Bank Resolution Regimes: Risk Shifting and Resolution Efficiency*

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This paper analyzes the private and social incentives of complex banking groups to choose one of the two possible resolution regimes: Single vs. Multiple Point of Entry (SPOE vs. MPOE). In our model, banking conglomerates form to exploit financial synergies resulting from differences in pledgeable income across subsidiaries. MPOE is privately optimal because it reduces (i) the regulator's ability to expropriate creditors in resolution and (ii) he bank's risk-shifting incentives. Under SPOE, the regulator can shift pledgeable income from one subsidiary to the other so as to ensure the continuation of all of the units. SPOE can thus be socially optimal precisely because it it is more likely that all the (positive net present value) units continue. Still, the amount of bail-inable debt may need to be larger in SPOE as compared to in MPOE. Moreover, imposing banks the choice of SPOE can backfire as it may prevent the formation of conglomerate banks in the first place.

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1. Introduction

The financial crisis exposed the large costs of failure of complex banking institutions. As a response, Title II of Dodd-Frank Act in the United States and the Bank Recovery and Resolution Directive in the European Union introduced new regulatory frameworks for the orderly resolution of these institutions with the aims of lowering the public costs of bank failure and minimizing market and operational disruptions. Banks are now required to identify and hold bail-inable debt that can absorb losses, before public resources are used to recapitalize failing banks, thereby shifting part of the costs to private investors. Second, large complex banking institutions are required to submit detailed resolution plans or "living-wills" and get them approved by the regulator.

Two resolution regimes can be adopted by large complex institutions: Single-Point-of-Entry (SPOE) or Multiple-Point-of Entry (MPOE). Under SPOE all parts of a banking group are liable for each other, effectively sharing a single balance sheet. Upon resolution the bank would be resolved as a single entity. Under the MPOE regime the different units of the banking group have limited liability vis-a-vis each other and resolution happens separately for each unit. While most global banks have chosen an SPOE regime, some banks, such as BBVA and HSBC, have chosen an MPOE regime. Seven of the eight systemically important US banking institutions adopted an SPOE approach in their 2016 resolution plans. MPOE was only adopted by Wells Fargo which, incidentally, was the only one that had its resolution plan rejected by the regulators. Some commentators have argued that the failing grade was because Wells Fargo had failed to pick up on the assumed preference of the regulators for an SPOE regime.[1] Despite the importance and intensity of the policy debate, banking theory provides little guidance for practitioners and policy makers as to which is the optimal resolution regime.

This paper analyzes the private and social trade-offs of choosing SPOE or MPOE. We show that the resolution regime affects risk-taking incentives outside resolution and the operation of the conglomerate upon resolution. From the bank's point of view, SPOE is dominated by MPOE for two reasons.

First, SPOE allows the regulator to shift resources from more to less profitable units upon resolution, so as to ensure the continuation of the less profitable units. It thereby lowers the creditors' ex-post recovery value, which increases the ex-ante price of debt and reduces the bank's inital equity value. Second, the joint liability of SPOE increases risk-shifting incentives by favoring correlation of loan returns. Indeed, the bank can increase the correlation between its more and less profitable units by not monitoring its most profitable units. But, continuing the least-profitable units may be socially desirable. Hence, when making the choice between SPOE and MPOE, the regulator trades-off the higher risk-shifting incentives of the SPOE with the inefficient continuation decisions of the MPOE. As a result of this, the bank's preferred resolution regime can differ from the socially optimal one.

We build a model in which a banking group owns two subsidiary units with access to

[1] See for instance "A Paradigm's Progress: The Single Point of Entry in Bank Resolution Planning" by Paul L. Lee in the Columbia Law School blog, January 18, 2017.

different portfolios of loans: one holds loans with safer returns than the other. Banks can raise financing by issuing fairly-priced short-term debt and mispriced (outside) equity. Risk shifting incentives induced by debt financing put a limit on banks' debt capacity and pledgeable income. Financial synergies that give rise to the formation of complex banking groups arise endogenously in our setting. The excess debt capacity of the safe ("high-debt capacity") banking unit can help raise funding in the other ("low-debt capacity") unit. Financial synergies, though, may disappear upon the realization of a liquidity shock that increases funding needs and triggers resolution.

The bank is resolved if it is unable to roll-over its debt and cover its liquidity needs. If the bank is resolved, the regulator can write down the bank's existing debt and issue new debt and equity to raise funding in order to continue the bank's operations. We assume that the regulator chooses the minimum write-down and the issuance of new claims so as to maximize the continuation asset value. Under SPOE, the conglomerate's holding company is not protected by limited liability towards its subsidiaries. Debt issued at any level and by any unit is backed by the conglomerate's entire cash flows. But, in resolution, the organizational structure of the conglomerate remains intact: units are restructured together so as to ensure the continuation of both units. Under MPOE, debt raised in the different parts of the organization is backed by the assets of the unit where the debt is raised. But, in case of resolution, the subsidiary units are separated and restructured individually.

When the bank is unable to pay back its initial debt, the regulator restructures the existing debt and issues new securities to cover the funding needs. In our model failure to service the initial debt will only occur if the conglomerate is hit by a liquidity shock. Under SPOE, the regulator requires the bank to jointly raise financing to continue operating both two units. While continuing both units is socially efficient due to its positive NPV, the pledgeable income of the low profit subsidiary is smaller than its required additional investment following a liquidity shock. As the high-profit subsidiary also faces additional financing needs, using its debt capacity to finance the continuation of the low profit subsidiary lowers the recovery value for initial debt holders.

Under MPOE units get separated and therefore the high profit subsidiary cannot be forced to use its free debt capacity to raise financing for the low profit subsidiary. As the low profit subsidiary's pledgeable income is smaller than the financing required to continue its operation, the regulator cannot raise sufficient funds to continue the low profit subsidiary even when it bails in the subsidiary's entire maturing debt. The low profit unit will thus cease to operate and creditors claims on the subsidiary become worthless. The high-profit unit remains in operation and its pledgeable income exceeding the additional investment need will be recovered by its initial creditors. It follows that in resolution initial creditors recover more under MPOE than under SPOE.

We also show that under SPOE the joint liability of units may create incentives to increase correlation between loan returns in the two units. This is achieved by not monitoring the high profit unit, thereby making it fail in low states of the world, when the low profit subsidiary fails too. Due to the limited liability of subsidiaries vis-a-vis each other, this type of risk-shifting can be avoided under MPOE by appropriately structuring the issuance of debt in the holding company and subsidiaries. With fairly priced debt it will be in the interest of equity holders to do so. Hence, outside of resolution expected payoffs from the loans as well as the value of debt and equity will be higher under MPOE than under SPOE.

As a consequence, MPOE has two advantages for the banking conglomerate vis-a-vis SPOE. MPOE leads to less risk-shifting outside resolution and higher recovery values for initial creditors in resolution, which lowers the price of initial debt and increases the value of the initial owners' equity. However, from the social point of view there is a trade-off between the SPOE and the MPOE. While under the SPOE risk-shifting is more likely, both subsidiaries continue operating following resolution in case of a liquidity shock. Under MPOE no risk-shifting takes place, but by separating the two subsidiaries in resolution the low-profit subsidiary can no longer raise sufficient financing to continue its operation. Hence, a positive NPV investment get lost. Thus, an MPOE is more efficient than an SPOE if the increased monitoring outweighs the shutdown of the low profit subsidiary following a negative liquidity shock. This is more likely to be the case when the probability of a large negative liquidity shock is sufficiently low.

Our model has a number of interesting policy implications. First, SPOE resolution only allows the regulator to continue the low profit unit following a liquidity shock, if he bails in a larger share of the bank's debt than required with MPOE, where the low profit unit is shut down. The reason is that the regulator must impose additional losses on the bank's creditors to raise the funding required to finance the low profit unit.

