order to reduce their exposure to these units' risks. In extreme cases, SPOE banks may find it necessary to divest of their weak units. MPOE banks are less likely to be affected because their weak units will be resolved separately.

8. TLAC

Global systemically important banks (G-SIBs) are required to have financial instruments available during resolution to absorb losses, the so-called "Total Loss-absorbing Capacity" (TLAC). The purpose of TLAC is to ensure that losses can be absorbed by debt and equity holders as part of a bail-in. Doing so allows for an orderly resolution and recapitalization of the bank without conducting a bail-out using public funds. In this section, we analyze and compare the amounts of TLAC that MPOE and SPOE banks need for successful resolution.

We have assumed that the regulator will impose losses on existing outside investors only to the extent that they are necessary to ensure the most efficient continuation possible (for a given resolution regime). Hence, we define the TLAC requirement as the value of the claims issued to outside investors at $t = 0$ that, following a liquidity shock, must be bailed-in by the regulator to implement the resolution plan. The regulator will first bail-in the bankers' (inside equity) claims, but, since efficient continuation always involves monitoring, the regulator must ensure that bankers retain claims that provide them with sufficient monitoring incentives. The remaining losses must thus be imposed on the bank's initial $t = 0$ investors, which determines the required TLAC.

First, consider SPOE resolution, which continues the L-unit following a liquidity shock. The cash flows that can be promised to outside investors following resolution without destroying monitoring incentives are given by the $t = 1$ pledgeable income P_S^1. Since the SPOE bank must raise an additional unit of new financing to continue the L-unit, the maximum expected income that the initial $t = 0$ outside investors can retain is $P_S^1 - 1$. The initial expected value of the $t = 0$ investors' claims must equal the bank's investment needs of 2. Hence, the losses the initial investors must absorb are given by

$$\lambda_S \equiv 2 - (P_S^1 - 1).$$

Second, consider MPOE resolution, which shuts down the L-unit unit following a liquidity shock. If an MPOE bank shuts down the L-unit, its pledgeable income following resolution at $t = 1$ is given by P_H^1 but the bank does not need to raise any new financing. Thus, the losses that the bank's original outside investors must absorb are given by[24]

$$\lambda_M \equiv 2 - P_H^1.$$

[24] To implement this minimum TLAC, the bank must, at $t = 0$, issue claims on the H-unit that are larger or equal to P_H^1. This ensures that the bank's entire income gets pledged following a liquidity shock at $t = 1$.

The following proposition compares the different TLAC requirements.

Proposition 5. *SPOE resolution requires more TLAC than MPOE resolution if and only if* $P_S^1 - 1 < P_H^1$.

Proof. Immediate from comparing λ_S to λ_M. □

This proposition implies that it is not necessarily the case that SPOE resolution requires less TLAC than MPOE resolution, as is often argued. The relative size of TLAC requirements for SPOE and MPOE banks depends on how much of an SPOE's investment need will be borne by the bankers. If the SPOE's pledgeable income is sufficiently high, the bankers require lower claims to monitor and thus the the regulator can impose higher losses on them. This reduces the losses that must be imposed on the existing outside investors, and thus the TLAC. Conversely, if the SPOE bank's pledgeable income is too low, then MPOE resolution, which shuts down the L-unit, limits outside investors' losses. Bankers' losses are always larger under MPOE because they lose their agency rents from motioning the L-unit.

When an an SPOE bank's required TLAC exceeds that of an MPOE bank, then the SPOE bank's $t = 0$ pledgeable income is smaller than the MPOE bank's (i.e., $P_S^0 < P_M^0$). But conversely, an MPOE bank's $t = 0$ pledgeable income can exceed that of an SPOE bank even when the MPOE bank's required TLAC is higher. The reason is that, in the absence of a liquidity shock, an SPOE bank's pledgeable income is always weakly smaller than that of an MPOE bank, due to the negative incentive effects of loss mutualization. Hence, an SPOE bank's pledgeable income must always be smaller than that of an MPOE bank when its outside investors' losses are larger following a liquidity shock. Conversely, even when an MPOE bank's investors' losses following a liquidity shock exceed those of an SPOE bank's investors, the MPOE bank's overall pledgeable income may still be larger.