Second, our model allows to say something about the interaction of bail-inable debt and public funds used in bailout. By using public money, the regulator can avoid inefficiencies occurring under both resolution regimes. Under MPOE, by injecting the difference between the investment need and the pledgeable income of the low profit subsidiary, the regulator can operate it as a standalone unit. While the shadow costs of public funds are clearly larger than one, the benefit of injecting public funds is the positive NPV of the subsidiary's investment. Under SPOE risk-shifting occurs when monitoring both subsidiaries leads to lower pledgeable income than monitoring only the low profit one, and the pledgeable income under monitoring does not cover the additional investment need following a large negative liquidity shock. The cost of bailout is injecting the difference between the pledgeable income under monitoring both subsidiaries and the additional financing needs, while the benefit is the increased loan returns due to monitoring.

Third, our model has implication for whether regulators should force banks to operate under SPOE. In the absence of restrictions the banking conglomerate will always choose MPOE which creates higher profits, but the regulator might prefer SPOE. However, requiring SPOE resolution may prevent the formation of a banking group. The reason is that due to the lower profits of an SPOE it can become more profitable to only operate the high profit subsidiary. In our framework this implies that the low-profit subsidiaries positive NPV investment gets lost, and permitting MPOE resolution would be more efficient.

Finally, we consider how banks' incentives to avoid resolution for different sizes of liquidity socks depends on their resolutions regimes. The results are ambiguous and depend on three different effects. First, an SPOE bank has greater incentives to avoid resolution than an MPOE bank, because the regulator decision with SPOE are not privately optimal. However, ceteris paribus an SPOE banks has less free pledgeable income that can be used to cover a liquidity shock because it engages in risk shifting. Third, an SPOE has less incentives to ensure the continuation of its low profit subsidiary because doing so causes risk shifting.

Despite the intense policy debate (see, in particular, Tucker, 2014a,b) on the virtues of SPOE and MPOE, the academic literature has been scarce on the issue. In a recent contribution Bolton and Oehmke (2018) provides a formal analysis of the trade-offs between MPOE and SPOE resolutions. In their paper the benefit of operating two units (located in different jurisdictions) together comes from two sources: operating synergies and a perfect negative correlation between investment returns that gives rise to potential diversification benefits to investors and thereby financing synergies. In their framework, SPOE allows to take advantage of both synergies, but national regulators might be unwilling 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. Furthermore, they might also be unwilling to enter any type of resource-sharing agreement ex ante to the extent that countries are two dissimilar. Hence, the focus of their paper is on regulatory commitment problems when resolution requires transfers across jurisdictions. The nice feature of their paper is that they are able to explain why regulators might opt for a resolution regime (MPOE) which allows ring-fencing of local assets.

Our paper is complementary to their paper. The benefit of conglomeration in our paper comes from financing synergies, however these do not result from diversification benefits. Similar to the paper of Fluck and Lynch (1999), banking conglomerates in our paper emerge by leveraging on the higher pledgeable income of a more profitable unit to finance a less profitable unit. However, we argue that while these synergies are there in normal times, they might evaporate following large liquidity shocks that trigger resolution. When financing synergies are no longer there, operating the two units after emerging from resolution will be less profitable than operating only the high-pledgeable income unit. Hence, one of the benefit of the MPOE is that allows the uncoupling of the less profitable unit from the more profitable unit in resolution. Furthermore, under MPOE risk-shifting is less likely. This feature of our model is similar to Kahn and Winton (2004), where separating safer loans from riskier loans by using a subsidiary structure reduces risk-shifting incentives in the safer subsidiary.

2. Model

Consider a three-date model of a banking group (the "bank" hereafter), formed by a holding company and two wholly-owned subsidiary units. One of the subsidiaries "H" has access to and can invest in a portfolio of low-risk loans. The other subsidiary "L" has access to and can invest in a portfolio of high-risk loans. All loans are illiquid and pay out at $t = 2$. Both loan portfolios require one unit of investment at $t = 0$ and an additional unit at $t = 1$ if a liquidity shock occurs. The following subsections describe the details of the model and we summarize the timing in Figure 1.

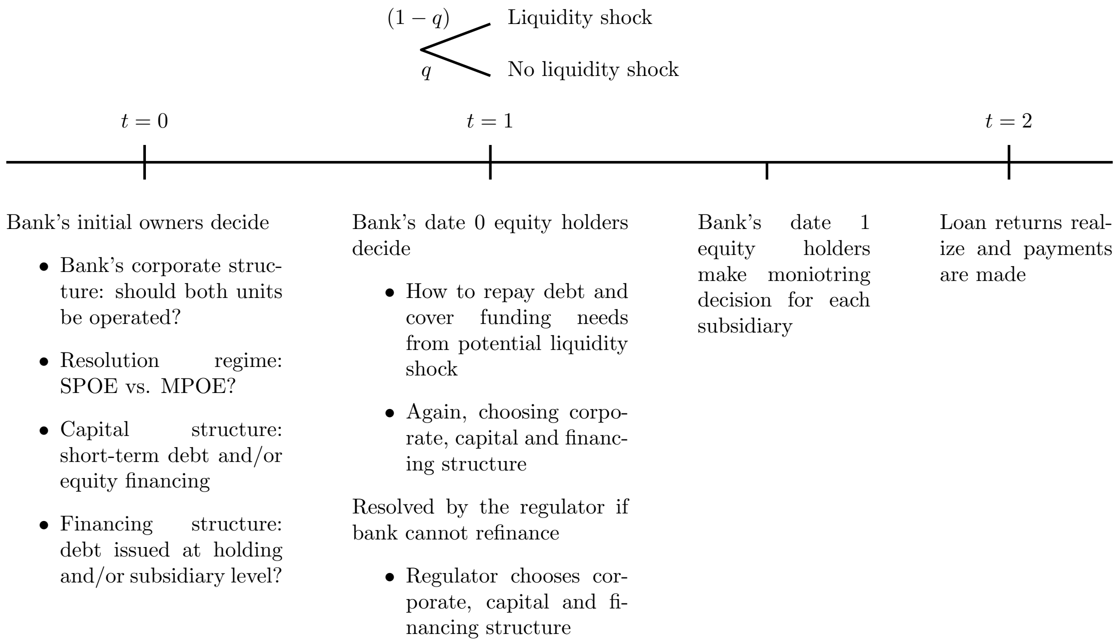

Figure 1: Time-line

2.1. Investment and resolution regimes

At $t = 0$, the equity holders of the bank ("inside equity") choose whether to operate the two units.[2] If the equity holders operate both units, they choose between two possible resolution regimes for the resulting banking group, single-point-of-entry (SPOE) or multi-point-of-entry (MPOE).[3] The bank's resolution regime determines the extent of limited liability between a bank's units and whether its organizational form is preserved in resolution. Under SPOE all subsidiaries are liable for each other, effectively sharing a single balance sheet and if the bank defaults and enters resolution its resolved as a single entity. Under MPOE, instead, subsidiaries have limited liability vis-a-vis each other, and resolution splits up the conglomerate. We denote the two regimes by S and M and further explain the the differences between the two regimes throughout the model description.

2.2. Bank financing

Besides choosing the resolution regime, equity holders at $t = 0$ decide how to raise one unit of funding for each subsidiary they operate. Bank financing may come from fairly priced short-term (i.e., one period) debt, to be repaid and rolled-over at $t = 1$, and/or

[2] We could also allow the banking group to form two separate stand-alone banks but, given our assumptions, described below, it is not optimal.

[3] If a banking group only operates one subsidiary there will be no difference between SPOE and MPOE.

outside equity.[4] Debt can be issued both at the holding and subsidiary levels. The bank can then make internal transfers in the form of equity (or junior debt) between the holding unit and its subsidiaries.[5] Outside equity is subject to a market imperfection that results in underpricing: the expected value of the associated cash flows is discounted by a factor $\phi < 1$. For simplicity we assume that the bank issues outside equity only at the holding level.

At $t = 1$, (but after a possible liquidity shock) the bank again issues short term debt and mispriced equity to raise the funds to cover debt repayments and any possible additional funding needs due to a liquidity shock. At $t = 1$, the bank can, thus, adjust its financing structure. The financing decisions are taken by the bank's existing equity holders, arising from the initial inside equity and any outside equity raised at $t = 0$.

We denote the face values of the different debt claims by F_i^t where subscript $i \in \{H, L, J\}$ refers to whether the debt was issued by subsidiary H or L or by the holding unit, respectively. The superscript $t \in \{0, 1\}$ refers to the date at which the debt is issued, i.e., at $t = 0$ or at $t = 1$. Debt is fairly priced and its market value, denoted by D_i^t, corresponds to its expected cash flows.