9. Conclusions

This paper analyzes how different resolution regimes affect banking groups' abilities to finance weak units. Resolution regimes are valuable because they allow banks to restructure existing claims following negative shocks. SPOE resolution mutualizes a banking group's losses, which allows for ex-post efficient continuation of weak units that experience negative liquidity shocks. However, loss mutualization can prevent the bank from fully exploiting incentive synergies and increase the losses outside investors must bear in the case of liquidity shocks. As a result, SPOE resolution can prevent efficient ex-ante investment in a banking group's weak units. MPOE resolution separately resolves different banking units and maintains limited liabilities between a banking group's holding and its subsidiaries. As a result, the group can fully exploit incentive synergies and shut down weak units following a liquidity shock, which limits outside investors' losses.

MPOE resolution is more efficient than SPOE resolution if MPOE resolution allows the group to finance the initial operation of its weak units and SPOE does not. Otherwise, SPOE resolution is more efficient than MPOE resolution. Since both cases are possible, we provide a rationale for the coexistence of different resolution regimes in practice. MPOE resolution is likely to be more efficient than SPOE resolution when a banking group's financing capacity is low, liquidity shocks are likely, and weak and strong units face different risks. These conditions are likely to be satisfied in a crisis, in which case MPOE banks are less likely to curtail investment in weak units than SPOE banks.

A. Symmetric Units

In the main analysis of the paper, the banking units are ex-ante asymmetric. This section discusses how the results would change if the units were ex-ante symmetric. The two units are symmetric when (i) their success probabilities and terminal payoffs at $t = 2$ are identical and (ii) they are both subject to a liquidity shock at $t = 1$, both with the same probability.

To analyze the choice of resolution regime in the case of symmetric units, we make use of the model and results of Laux (2001a). First, the incentive contract that ensures monitoring of both units and maximizes pledgeable income consists of rewarding the bankers if and only if both units create a positive return. Second, the cost of providing monitoring incentives in a banking group is lower and thus incentive synergies are strictly positive.[25] Hence, in the case of two symmetric units, we would have $\tau_2^* > 0$, $\tau_H^* = \tau_L^* = 0$, and $P_J^1 > 0$.[26]

As discussed in Section 5, both SPOE and MPOE resolution can implement an incentive contract that consist of a single payment if both units succeed.[27] We thus obtain the following lemma.

[25]Both results hold as long as the correlation between the two units' payoffs is not perfect and does not change based on bankers' monitoring decisions.

[26]Note that we are abusing our own notation to describe the results of Laux (2001a), as the parameters of our model do not fully correspond to those of Laux (2001a).

[27]We maintain the requirement that the incentive payment is smaller than each unit's payoff, which corresponds to Assumption 4.

Lemma 11. *If the two banking units are perfectly symmetric with success probabilities as in Laux (2001a), then SPOE and MPOE resolution can always implement an incentive contract* T_G^* *in the absence of a liquidity shock by issuing debt and equity and the banking group's* $t = 1$ *pledgeable income will satisfy* $P_S^1 = P_M^1 = P_G^1$.[28]

Proof. Follows from Proposition 1 in Laux (2001a) and the above discussion. □

We now show that continuation of either unit, following a liquidity shock, is always constrained optimal. Notice that, as before, a necessary condition, for a (symmetric) banking group, to finance the operation of both units at $t = 0$ which requires two units of capital, is that

$$P_G^1 = P_L^1 + P_H^1 + P_J^1 > 2.$$

In the case of symmetric units, $P_L^1 = P_H^1$, and hence, this condition implies in particular that

$$P_i^1 + P_J^1 > 1 \, \forall i \in \{H, L\}.$$

This in turn implies that the pledgeable income that is created by continuing either of the two units, following a liquidity shock at $t = 1$, exceeds the cost of continuing this unit. Hence, the $t = 0$ pledgeable income is maximal when the bank always continues both units following a liquidity shock. Since continuation creates positive NPV, continuing both units is constrained optimal.

As explained earlier, the regulator will always be able to continue either unit, following a liquidity shock, when a banking group operates under SPOE resolution. Thus SPOE resolution implements the constrained optimal continuation decision. Since SPOE resolution also allows the bank to implement the relevant incentive contract T_G^*, we obtain the following result.

Proposition 6. *If the two banking units are perfectly symmetric with success probabilities as in Laux (2001a), then SPOE resolution implements the constrained optimum.*

Proof. Follows from Lemma 11 and the above discussion. □

In contrast, MPOE resolution may fail to implement the constrained optimum because MPOE separates the two banking units following a liquidity shock. This separation

[28] Using the notation of Laux (2001a),

$$P_G^1 \equiv p_h \overline{\pi} + (1 - p_l)\underline{\pi} - p_h \frac{2c}{p_h - p_l}.$$

destroys the incentive synergies P_J^1, which reduces the bank's ability to raise financing at $t = 0$.

The above results show that MPOE resolution is crucial in a setting where banks consist of asymmetric units. Asymmetry between units may require MPOE resolution for two reasons. First, providing monitoring incentives can require more complex financing arrangements that conflict with SPOE resolution. Second, with asymmetric units it can be necessary to shut down some units following negative liquidity shocks, which is not possible under SPOE resolution.

B. Proofs

B.1. Lemma 1

The financing contract that maximizes the financing of an L-unit bank follows from the discussion in Section 3.2.1. The bank can operate the L-unit as a stand-alone bank if and only if there exists a continuation policy $\chi \in \{L, 0\}$ such that $P_L^0(\chi) \geq 1$.

It is easy to see that $P_L^0(\chi) < P_L^1$ 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 $P_L^1 > 1$. In this case, continuation maximizes the bank's pledgeable income such that $P_L^0(L) \geq P_L^0(0)$. It follows that an L-unit bank can operate at $t = 0$ if and only if $P_L^0(L) \geq 1$, which is equivalent to $P_L^1 \geq 1 + q$. It also follows that an L-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.

B.2. Proposition 1

The contract that ensures monitoring of both units and maximizes financing minimizes the bankers' expected compensation when they monitor both units

$$(1 - p_B)\tau_2 + p_B\tau_H \tag{14}$$

subject to the IC-constraints (3-5) and banker's limited liability constraints $\tau_L, \tau_H, \tau_2 \geq 0$. We let $\{\tau_L^*, \tau_H^*, \tau_2^*\}$ denote a solution of this linear program and call it a contract that minimizes the bankers' compensation.[29]

[29]The existence of a bounded solution follows from the economic content of the problem.

Recall that we are only interested in generic properties that hold for an open set of probabilities p_S (inside the simplex) and monitoring costs c.

We will split the proof of the Proposition into three lemmata. In the first lemma we characterize basic properties of the compensation contracts T_G^*, which yield the conditions in Part (ii) of Proposition 1.

Lemma 12. *Any contract* $\{\tau_L^*, \tau_H^*, \tau_2^*\}$ *that minimizes bankers' compensation satisfies* $\tau_2^* > \tau_H^*$ *and* $\tau_H^* \in [0, \tau^H]$.

If a contract $\{\tau_L^*, \tau_H^*, \tau_2^*\}$ *minimizes bankers' compensation, any contract in the set* $\{\tau_L, \tau_H^*, \tau_2^* \mid \tau_L \in [0, \bar{\tau}_L]\}$ *where*

$$\bar{\tau}_L \equiv \tau_2^* - \frac{c - p_B \tau_H^*}{p_X} \tag{15}$$

also minimizes bankers' compensation.

Proof. Note that, a banking group can always replicate the incentive payments of two standalone banks τ^H and τ^L, by setting $\tau_L = 0$, $\tau_H = \tau^H$, and $\tau_2 = \tau^H + \tau^L$. Hence, bankers' expected compensation (14) from contract T_G^* must be weakly smaller than the expected compensation from monitoring two stand-alone banks.