2.3. Liquidity shocks and resolution

Before debt is rolled over at $t = 1$, the bank may suffer a liquidity shock $\lambda \in \{l, nl\}$. With probability q, each (operated) subsidiary will need to make an additional investment of one unit at $t = 1$ to continue operating ($\lambda = l$). The bank can choose not to make the required investment and close down the subsidiary, which eliminates any returns at $t = 2$. Such a liquidity shock can result from higher draw-downs on the bank's 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. Banks' ability to close down a unit corresponds to the possibility to revoke credit lines as in Acharya et al. (2014).[6]

If the bank fails to raise sufficient funding to repay its debts it enters resolution. In this case the bank regulator recapitalizes the bank in order to maximize the value of its expected net cash flows. Subject to maximizing the expected net cash flows, the regulator maximizes the payoffs to the bank's existing claim holders (according to their priority). The regulator can wipe out existing equity and write down (part or all of) the existing debt claims (bail-in) and then issue new (short-term) debt and/or (mispriced) outside equity to raise the funds the bank requires to continue its operations, including the repayment of any remaining debt claims.[7] If the regulator does not raise sufficient

[4] The bank would optimally choose to issue short-term debt because it would have ex-post incentives to expropriate long-term debtholders. But our framework would be equivalent to having long-term debt including a covenant that disallow the bank to expropriate the initial debt holders (those that bought debt at $t = 0$) by issuing senior debt at $t = 1$.

[5] We assume away potential agency problems between the holding unit and the subsidiaries. In particular, the subsidiaries cannot hide away the payoffs obtained.

[6] Sufi (2007) empirically documents how bank can use covenant violations to renegotiate precommited credit lines.

[7] In our model, writing down existing debt claims is equivalent to convert them into (mispriced) equity.

funds to satisfy a unit's investment needs following a liquidity shock, the unit shuts down. We assume away any direct costs of default or resolution.

If the banks operates two subsidiaries the bank's resolution plan determines which units enter resolution and how they can be recapitalized. Under SPOE the entire banking group enters resolution whenever the bank defaults on any of its debts. The regulator then writes down the debts of the different units and raises new funding to recapitalize the entire banking group, preserving its organizational structure. Conversely, under MPOE different parts of the banking group may enter resolution separately. If a subsidiary defaults on its debts, the regulator separates it from the banking group, wipes out the subsidiary's equity that is held by the holding company, and recapitalizes the subsidiary as a stand alone bank. If the holding company defaults on its debt, the conglomerate is also split up and each subsidiary becomes a stand alone bank. If necessary these stand alone banks are then recapitalized separately. If a subsidiary does not need to be recapitalized the holding company's debt holders obtain claims on the subsidiary's free cash flows. Note, that the separation of the banking units under MPOE prevents the regulator from transferring funds between those two units.

2.4. Loan monitoring and investment returns

The returns on loans in the two subsidiaries H and L depend on whether the a subsidiary's loans are monitored ($\mu_i = m$) by the equity holders or not ($\mu_i = n$). Table 1 describes the loan returns depending on the monitoring decisions and the overall state of the world, which can be good (G), medium (M) or bad (B), each occurring with the respective probability p_s ($s \in \{G, M, B\}$).[8] Monitoring entails a cost but it allows the subsidiary to identify and deal with troubled loans in a timely fashion, thus increasing average recovery rates (Winton, 1999).[9] Thus, monitoring reduces payoffs in relatively good states of the world but it increases payoffs in relatively bad states of the world.

By monitoring, loans in subsidiary H become safe and generate a payoff R_H in every state of the world. Unmonitored loans generate payoffs $R_H + \Delta_H$ in the good and medium states and 0 in the bad state. The loans of subsidiary L are always risky. However, if monitored, they generate a payoff R_L in the good and medium states and 0 in the low one. If they are not monitored, they generate a payoff $R_L + \Delta_L$ in the good state and 0 in the medium and bad states.

The subsidiary's monitoring decisions are taken by the equity holders of the bank's holding company (arising from inside equity as well as from all the outside equity raised), so as to maximize their equity value. In case the banking units have been separated (following MPOE resolution), monitoring decisions are taken separately by the equity holders of the two stand-alone banks. The monitoring decisions are taken between $t = 1$ and $t = 2$. The terminal state s is unobservable and bank shareholders cannot commit

[8] The two subsidiaries do not compete against each other, either because they operate in different geographical areas or in different business lines.

[9] The bank may increase its average recovery by invoking protective covenants, renegotiating maturing loans, forcing foreclosure, and so forth.

states	subsidiary H		subsidiary L	
	monitoring	no monitoring	monitoring	no monitoring
G	R_H	$R_H + \Delta_H$	R_L	$R_L + \Delta_L$
M	R_H	$R_H + \Delta_H$	R_L	0
B	R_H	0	0	0

Table 1: Subsidiary payoffs

themselves to monitor their loans, but monitoring costs are pecuniary.[10]

At $t = 2$, loan returns realize and payments are made. The allocation of the subsidiaries' cash flows depends on the bank's capital structure and its resolution regime. Under SPOE the debtors of one subsidiary have claims on the other subsidiary's cash flow that are senior to those of the holding unit's equity holders. Conversely, under MPOE a subsidiaries debtors do not have claims on the cash flows of the other subsidiary and hence, the holding's equity holder can obtain a positive payoff while one of the bank's subsidiaries fails. In case banking units have been separated the payoffs are simply determined by the capital structures of the two stand-alone banks. We again assume away direct cost of default or bankruptcy.

2.5. Parameter Assumptions and Notation

We focus on the case where monitoring is efficient for both units. However, subsidiary H generates positive net present value even when it does not monitor its loans. In contrast subsidiary L only generates positive net present value if it monitors its loans. We also assume that no subsidiary has sufficient expected cash flows to repay two units of capital, which would be required to make the initial investment and the new investment required to continue after a liquidity shock.

We let $R(i, \mu, s)$ denote the payoff of subsidiary $i \in \{H, L\}$ with monitoring $\mu_i \in \{m, n\}$ in state s and $V(i, \mu)$ denotes the expected value of $R(i, \mu, s)$. We further let $\mu \equiv \mu_H \mu_L \in \{m, n\}^2$ denote the monitoring decisions of a banking group. These above assumptions thus correspond to the following formal conditions.

Assumption 1. *The returns of the H-unit satisfy*

$$2 > V(H, m) = R_H > V(H, n) = (1 - p_B)(R_H + \Delta_H) > 1 + q$$

whereas the returns of the L-unit satisfy

$$2 > V(L, m) = (1 - p_B)R_L > 1 + q > V(L, n) = p_G(R_L + \Delta_L)$$

[10] In reality, the costs of monitoring represent the effort on the part of the banks management, employees, and directors. Still, some of these costs may be compensated on an ongoing basis, through salaries and director's fees. If the monitoring costs were assumed to be, instead, non-pecuniary and did not reduce the bank assets before debt holders are paid, the underinvestment problem would be even more severe (see Winton, 1999).

For brevity we denote the bank's debt structure by $\mathbf{F}^t \equiv \{F_J^t, F_H^t, F_L^t\}$, the face value of the bank's total claims by $F^t \equiv F_H^t + F_L^t + F_J^t$, and the market value of the bank's total debt claims by D^t.

3. High-profit single-unit bank

To begin with, we assume in the next two sections that the bank only operates one of its subsidiaries, H or L, respectively. We proceed backwards, analyzing the bank's monitoring decisions between $t = 1$ and $t = 2$, its financing decisions at $t = 1$ depending on whether the bank enters resolution or not, and its financing decisions at $t = 0$. Decisions are taken by the bank's equity holders at each point in time, who maximize their expected of profits i.e., the value of their equity. The only exception is when the bank is resolved, in which case the supervisor chooses the financing structure to maximise the bank's asset value.