The IC-constraint (4) can be rewritten as $\tau_2 - \tau_H \geq \frac{c}{p_M + p_X}$,which implies $\tau_2^* - \tau_H^* \geq \tau^L$ and hence, $\tau_2^* > \tau_H^*$. It also follows that $\tau_H^* \leq \tau^H$, because otherwise bankers' expected compensation (14) would exceed their compensation from monitoring two stand-alone banks. The lower bound of $\tau_H \geq 0$ follows from bankers' limited liability.

The incentive payment τ_L only appears on the right-hand-side of the IC-constraint (3) and does not directly affect bankers' expected compensation (14) if both units are monitored. It follows that for given τ_H^* and τ_2^* any τ_L that satisfies the IC-constraint (3) weakly minimizes bankers' compensation, which yields Expression (15). The lower bound $\tau_L \geq 0$ follows from bankers' limited liability. □

Second, we fully characterize τ_H^* and τ_2^* in all generic cases i.e., cases that include an open set of probabilities p_S (inside the simplex) and monitoring costs c. In doing so, we show that τ_H^* and τ_2^* are generically unique, which implies that $\bar{\tau}_L$ from Expression (15) is generically unique as well. This finishes the proof of Part (ii) of Proposition 1. The characterization of τ_H^* also implies Part (iii) of Proposition 1.

Lemma 13. *Generically,* τ_H^* *and* τ_2^* *are unique and are given by*

$$\tau_H^* \equiv \begin{cases} 0 & p_X > p_M \text{ and } \frac{p_M+p_X}{p_G} > \frac{p_X+p_B}{p_G+p_M} \\ \frac{p_M-p_X}{(p_X+p_B)p_M}c & p_X < p_M \text{ and } \frac{p_M+p_X}{p_G} > \frac{p_X+p_B}{p_G+p_M} \\ \frac{c}{p_X+p_B} & \frac{p_M+p_X}{p_G} < \frac{p_X+p_B}{p_G+p_M} \end{cases} \tag{16}$$

and

$$\tau_2^* \equiv \frac{2c + (p_M - p_B)\tau_H^*}{p_M + p_X}. \tag{17}$$

Proof. We know from Lemma 12 that $\tau_L^* = 0$ weakly minimizes bankers' compensation subject to all relevant constraints. Moreover the IC-constraint (3) is most slack for $\tau_L^* = 0$ and thus, it only affects τ_H^* and τ_2^* if it is binding for $\tau_L^* = 0$. It follows that we only need to consider the case $\tau_L^* = 0$ which yields a reduced linear program that determines the values of τ_H^* and τ_2^*.

Proof. The reduced linear program is two dimensional. Hence, the solution of this reduced problem is unique if the objective function, bankers' expected compensation (14), is not orthogonal to any of the program's constraints. Generically, bankers' expected compensation must not be orthogonal to any of the constraints, since orthogonality cannot hold on any open set of probabilities p_S. □

Because the reduced linear program is two dimensional and the bankers' expected compensation is not orthogonal to any of the constraints, two constraints must be binding for any solution of the linear program. Note that, we already know from Lemma 12 that the limited liability constraint $\tau_2 \geq 0$ is not binding and hence, we can omit the corresponding cases. Table 2 lists all remaining candidate solutions as characterized by a combination of two binding constraints as well as the corresponding values for τ_H, τ_2, and bankers' compensation (14). One can check that the candidates (E-F) can never be solutions because they violate the IC-constraint (5). Hence, in the following we only need to consider candidates (A-D).

We distinguish three cases based on the conditions $p_M > p_B(1 - p_B - p_X)$, which is equivalent to Condition (6), and $p_X > p_M$. (Any remaining cases correspond to $p_X = p_M$ or $p_M = p_B(1 - p_B - p_X)$, which are not open sets and hence, are not generic cases. In these cases, the solution would typically not be unique.)

Case 1: $p_M > p_B(1 - p_B - p_X)$ **and** $p_X > p_M$**.** Simple algebra can be used to verify the following observations. First, candidate (C) always satisfies the IC-constraints (4-5) and the limited liability constraints. Second, $p_X > p_M$ implies that candidate (C) also

cand.	constraints	τ_H	τ_2	expected compensation
(A)	(5)$\wedge$(3)	$\frac{p_M - p_X}{(p_X+p_B)p_M}c$	$\frac{p_M+p_B}{(p_X+p_B)p_M}c$	$\left(\frac{1}{p_X+p_B} + \frac{(p_G+p_M)p_B}{(p_X+p_B)p_M}\right)c$
(B)	(5)$\wedge$(4)	$\frac{1}{p_X+p_B}c$	$\frac{p_M+2p_X+p_B}{(p_M+p_X)(p_X+p_B)}c$	$\left(\frac{1}{p_X+p_B} + \frac{1-p_B}{p_M+p_X}\right)c$
(C)	(5)$\wedge\tau_H \geq 0$	0	$\frac{2}{p_M+p_X}c$	$2\frac{1-p_B}{p_M+p_X}c$
(D)	(3)$\wedge\tau_H \geq 0$	0	$\frac{1}{p_X}c$	$\frac{1-p_B}{p_X}c$
(E)	(3)$\wedge$(4)	$\frac{p_M}{(p_M+p_X)(p_X+p_B)}c$	$\frac{p_X+p_M+p_B}{(p_M+p_X)(p_X+p_B)}c$	$\frac{p_M+(1-p_B)(p_X+p_B)}{(p_M+p_X)(p_X+p_B)}c$
(F)	(4)$\wedge\tau_H \geq 0$	0	$\frac{1}{p_M+p_X}c$	$\frac{1-p_B}{p_M+p_X}c$

Table 2: Candidate Solutions

satisfies the IC-constraint (3). Third, $p_X > p_M$ implies that candidate (D) cannot be a solution because it violates the IC-constraint (5) and candidate (A) cannot be a solution because it violates the limited liability $\tau_H \geq 0$. Fourth, $p_M > p_B(1 - p_B - p_X)$ implies that the expected compensation of candidate (C) is smaller than of candidate (B). It follows that candidate (C) is the unique solution that minimizes bankers' compensation.

Case 2: $p_M > p_B(1 - p_B - p_X)$ **and** $p_X < p_M$. First, observe that candidate (A) always satisfies the IC-constraints (3-5) and satisfies the limited liability constraints due $p_X < p_M$. Second, observe that candidate (C) cannot be a solution because it violates the IC-constraint (3) due to $p_X < p_M$. Third, $p_X < p_M$ implies that the expected compensation of candidate (A) is lower than the expected compensation of candidate (D). Fourth, $p_M > p_B(1-p_B-p_X)$ implies that the expected compensation of candidate (A) is lower than that of candidate (B). It follows that candidate (A) is the unique solution that minimizes bankers' compensation.

Case 3: $p_M < p_B(1 - p_B - p_X)$. First, observe that candidate (B) always satisfies the IC-constraints (3-5) and the limited liability constraints. Second, $p_M < p_B(1-p_B-p_X)$ implies that the expected expected compensation of candidate (B) is smaller than those of candidates (A) and (C). Third, candidate (D) either is not viable ($p_X > p_M$) or its expected compensation is even higher than for candidate (A). It follows that candidate (B) is the unique viable solution that minimizes bankers' compensation.

These three cases together yield Expression (16). In all three cases, the IC-constraint (5) is binding. Solving this constraint with equality yields Expression (17). □

Finally we use Lemma 13 to characterize the pledgeable income of a two-unit banking group. Part (i) of Proposition 1 directly follow from the following lemma.