3.1. Monitoring and risk-shifting incentives

Monitoring decisions between dates $t = 1$ and $t = 2$ are taken so as to maximize the profits of the bank's date 1 equity holders. The bank's equity holders are protected by limited liability and only make profits if they repay the banks total outstanding debt F^1 at date 2. For any monitoring choice μ_H the equity holders' profits are thus given by

$$\pi^2(\mu_H; H, \mathbf{F}^1) = \sum_{s \in \{G,M,B\}} p_s \max\{R(H, \mu_H, s) - F^1, 0\} \tag{1}$$

where the maximum operator accounts for the bank's limited liability.

Comparing the profits with and without monitoring, $\pi^2(m; H, \mathbf{F}^1) > \pi^2(n; H, \mathbf{F}^1)$, and using $R(H, \mu_H, s)$ in Table 1, the bank will monitor its loans if and only if

$$F^1 \leq R_H - \frac{1 - p_B}{p_B} \Delta_H \tag{2}$$

Although monitoring is efficient, the bank will engage in risk shifting if its debt exceeds this threshold. Debt financing, thus, creates the typical risk-shifting incentives.

3.2. Debt capacity and pledgeable income at date 1

We now introduce the two key concepts of our analysis: the bank's debt capacity and pledgeable income. Suppose first that the debt level F^1 satisfies Condition (2) thus ensuring monitoring. With monitoring the return in every state of the world R_H is higher than the right-hand side of Condition (2). Hence, the debt is safe and the debt value is equal to its face value. Thus, the bank's debt capacity when it monitors i.e., the maximum amount of debt financing that the bank can raise without destroying its monitoring incentives is

$$\bar{D}(H, m) = R_H - \frac{1 - p_B}{p_B} \Delta_H \tag{3}$$

Debt financing is cheaper than equity financing because equity is mispriced. Hence, when the bank maximizes its financing ability for a given monitoring choice it will exhaust its corresponding debt capacity and pledge only the remaining income to outside equity holders. Hence, when it monitors its loans, the bank's pledgeable income or market value, i.e., the maximum amount of (debt and equity) financing that the bank can raise at $t = 1$, is

$$P(H, m) = \bar{D}(H, m) + \phi(V(H, m) - \bar{D}(H, m)) = R_H - (1 - \phi)\frac{1 - p_B}{p_B}\Delta_H, \qquad (4)$$

where $V(H, m) - \bar{D}(H, m)$ is the expected net present value of the banks equity (without mispricing). The second equality follows from Expression (3) and $V(H, m) = R_H$.

Now, suppose the debt level F^1 does not satisfy Condition (2) and thus monitoring does not occur. In this case, the bank can pledge its entire expected income to debt holders issuing risky debt. The bank can, thus, avoid issuing mispriced equity which yields,

$$P(H, n) = \bar{D}(H, n) = V(H, n) = (1 - p_b)(R_H + \Delta_H). \qquad (5)$$

Comparing Expressions (4) and (5), the pledgeable income may be higher in case of monitoring than in the case of not monitoring because monitoring is efficient, $V(H, m) > V(H, n)$. But it may also be lower when $\bar{D}(H, m) < \bar{D}(H, n)$ because equity is mispriced, $\phi < 1$. In the remainder of the paper we assume that the pledgeable income of the high profit subsidiary is maximal when it is finances such that it monitors its loans.

Assumption 2. *The pledgeable income of stand-alone high profit bank satisfies*

$$P(H, m) > P(H, n).$$

This assumption will be satisfied when the risk shifting incentives for the high profit subsidiary $\frac{1-p_B}{p_B}\Delta_H$ are sufficiently small.

3.3. Financing Outside of Resolution

At date 1 the bank needs to raise financing to repay its maturing debts and make the additional investments required in case of a liquidity shock. We first analyze the model for an arbitrary I^1 and then discuss its values. If the bank does not raise the required financing it defaults and enters resolution which we analyze in the next section.

The bank chooses its financing structure to maximize the profits of the bank's date 0 equity holders and trades of the possible agency costs of issuing debt and the cost of equity mispricing. For a given choice of future monitoring μ_H, the bank thus raises the required funds through issuing debt whenever possible and only resorts to issuing equity when it has exhausted its debt capacity.

It follows that when $\bar{D}(H, \mu_H) \geq I^1$ the bank will fully rely on debt financing. Because debt is fairly priced the existing equity holders' profits are given by

$$V(H, \mu_H) - I^1. \qquad (6)$$

Conversely, when $\bar{D}(H, \mu_H) < I^1$, the bank must raise the difference $I^1 - \bar{D}(H, \mu_H)$ in the form of equity financing. Because equity is mispriced the bank must promise new equity holders $\frac{1}{\phi}$ units of expected profits per unit of financing. Hence, the existing equity holders' profits are given by

$$V(H, \mu_H) - [\bar{D}(H, \mu_H) + \frac{1}{\phi}(I^1 - \bar{D}(H, \mu_H))] \tag{7}$$

Combining Expressions (6) and (7) we can thus write the existing equity holders' expected profits as a function of the bank's monitoring decision.

$$\pi^1(\mu_H; H, I^1) = V(H, \mu_H) - I^1 - \frac{1-\phi}{\phi} \max\{I^1 - \bar{D}(H, \mu_H), 0\}. \tag{8}$$

where the maximum operator accounts for the cost of mispricing when the bank issues equity.

One can use Expression (8) to show that outside of resolution the bank will always choose a debt level that allows it to monitor its loans. To gain intuition, first, consider the case when the debt capacity with monitoring is sufficient to finance the investment ($\bar{D}(H, m) \geq I^1$). In this case, equity holders profits are higher with monitoring because monitoring is efficient and does not lead to any mispricing.

Second, consider the case when the debt capacity with monitoring is not sufficient to finance the investment ($\bar{D}(H, m) < I^1$). Assumption (2) guaranties that the bank's pledgeable income is still higher with monitoring, which implies that the banks market value is higher. Hence the bank's existing date 0 equity holder's can raise the required financing I^1 by pledging a smaller share of the banks income to outside investors, which maximizes the value of their own equity claims.

The face value of the bank's maturing debt and the occurrence of a liquidity shock determine the bank's date 1 financing need, which is given by

$$I^1(H, \mathbf{F}^0, \lambda) = F^0 + \mathbb{I}_\lambda$$

where $\mathbb{I}_\lambda$ is an indicator function that takes the value of one if the bank is hit by a liquidity shock and zero otherwise. Given the bank's optimal monitoring choice and financing need we can thus state the following Lemma.

Lemma 1. *Outside of resolution a high-profit stand alone bank will always choose a date 1 financing structure such that it monitors its loans. Its profits are given by*

$$\pi^1(H, \mathbf{F}^0, \lambda) = V(H, m) - F^0 - \mathbb{I}_\lambda - \frac{1-\phi}{\phi} \max\{F^0 + \mathbb{I}_\lambda - \bar{D}(H, m), 0\}. \tag{9}$$

3.4. Bank resolution

The bank can finance its date 1 investment needs if and only if $P(H, m) \geq I^1$. In this case the bank can raise the required funds while its existing equity holder make non-negative profits. Conversely, when $P(H, m) < I^1$ the pledgeable income is not sufficient to cover the investment needs and the bank will need to go into resolution.

Upon resolution, the regulator can wipe out existing equity, bail in existing debt claims, and issue new debt and/or outside equity to continue the bank. The objective of the supervisor is to maximize the bank's asset value $V(H, \mu_H)$. Hence the regulator will choose a new financing structure that ensures monitoring, which is efficient.

The level of debt needs to be reduced such that the free pledgeable income covers the bank's (new) investment needs. As the supervisor minimizes the amount of debt conversion, it will choose a reduction such that these investment needs are exactly equal to the pledgeable income. In case the bank receives the liquidity shock the value of the old creditors claims must thus be

$$C(H) = P(H, m) - 1.$$

Note that because $P(H, m) > P(H, n)$ the regulator's financing also maximizes the payoff of the bank's creditors who internalize the mispricing of equity (as well as its asset value $V(H)$).

3.5. Insider profits at date 0

At date 0, the bank chooses a financing structure in order to raise the required investment. The profits of the bank's initial owners are given by

$$\pi^0(H, \mathbf{F}^0) = (1 - q) \max\{\pi^1(H, \mathbf{F}^0, nl), 0\} \\ + q \max\{\pi^1(H, \mathbf{F}^0, l), 0\} - \frac{1}{\phi} \max\{1 - D^0, 0\} \quad (10)$$

The first two terms describe the date 0 equity holders expected payoffs at date 1 when it must repay the debt $\mathbf{F}^0$depending on whether it is hit by a liquidity shock or not. The profit functions π^1 are given by Expression (9) and the maximum operators account for the bank's limited liability. The profit functions π^1 also account for the cost of debt financing at date 0. The last term accounts for the cost of issuing mispriced outside equity at date 0 when the market value of the firms debt does not cover the bank's investment need $D^0 < 1$. Per unit of of equity financing, the initial owners must pledge new equity holders $1/\phi$ units of the date 0 equity holders' expected profits.

When $F^0 + 1 \leq P(H, m)$ the bank can avoid resolution even when it experiences a liquidity shock. In this case the date 0 debt is safe and its market value equals the face value. But when $F^0 + 1 > P(H, m)$, then the bank will enter resolution following liquidity shock and the market value of the bank's debt satisfies

$$D^0 = (1 - q)F^0 + qC(H) \quad (11)$$

The bank maximizes its profits if it minimizes its reliance on equity financing. Doing so reduces its financing costs while the possibility to enter resolutions does not create any private costs. Resolution does not create any private costs because (i) there are no direct costs of resolution and (ii) in resolution the regulator chooses the banks financing structure that maximizes the bank's creditors' payoffs.

It follows that the the bank's profits are strictly increasing in F^0 if two conditions are met. First, the bank's financing from debt must not exceed its total financing need, such that $D^0 < 1$. Second, there is free debt capacity at $t = 1$,

$$F^0 < \bar{D}(H, m).$$

which, allows the bank to roll over the additional debt using debt (in the absence of a liquidity shock). If the the debt level $F^0 \geq \bar{D}(H, m)$, then issuing additional debt at $t = 0$ increases the amount of equity the bank must issue at $t = 1$ to refinance the debt. As a result the bank's financing costs do not decreases when it issues more equity at $t = 1$.[11]

It follows that a profit maximizing bank will only choose a financing structure that avoid resolution if doing so does not lead to unused debt capacity. Since the bank can avoid resolution following a liquidity shock if and only if $F^0 \leq P(H, m) - 1$ doing so leads to unused debt capacity when

$$P(H, m) - 1 < \bar{D}(H, m) \tag{12}$$

More formally the above argument can be verified by substituting for the profit functions π^1 and D^0 in Expression (10). We thus obtain the following Lemma.

Lemma 2. *A bank that chooses to operate only subsidiary H finds it strictly optimal to minimize its reliance of equity financing. It raises its initial financing such that it enters resolution following a liquidity shock when Condition (12) holds. Both in the presence and in the absence of a liquidity shock, the bank will monitor its loans. Bank profits are:*

$$\begin{aligned}\pi^0(H) = V(H, m) - (1 + q) - q(V(H, m) - P(H, m))\\ - \frac{1 - \phi}{\phi} \max\{1 + q - qP(H, m) - (1 - q)\bar{D}(H, m), 0\}\end{aligned} \tag{13}$$

The first two terms of this expression describe the expected net present value of the high profit subsidiary, which it is continued following a liquidity shock. The second expression describes the expected costs of equity financing that are borne by the bank's creditors in resolution. The third expression describes the expected costs of equity financing that are borne directly by the bank equity holders.

4. Low-profit single-unit bank

Analogously to the last section, the bank monitors its loans if and only if

$$F^1 \leq R_L - \frac{p_G}{p_M} \Delta_L \tag{14}$$

Suppose first that the debt level F^1 satisfies (14) thus ensuring monitoring. Notice that in this case, even if the bank monitors, debt only repays with probability $1 - p_B$

[11] Note however that even in this case increasing F^0 is weakly optimal as long as $D^0 < 1$.

(and in those cases, it repays in full). The maximum amount of debt financing that is compatible with the bank monitoring its loans is thus given by

$$\bar{D}(L,m) = (1-p_B)(R_L - \frac{p_G}{p_M}\Delta_L)$$

which implies that the bank's total pledgeable income is

$$P(L,m) = (1-p_B)(R_L - (1-\phi)\frac{p_G}{p_M}\Delta_L),$$

Now, consider the case in which the debt level $\mathbf{F}^1$ does not satisfy (14) and thus monitoring does not occur. In that case, the bank can pledge its entire expected income to debt holders, and therefore it will not make use of any equity financing. As a result,

$$P(L,n) = \bar{D}(L,n) = V(L,n) = p_G(R_H + \Delta_H)$$

The structure of the banks decision making is the same as for a stand alone high profit subsidiary, but in the remainder of the paper we assume that the stand alone low profit subsidiary's pledgeable income is insufficient to raise one unit of capital.

Assumption 3. *The pledgeable income of stand-alone low profit subsidiary satisfies*

$$P(L,n) < P(L,m) < 1$$

This assumption implies that it will be impossible for the low profit subsidiary to operate as a stand alone bank, because the market value of all securities that it can issue is below the required initial investment at date 0. The lack of investment is inefficient because the value of the low profit subsidiary's assets with monitoring satisfies $V(H,m) \geq 1+q$. This inefficient lack of investment results from sufficiently severe risk shifting incentives $\frac{p_G}{p_M}\Delta_L$ and equity mispricing ϕ. In the following sections we will show that the formation of a banking group can create financial synergies that can overcome this inefficiency.

5. MPOE banking group

The banking groups financing comes from the debt and equity issued by the holding company and as well as the debts issued by its subsidiaries Under MPOE the subsidiaries' creditors only have a claims against the subsidiary whose debt they hold. The holding's creditors have claims against the cash flows of both subsidiaries but are junior to the subsidiaries' direct creditors.

The bank distributes the proceeds its raises at the holding level to its subsidiaries. Because the holding's creditors and equity holders have claims on both subsidiaries' cash flows raising financing at the holding level allows the bank to use the pledgeable income of one subsidiary's to finance the other subsidiary. As we will show below issuing debt a the holding company also allows to transfer debt capacity between the subsidiaries.

5.1. Monitoring, debt capacity and pledgeable income

Between dates 1 and 2 the bank decides separately whether to monitor the loans of each subsidiary. The bank's equity holders are protected by the limited liabilities of both subsidiaries and the holding company. Hence, the expected profits of a bank's equity holders at date 2 are given by

$$\pi(\mu; M, \mathbf{F}^1) = \sum_{s\in\{G,M,B\}} p_s \max\big\{ \max\{R(H,\mu_H,s) - F_H^1, 0\} + \max\{R(L,\mu_L,s) - F_L^1, 0\} - F_J^1, 0\big\} \quad (15)$$

where the maximum operators correspond to the three limited liability constraints.

The profit function (15) shows that the bank's monitoring decisions depend on the face values of its units' outstanding debts $\mathbf{F}^1$. Its is easy to show that the bank will monitor its high profit subsidiary if and only if

$$F_H^1 + F_J^1 \leq R_H - \frac{1-p_B}{p_B}\Delta_H \quad (16)$$

The monitoring decision of the high profit subsidiary depends on both F_H^1 and F_J^1 because the bank must repay both debt claims before it can pay out profits from its high profit subsidiary. The incentives to monitor the high profit subsidiary do not depend on F_L^1 for two reasons. First, the limited liabilities of the different units ensure that these creditors do not have any claims on the cash flows R_H. Second, monitoring the high profit subsidiary only increases cash flows in a state where the low profit subsidiary does not create any returns, which could reduce the risk shifting incentives by repaying (parts of) the holding's debt F_J^1.

Similarly, one can show that the bank monitors its low profit subsidiary if and only if

$$F_L^1 \leq R_L - \frac{p_G}{p_M}\Delta_L - \max\{F_J^1 - \max\{R(H,\mu_H,M),0\},0\} \quad (17)$$

The last term captures the risk-shifting incentives created by F_J^1 , which are reduced by the the high profit subsidiary's cash flows that accrue to the holding company in state M. The maximum operators account for the limited liability constraints that preclude any repayment of F_L^1 from the high profit subsidiary's cash flows.