Lemma 14. *The banking group's pledgeable income at $t = 1$ is given by*

$$P_G^1 \equiv P_H^1 + P_L^1 + P_J^1$$

where

$$P_J^1 \equiv \begin{cases} -\frac{1-p_B}{p_M+p_X}c + \frac{1}{p_X+p_B}c & p_X > p_M \textit{ and } \frac{p_G+p_M}{p_X+p_B} > \frac{p_G}{p_M+p_X} \\ \frac{1-p_B}{p_M+p_X}c - \frac{p_B}{p_M}\frac{p_G+p_M}{p_X+p_B}c & p_X < p_M \textit{ and } \frac{p_G+p_M}{p_X+p_B} > \frac{p_G}{p_M+p_X} \\ 0 & \frac{p_G+p_M}{p_X+p_B} < \frac{p_G}{p_M+p_X} \end{cases}$$

Proof. The banking group's pledgeable income P_G^1 is given by the expected return with monitoring $R_H + (1 - p_B)R_L$ minus bankers' expected compensation (14) for τ_H^* and τ_2^*. From Lemma 13 it follows that bankers' expected compensation is given by

$$\begin{cases} 2\frac{1-p_B}{p_M+p_X}c & p_X > p_M \text{ and } p_B < \frac{p_M}{1-p_B-p_X} \\ \frac{p_M+p_B(1-p_X-p_B)}{(p_X+p_B)p_M}c & p_X < p_M \text{ and } p_B < \frac{p_M}{1-p_B-p_X} \\ \frac{1}{p_X+p_B}c + \frac{1-p_B}{p_M+p_X}c & p_B > \frac{p_M}{p_G+p_M} \end{cases}$$

Comparing the pledgeable income of the two-unit banking group with the pledgeable income of two stand-alone units then yields P_J^1. □

B.3. Lemma 3

Proof. A bank can only implement incentive schemes that satisfy two sets of conditions. First, banks can never make payments that exceed its cash flows and hence, bankers' compensation must satisfy

$$\tau_L \leq R_L,\ \tau_H \leq R_H, \text{ and } \tau_2 \leq R_L + R_H. \tag{18}$$

Second, the payoffs of debt and equity claims are weakly increasing in the bank's cash flows. Hence, bankers' remaining compensation payments must never grow faster than the bank's overall cash flows, going from one to two positive returns:

$$\tau_2 - \tau_L \leq R_H \text{ and } \tau_2 - \tau_H \leq R_L. \tag{19}$$

Consider the capital structure $e = 0$, $F_L = R_L - (\tau_2^* - \tau_H^*)$, $F_H = 0$, and $F_J = R_H - \tau_H^*$. Substituting the above capital structure into Expression (9), it is easy to check that the bank implements the payments τ_H^*, and τ_2^*. When Conditions (18) and (19) are satisfied for $\bar{\tau}_L$, τ_H^*, and τ_2^* the above debt claims F_L and F_J are positive and thus feasible. Moreover, the resulting contract satisfies $\tau_L = R_L - F_L - F_J = \tau_2^* - R_H \leq \bar{\tau}_L$ due to Condition (19). It follows that the bank can implement a contract T_G^* if and only if $\bar{\tau}_L$, τ_H^*, and τ_2^* satisfy Conditions (18) and (19)

Expressions (15), (16), and (17) in Appendix B.2 show that the payments $\bar{\tau}_L$, τ_H^*, and τ_2^* are all multiples of the monitoring costs c. Hence, by continuity, there exists a maximum $\bar{c}$ such that Conditions (18) and (19) are satisfied if and only if $c \leq \bar{c}$. One can calculate $\bar{c}$ by substituting for the incentive payments in Conditions (18) and (19) using Expressions (15), (16), and (17). □

B.4. Lemma 5

Proof. Bankers will monitor the H-unit following a liquidity shock if and only if the initial claims are such that $\tau_H \geq \tau^H$. Outside investor's cash flows are given by the two units' returns minus bankers' cash flows, which are given by Expression (9). It follows that outside investors' expected cash flows (with bankers monitoring in the absence of liquidity shock) are given by

$$(1-q)((1-p_B)(R_H+R_L-\tau_2)+p_B(R_H-\tau_H))+q\begin{cases}(p_G+p_M)(R_H-\tau_H) & \tau_H < \tau^H\\ R_H-\tau_H & \tau_H \geq \tau^H.\end{cases} \tag{20}$$

First, suppose that the bank issues claims such that $\tau_H < \tau^H$ and bankers only monitor in the absence of a liquidity shock. In the absence of a liquidity shock, outside investors' expected cash flows are smaller or equal to the pledgeable income P_G^1. Without monitoring, the H-unit creates negative NPV following a liquidity shock and $(p_G + p_M)R_H < 1 < P_H^1$. It follows from Expression (20) that the bank's $t = 0$ pledgeable income is strictly smaller than

$$(1-q)P_G^1 + qP_H^1 = P_G^0(H).$$

Second, suppose that the bank issues claims such that $\tau_H \geq \tau^H$ and bankers monitor regardless of whether a liquidity shock occurs. Expressions (1) and (4) imply that bankers will only monitor the L-unit in the absence of a liquidity shock if $\tau_2 - \tau_H \geq \tau^L$. The bank maximizes its financing if it issues claims such that both inequalities are binding.[30] Hence, the bank's $t = 0$ pledgeable income is given by

$$(1-q)((1-p_B)(R_H + R_L - (\tau^L + \tau^H)) + p_B(R_H - \tau^H)) + q(R_H - \tau^H)$$
$$= (1-q)(P_H^1 + P_L^1) + qP_H^1 = P_G^0(H) - (1-q)P_J^1.$$

Together these two cases yield the lemma. □

B.5. Lemma 7

Proof. First, in case $\tau_H^* = 0$ an SPOE bank can implement an incentive contract T_G^* by setting $e = 0$ and $F_G = R_L + R_H - \tau_2^*$. From Assumption 4 and Condition (19) it follows that this debt claim satisfies $F_G > R_L$ and $F_G > R_H$. Substituting these claims into Expression (10) thus yields $\tau_L = 0$, $\tau_H = 0 = \tau_H^*$, and $\tau_2 = \tau_2^*$. It then follows from Lemma 12 that this contract maximizes the bank's financing.

Second, consider the case $\tau_H^* > 0$. Expression (10) implies that the bank can only implement a contract T_G^* when it issues debt and equity such that

$$\tau_H^* = (1-e)(R_H - F_G)$$
$$\tau_2^* = (1-e)(R_H + R_L - F_G).$$

Solving the above system of equations yields

$$(1-e) = (\tau_2^* - \tau_H^*)R_L^{-1}$$
$$F_G = R_H - \frac{\tau_H^*}{\tau_2^* - \tau_H^*}R_L. \tag{21}$$

From Lemma 12 it follows that this capital structure does not implement a contract T_G^* if and only if

$$\tau_L = (1-e)\{R_L - F_G\}^+ > \bar{\tau}_L.$$

Substituting for e, F_G, and $\bar{\tau}_L$ from Expressions (21) and (15) into the above expression

[30] It is easy to check that the IC-constraints (3-5) are all satisfied in this case.

we obtain Condition (11).[31]

Together the above cases imply that an SPOE bank cannot implement a contract T_G^* if and only if Condition (11) and $\tau_H^* > 0$ both hold. In this case, the bank must pay a higher compensation to incentivize monitoring than a bank that can implement T_G^*. It follows that the SPOE banks pledgeable income is smaller than P_G^1. □

B.6. Remark 1

Proof. First, Proposition 1 shows that $p_M > p_X$ implies that $\tau_H^* > 0$. Second, using Expressions (16-17) from Lemma 13 to substitute for $\bar{\tau}_L$, τ_H^* and τ_2^* in the left-hand-side of Condition 11 yields

$$\frac{\tau_2^* - \bar{\tau}_L}{\tau_2^* - \tau_H^*} = \begin{cases} \frac{p_M+p_X}{2p_X} & p_X > p_M \text{ and } \frac{p_G+p_M}{p_X+p_B} > \frac{p_G}{p_M+p_X} \\ \frac{p_M+p_B}{p_X+p_B} & p_X < p_M \text{ and } \frac{p_G+p_M}{p_X+p_B} > \frac{p_G}{p_M+p_X} \\ \frac{p_M+p_X}{p_X+p_B} & \frac{p_G+p_M}{p_X+p_B} < \frac{p_G}{p_M+p_X}. \end{cases}$$

Evaluating the different cases shows that the right-hand-side of Condition 11 is larger than 1 if and only if $p_X < p_M$ and $\frac{p_G+p_M}{p_X+p_B} > \frac{p_G}{p_M+p_X}$. Proposition 1 shows that the second of these conditions is equivalent to $P_J^1 > 0$. Finally, $\frac{R_H}{R_L} < 1$ when $R_H < R_L$. It follows that the conditions of Remark 1 imply Condition 11. □

B.7. Lemma 10

Proof. We distinguish three cases which together yield the bank's pledgeable income.