The bank's monitoring decisions for the high and low profit subsidiaries depend on different debt claims as long as $F_H^1 + F_J^1 \leq R_H$. In this case, the debt issuance and monitoring decisions for the two subsidiaries can be separated. Moreover, the subsidiaries' cash flows and conditions (16) and (17) coincide with the respective cash flows and monitoring conditions (2) and (14) of stand alone banks. It thus follows that the MPOE's debt capacity equals the sum of its subsidiaries debt capacities

$$\bar{D}(M,\mu) = \bar{D}(H,\mu_H) + \bar{D}(L,\mu_L). \quad (18)$$

One can show further that this expression also holds for $F_H^1 + F_J^1 > R_H + \Delta_H$ because any increases in the market value of F_J^1 must result in an offsetting decreases in the market value of F_L^1.

Analogously to the stand alone case the pledgeable income of an MPOE bank is given by

$$P(M, \mu) = \phi(V(H, \mu_H) + V(L, \mu_L)) + (1 - \phi)\bar{D}(M, \mu)$$

Hence, Expression (18) implies the following Lemma.

Lemma 3. *The pledgeable income of an MPOE satisfies*

$$P(M, \mu) = P(H, \mu_H) + P(L, \mu_L) \forall \mu$$

5.2. Financing Outside of Resolution

At date 1 the bank needs to raise financing to repay its maturing debts and make the additional investments required in case of a liquidity shock. We start by considering the case of a bank that operates both subsidiaries for an arbitrary financing need I^1. As before the bank chooses its financing structure trading off of the possible agency costs of issuing debt and the cost of raising additional mispriced equity financing. For a given monitoring decision, the bank thus raises the required funds through issuing debt whenever possible and only resorts to issuing equity when it has exhausted its debt capacity. It follows that profits of the date 0 equity holders can be written as a function of the bank's monitoring decisions

$$\pi^1(\mu; M, I^1) = V(H, \mu_H) + V(L, \mu_L) - I^1 - \frac{1 - \phi}{\phi} \max\{I^1 - \bar{D}(H, \mu_H) - \bar{D}(L, \mu_L), 0\} \quad (19)$$

The first three terms of this expression describe the expected payoff from the bank's subsidiaries minus the funds required to operate those subsidiaries. The last term describes the additional cost of issuing mispriced equity when the bank's financing needs I^1 exceed its debt capacity for a given monitoring choice.

From the analysis of the stand alone subsidiaries it follows that monitoring both subsidiaries maximizes both the bank's expected cash flows and its pledgeable income. Hence, analogously to the stand-alone case an MPOE will optimally choose to monitor both subsidiaries.

The bank at $t = 1$ must decide whether it continues as MPOE banking group operating both subsidiaries or only continues to operate a single subsidiary and close down the other one. The bank's continuation decision $c \in \{M, L, H\}$, determines it funding needs $I^1(c; M, \mathbf{F}^0, \lambda)$ and profits $\pi^1(c; M, \mathbf{F}^0, \lambda)$.

It the bank continues both subsidiaries its financing need is given by

$$I^1(M; M, \mathbf{F}^0, \lambda) = F^0 + 2\mathbb{I}_\lambda.$$

Given the banks optimal monitoring decisions substituting into (19) yields following Lemma.

Lemma 4. *An MPOE that operates both subsidiaries will choose* $\mathbf{F}^1$ *such that it will monitors both subsidiaries. The banks profits are given by*

$$\pi^1(M; M, \mathbf{F}^0, \lambda) = V(H, m) + V(L, m) - F^0 - 2\mathbb{I}_\lambda \\ - \frac{1-\phi}{\phi} \max\{F^0 + 2\mathbb{I}_\lambda - \bar{D}(H, m) - \bar{D}(L, m), 0\}$$

If the bank continues only one subsidiary $i \in \{L, H\}$ it defaults on the other subsidiary's debt and its financing needs are given by

$$I^1(i; M, \mathbf{F}^0, \lambda) = F_J^0 + F_i^0 + \mathbb{I}_\lambda$$

The bank's profits, similarly to those of a stand-alone bank, can then be written as

$$\pi^1(i; M, \mathbf{F}^0, \lambda) = V(i, m) - F_J^0 + F_i^0 - \mathbb{I}_\lambda - \frac{1-\phi}{\phi} \max\{F_J^0 + F_i^0 + \mathbb{I}_\lambda - \bar{D}(i, m), 0\}.$$

5.3. Corporate Structure and Resolution

A bank continues subsidiary i at date 1 if and only if doing so maximizes the profits of the bank's date 0 equity holders. Hence, the bank's profits outside of resolution are given by

$$\pi^1(M, \mathbf{F}^0, \lambda) = \max_{c \in \{M, H, L\}} \pi^1(c; M, \mathbf{F}^0, \lambda)$$

Continuing subsidiary i is always profitable when the subsidiaries pledgeable income exceeds the financing need of the stand alone subsidiary

$$P(i, m) \geq F_i^0 + F_J^0 + \mathbb{I}_\lambda \tag{20}$$

This condition is necessary and sufficient to ensure that the bank will operate the subsidiary i when it does not operate the other subsidiary. It is also sufficient (but not necessary) to ensure that the bank will operate subsidiary i when it does operate the other subsidiary.

Hence when condition (20) is not satisfied then the bank will operate subsidiary i if and only if operates both subsidiaries, which depends on two conditions. First, operating both subsidiaries must yield positive profits which gives

$$P(H, m) + P(L, m) \geq F^0 + 2\mathbb{I}_\lambda. \tag{21}$$

Second operating both subsidiaries must be more profitable than only operating the other subsidiary i^c, such that $\pi^1(M; M, \mathbf{F}^0, \lambda) \geq \pi^1(i^c; M, \mathbf{F}^0, \lambda)$. Substituting for the profit functions and simple algebra then yields

$$V(i, m) - F_i^0 - \mathbb{I}_\lambda \geq \frac{1-\phi}{\phi} [\max\{F^0 + 2\mathbb{I}_\lambda - \bar{D}(H, m) - \bar{D}(L, m), 0\} \\ - \max\{F_{i^c}^0 + F_J^0 + \mathbb{I}_\lambda - \bar{D}(i^c, m), 0\}]. \tag{22}$$

The left-hand-side of the condition denotes the equity holders added net cash flows from operating subsidiary i in addition to i^c. The right-hand-side denotes the associate increase in the costs of equity financing.

Whether continuing a subsidiary is profitable clearly depends on whether the bank is subject to a liquidity shock that makes continuation more expensive. Accordingly, Conditions (20)-(22) will be tighter following such a shock and the bank will continue subsidiaries only for lower levels of maturing debt. Based on these considerations we can state the following Lemma.

Lemma 5. *An MPOE bank operates a subsidiary $i \in \{H, L\}$ at date 1 if and and only if Condition (20) or Conditions (21) and (22) are satisfied. If the bank continues a subsidiary following a liquidity shock then it also continues that subsidiary without a liquidity shock.*

If an MPOE bank does not continue a subsidiary and defaults on its debt the subsidiary will enter resolution. When a subsidiary enters resolution under MPOE the banking group is split up and the subsidiary becomes a stand alone bank. The regulator then restructures the subsidiary's financing to maximizes the subsidiary's NPV. Because both subsidiaries can create positive NPV following a liquidity shock the regulator always prefers to continue a subsidiary that enters resolution.

However, if the low profit subsidiary enters resolution following a liquidity shock its pledgeable income is smaller than the financing required to continue its operation $P(L, m) < 1$. Hence, the regulator cannot raise sufficient funds to continue the low profit subsidiary even when it bails in the subsidiary's entire maturing debt. The low profit subsidiary with will thus cease to operate and creditors claims on the subsidiary become worthless.

In contrast, the regulator can continue the operations of the high profit subsidiary following a liquidity shock as discussed in the stand-alone case. The creditors claims on the subsidiary are then worth $C(H)$. Hence, we arrive at the following Lemma.

Lemma 6. *A subsidiary that enters resolution following a liquidity shock will only continue its operation if and only it is the high profit subsidiary. If both subsidiaries are resolved following a liquidity shock then the value of the bank's date 0 debt claims is*

$$C(M) = C(H) = P(H, m) - 1.$$

If a subsidiary enters resolution in the absence of a liquidity shock, the regulator can always continue its operations. The regulator only needs to bail in the maturing debt such that the creditors claims do not exceed the banks pledgeable income. The regulator will restructure the financing such that the subsidiary will monitor its loans as this maximizes the NPV. Hence, the creditors claims on a subsidiary i will be worth $P(i, m)$.