Case 1: $P_J^1 \geq 1 - P_1^L \Leftrightarrow P_G^1 - 1 \geq P_H^1$. If the bank issues the claims $e = 0$, $F_L = R_L - (\tau_2^* - \tau_H^*)$, $F_H = 0$, and $F_J = R_H - \tau_H^*$, the bank implements an incentive contract T_G^*. Lemma 9 implies that following liquidity shock private restructuring ensures the continuation of the L-unit and the outside investors' payoff will be $P_G^1 - 1$. It follows that 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: $P_J^1 < 1 - P_1^L \Leftrightarrow P_G^1 - 1 < P_H^1$ **and the bank issues claims such that private restructuring continues the L-unit.** Lemma 9 implies that private restructuring will ensue and continue the L-unit if and only if the bank issues claims such that $R_H - \tau_H \leq P_G^1 - 1$. From Condition (4) it follows that bankers will monitor the L-unit in the absence

[31]Note that $e \in [0, 1)$ because Proposition 1 and Assumption 4 ensure that $0 < \tau_2^* - \tau_H^* \leq R_L$.

of a liquidity shock if and only if $\tau_2 - \tau_H \geq \frac{c}{p_M + p_X} = \tau^L$. It follows that the outside investors' expected payoff in the absence of a liquidity shock must satisfy

$$R_H + (1 - p_B)R_L - \tau_H - (1 - p_B)(\tau_2 - \tau_H) \\ \leq P_G^1 - 1 + (1 - p_B)R_L - (1 - p_B)\tau^L = P_G^1 - 1 + P_L^1. \quad (22)$$

Furthermore, the outside investors' expected payoff is maximal when Condition (22) is binding and $\tau_H \geq R_H - (P_G^1 - 1)$ and the IC constraints (3-5) are satisfied.

Issuing claims $e = 0$, $F_L = R_L - \tau^L$, $F_H = 0$, $F_J = P_G^1 - 1$ yields $\tau_L = \{\tau^L - (P_G^1 - 1)\}^+$, $\tau_H = R_H - (P_G^1 - 1)$ and $\tau_2 = \tau_H + \tau^L$. It is easy to check that this contract satisfies the IC constraints (3-5) and satisfies Condition (22) with equality. Following a liquidity shock, restructuring will ensue that continues the L-unit and hence the outside investors' payoff is given by $P_G^1 - 1$. It follows that the bank's $t = 0$ pledgeable income when it relies on private restructuring to continue the L-unit is given by $(1 - q)(P_G^1 - 1 + P_L^1) + q(P_G^1 - 1)$.

Together, the above two cases yield $P_R^0(2)$.

Case 3: $P_J^1 < 1 - P_1^L \Leftrightarrow P_G^1 - 1 < P_H^1$ and the bank issues claims such that private restructuring shuts down the L-unit. The bank can implement a contract T_G^* by issuing claims $e = 0$, $F_L = R_L - (\tau_2^* - \tau_H^*)$, $F_H = 0$, and $F_J = R_H - \tau_H^*$. In the absence of a liquidity shock, the investors' claims yield an expected payoff of P_G^1. Since $\tau_H^* \leq \tau^H$ and $P_G^1 - 1 \leq P_H^1$ (Lemma 9) the bank will shut down the L-unit following a liquidity shock. The bank will then restructure its claims to ensure monitoring and the outside investors' payoff is P_H^1. Hence, the $t = 0$ pledgeable income is given by $(1 - q)P_G^1 + qP_H^1 = P_G^0(H)$. □

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