5.4. Date 0 Financing

At date 0 the bank chooses a financing structure in order to raise the required investment. This section analyzes the financing choices of a bank that operates both subsidiaries.

In the next section, we will then analyze the bank's choice between operating both subsidiaries or operating only one subsidiary at $t = 0$.

A bank that operates both subsidiaries must raise two units of financing. It chooses a financing structure that maximizes the profits of its initial owners, which are given by

$$\pi^0(M, \mathbf{F}^0) = (1 - q) \max\{\pi^1(M, \mathbf{F}^0, nl), 0\} \\ + q \max\{\pi^1(M, \mathbf{F}^0, l), 0\} - \frac{1}{\phi} \max\{2 - D^0, 0\} \quad (23)$$

which is analogous to expression 10. The profit functions π^1 are described in the preceding sections. As in the case of a stand alone bank the MPOE minimizes its reliance on equity financing. Resolution is again costless because the decisions of the regulator following resolution are privately optimal. Hence, the bank will never choose a debt structure where $D^0 < 2$ and date 1 debt capacity remains unused. There is unused debt capacity in the absence of a liquidity shock when the face value of the debt satisfies

$$F^0 < \bar{D}(H, m) + \bar{D}(L, m) \quad (24)$$

Note that because $D^0 \leq F^0$ it follows from Condition (24) that $F^0 \geq \min\{\bar{D}(H, m) + \bar{D}(L, m), 2\}$. For both $F^0 = \bar{D}(H, m) + \bar{D}(L, m)$ and $F^0 = 2$ it follows from condition (21) that (a part of) the bank will enter resolution following a liquidity shock. Substituting into the profit function (23) and the preceding discussion yields the following result.

Lemma 7. *For an MPOE that operates both subsidiaries it is strictly optimal to finance at date 0 such that at least one unit enters resolution following a liquidity shock. The bank's initial owner's profits are given by*

$$\pi^0(M) = V(H, m) + (1 - q)V(L, m) - 2 - q - q(V(H, m) - P(H, m)) \\ - \frac{1 - \phi}{\phi} \max\{2 + q - qP(H, m) - (1 - q)(\bar{D}(H, m) - \bar{D}(L, m))\} \quad (25)$$

The interpretation of the different terms is analogous to the high profit stand alone case, taking into account that the low profit subsidiary is shut down following liquidity shock.

There are multiple optimal debt structures. Importantly there always exists an optimal debt structure $\mathbf{F}^0$ that avoids the resolution of any subsidiary in the absence of a liquidity shock.

Lemma 8. *It is optimal to choose a date* 0 *financing structure such that no subsidiary gets resolved if there is no liquidity shock.*

One such debt structure consists of financing the bank entirely with joint debt F_J^0 at date 0. This is weakly optimal because resolution is costless and the bank adapt its debt structure at $t = 1$. In this case the holding company becomes insolvent following a liquidity shock and both subsidiaries enter resolution, which implies that

$$F_J^0 = F^0(M) \equiv \frac{2 - q(P(H, m) - 1)}{1 - q}. \quad (26)$$

No subsidiary enters resolution in the absence of liquidity shock as long as the banks pledgeable income is sufficient to operate both subsidiaries at $t = 0$, such that

$$(1-q)(P(H,m)+P(L,m))+q(P(H,m)-1)\geq 2.$$

5.5. Choice of corporate structure.

At $t = 0$, an MPOE banking group will operate both subsidiaries if and only if the initial owners' profits are larger than when the bank only operates the high profit subsidiary. Although it is not profitable to operate the low profit subsidiary as a stand alone bank due to equity mispricing it can be profitable for an MPOE banking group if it can finance the low profit subsidiary at lower costs.

An MPOE can reduce the cost of financing the low profit subsidiary if it can raise more debt financing than two stand alone banks. This is possible if the high profit stand alone subsidiary has free debt capacity in the sense that its date 1 debt capacity exceeds its maturing debt

$$\bar{D}(H,m)\geq\frac{1-q(P(H,m)-1)}{1-q}.$$

In this case the formation of a banking group makes its possible to raise additional date 1 debt at the holding company. The proceeds of this additional debt can then be used to finance the low profit subsidiary, which reduces the amount of equity the banks must issue in order to refinance the initial debt $\mathbf{F}^0$. Comparing the profits of an MPOE banking group that operates both subsidiaries (25) with the profits of a stand alone high profit subsidiary (13) yields the following Proposition.

Proposition 1. *An MPOE will operate both subsidiaries if and only if*

$$\begin{aligned}&(1-q)V(L,m)-1\\&\quad\geq\frac{1-\phi}{\phi}\max\left\{2-q(P(H,m)-1)-(1-q)(\bar{D}(H,m)+\bar{D}(L,m)),0\right\}\end{aligned}\tag{27}$$

The left hand side of this condition is the NPV created by the low profit subsidiary under MPOE resolution, which only creates cash flows with probability $1-q$ because it is shut down following a liquidity shock. The right hand side are the costs of equity financing that arise due to the operation of the low profit subsidiary.

6. SPOE Banking Group

6.1. Monitoring, Debt Capacity, and Pledgeable Income

With SPOE all the bank's creditors have claims on all cash flows of the bank. Hence, in contrast to the MPOE, the bank's equity holders do not benefit from limited liabilities of their subsidiaries and are only protected by the limited liability of the holding company. Hence, the expected profits of a bank's equity holders at date 2 are given by

$$\pi(\mu;S,\mathbf{F}^1)=\sum_{s\in\{G,M,B\}}p_s\max\left\{R(H,\mu_H,s)+R(L,\mu_L,s)-F^1,0\right\}\tag{28}$$

It follows that the bank's monitoring decision will only depend on the total face value of the bank's debts $F^1 = F_L^1 + F_H^1 + F_J^1$. Accordingly, the SPOE banking group will monitors its high profit subsidiary if and only if

$$F^1 \leq R_H - \frac{1 - p_B}{p_B}\Delta_H \tag{29}$$

Again, the profitability of monitoring the high profit subsidiary does not depend on the low profit subsidiary's monitoring because monitoring the high profit subsidiary increases cash flows only in state B, in which the low profit subsidiary never creates positive cash flows. Condition (29) is stricter than its MPOE equivalent (16) because the the bank cannot separately default on the debt F_L^1 in state B. Hence, the debt F_L^1 increases an SPOE's incentives to engage in risk shifting with the high profit subsidiary.

From the profit function (28) and Assumption 1 it follows that the SPOE banking group will monitor its low profit subsidiary if and only if

$$F^1 \leq R_H + \Delta_H + R_L - \frac{p_G}{p_M} \tag{30}$$

Comparing Conditions (29) and (30) shows that the bank will always monitor the low profit subsidiary when it monitors its high profit subsidiary. Hence, we can state the following Lemma

Lemma 9. *If an SPOE operates both subsidiaries, then its debt capacity for a given monitoring decision is given by*

$$\bar{D}(S, \mu) = \begin{cases} \bar{D}(H, m) & \mu = mm \\ \bar{D}(H, \mu_H) + \bar{D}(L, \mu_L) & \mu \in \{nm, nn\} \end{cases} \tag{31}$$

The subsidiaries' lack of limited liability increases the risk shifting incentives of the SPOE and hence the debt capacity when the bank monitors both subsidiaries is smaller than with MPOE i.e., $\bar{D}(S, mm) < \bar{D}(M, mm)$. because . The bank's pledgeable income is again given by

$$P(S, \mu) = \phi(V(H, \mu_H) + V(L, \mu_L)) + (1 - \phi)\bar{D}(S, \mu)$$

and hence, it follows that the pledgeable income under SPOE is smaller than under MPOE $P(S, mm) < P(M, mm)$.

6.2. Financing Outside of Resolution

At date 1 the bank needs to raise financing to repay its maturing debts and make the additional investments required in case of a liquidity shock. The banks's profits depend on whether it continues as SPOE banking group operating both subsidiaries or only continues to operate a single subsidiary. The bank's continuation decision $c \in \{S, L, H\}$, determines it funding needs $I^1(c; S, \mathbf{F}^0, \lambda)$ and profits $\pi^1(c; S, \mathbf{F}^0, \lambda)$.

We start by considering the case of a bank that operates both subsidiaries for an arbitrary financing need I^1. When the bank chooses its financing structure it trade off the possible agency costs of issuing debt and the cost of raising additional mispriced equity financing. For a given choice of future monitoring, the bank only resorts to issuing equity when it has exhausted its debt capacity. Hence, the profits of the date 0 equity holders can be written as

$$\pi^1(S,\mu;S,\mathbf{F}^0,\lambda) = V(H,\mu_H) + V(L,\mu_L) - I^1 - \frac{1-\phi}{\phi}\max\{I^1 - \bar{D}(S,\mu),0\} \quad (32)$$

It is always optimal to monitor the low profit subsidiary because this maximizes both the expected cash flows and the pledgeable income. But monitoring both subsidiaries with an SPOE reduces the the bank's debt capacity below those of two independent banks increasing the banks financing costs. If this increase in the bank's financing costs is large enough then it will be optimal to monitor only the low profit subsidiary. The following Lemma provides conditions when its is indeed the case that $\pi^1(S,nm;S,\mathbf{F}^0,\lambda) > \pi^1(S,mm;S,\mathbf{F}^0,\lambda)$.

Lemma 10. *Outside of resolution an SPOE banking group that operates both subsidiaries will choose* $\mathbf{F}^1$ *such that it monitors only the low profit subsidiary if and only if*

$$(1-\phi)\bar{D}(L,m) > P(H,m) - P(H,n) \quad (33)$$

and

$$(1-\phi)(I^1 - \bar{D}(H,n) > P(H,m) - P(H,n) \quad (34)$$

Otherwise, it will monitor both subsidiaries.

The left-hand-side of Condition (33) is the maximum increase in the the bank's market value that results from using the low profit subsidiary's debt capacity. The right-hand-side is the reduction of the high profit subsidiary's market value that results from risk shifting. The left-hand-side of Condition (34) describes an increase in the bank's market value if the bank finances its entire funding need with debt. The right-hand-side is equivalent to Condition (33).

If the bank operates both subsidiaries its financing need for a given F^0 is the sames as in the MPOE case $I^1(S;S,\mathbf{F}^0,\lambda) = I^1(M;M,\mathbf{F}^0,\lambda) = F^0 + 2\mathbb{I}_\lambda$. Hence, when the bank operates both subsidiaries it will monitor the low profit subsidiary if and only if Conditions (33) and (34) are satisfied for $I^1 = F^0 + 2\mathbb{I}_\lambda$. Depending on the optimal monitoring decision μ_H the bank's profits are given by

$$\begin{aligned}\pi^1(S,\mu_H m;S,\mathbf{F}^0,\lambda) &= V(H,\mu_H) + V(L,m) - F^0 - 2\mathbb{I}_\lambda \\ &\quad - \frac{1-\phi}{\phi}\begin{cases}\max\{F^0 + 2\mathbb{I}_\lambda - \bar{D}(H,n) - \bar{D}(L,m),0\} & \mu_H = n\\ \max\{F^0 + 2\mathbb{I}_\lambda - \bar{D}(H,m),0\} & \mu_H = m\end{cases}\end{aligned}$$

An SPOE bank that only continues to operate a single subsidiary i cannot default on the other subsidiary debt, and hence, its financing need is $I^1(i;S,\mathbf{F}^0,\lambda) = F^0 + \mathbb{I}_\lambda$. Otherwise, the bank behaves like a stand-alone bank and its profits are given by

$$\pi^1(i;S,\mathbf{F}^0,\lambda) = V(i,m) - F^0 - \mathbb{I}_\lambda - \frac{1-\phi}{\phi}\max\{F^0 + \mathbb{I}_\lambda - \bar{D}(i,m),0\}.$$

6.3. Corporate Structure and Resolution

A bank continues a subsidiary i at date 1 if and only if doing so maximizes the profits of the bank's date 0 equity holders. Hence, the bank's profits outside of resolution are given by

$$\pi^1(S, \mathbf{F}^0, \lambda) = \max_{c,\mu} \pi^1(c, \mu; S, \mathbf{F}^0, \lambda), c \in \{S, H, L\}$$

We will focus on the case where operating both subsidiaries is efficient even when this results in risk shifting by the high profit subsidiary and operating the low profit subsidiary requires additional investment due to a liquidity shock.

Assumption 4. *The returns of the subsidiaries satisfy*

$$V(L, m) - 1 > V(H, m) - V(H, n).$$

It follows from this assumption that an SPOE bank never discontinues a subsidiary if it is not subject to a liquidity shock. In this case, there is no additional financing need of continuing the low profit subsidiary, the expected cash flows will be higher, and the financing costs will be lower because $\bar{D}(S, nm) > \bar{D}(H, m)$. Hence, a bank that is not hit by a liquidity shock will enter resolution if and only if $\max_\mu P(S, \mu) < F^0$.

Conversely if a bank is hit by a liquidity shock, then closing down one subsidiary allows the bank to reduce the amount of additional investment it needs to finance. Due to Assumption 4 continuing both subsidiaries is still efficient, but the pledgeable income of the low profit subsidiary is smaller than its required additional investment following a liquidity shock. Hence, it can only be profitable to continue the low profit subsidiary if the high profit subsidiary has free debt capacity that can be used to reduce the cost of financing the continuation of the low profit subsidiary. Conversely, when the financing needs are large there will be no free debt capacity and the bank would like to optimally shut down the low profit subsidiary following a liquidity shock.

It follows that when the bank is hit by a liquidity shock it will enter resolution if and only if

$$P(H) < F^0 + 1 \tag{35}$$

This condition implies that the bank cannot avoid resolution when it operates both subsidiaries because

$$P(S) - F^0 - 2 \leq P(H, m) + P(L, m) - F^0 - 2 < P(H, m) - F^0 - 1$$

where the first inequality follows from Expression (31) and the second inequality follows from $P(L, m) < 1$.

If the bank enters resolution the regulator chooses its financing structure to maximize its net present value. With and without a liquidity shock this corresponds to operating and monitoring both subsidiaries. However, following a liquidity shock the regulator can only finance the additional investment and ensure monitoring if $P(S, mm) > 2$. If this is not the case, the regulator still prefers to operate both subsidiaries and it can raise the required financing when $P(S, nm) > 2$.[12] As before the regulator bails in the minimum amount of exiting debt that allows it to implement the (constrained) efficient continuation. Hence, the existing creditors claims in resolution following a liquidity shock are given by

$$C(S) = \begin{cases} P(S, mm) - 2 & P(S, mm) > 2 \\ P(S, nm) - 2 & \text{otherwise} \end{cases}$$

If the bank enters resolution in the absence of a liquidity shock then the regulator can always choose a financing structure such that the bank will monitor both subsidiaries, and the existing creditors claims will be worth $P(S, mm)$.

Note, that that when the regulator operates both subsidiaries following a liquidity shock, then the existing creditors' payoff is smaller than in the case of an MPOE where the regulator only operates a high profit subsidiary. The reason is that in order to operate the low profit subsidiary the regulator must free up debt capacity of the high profit subsidiary in order to finance the low profit subsidiary. This decreases the value of the existing creditors' claims due to equity mispricing. Formally, if the regulator finances the banks such that it monitors both subsidiaries

$$P(S, mm) - 2 = \phi V(L, m) + P(H, m) - 2 < P(H, m) - 1 = C(M)$$

and if it only monitors the low profit subsidiary

$$P(S, nm) - 2 = P(H, n) + P(L, m) - 2 < P(H, n) - 1 < P(L, m) - 1 = C(M)$$

Put differently, when the high profit subsidiary doe not have sufficient free debt capacity following a liquidity shock it would be privately optimal to shut down the low profit subsidiary. However the regulator will recapitalize the bank such that it continues to operate both subsidiaries.

6.4. Date 0 Financing

At date 0 the bank chooses a financing structure in order to raise the required investment. The financing choices of a bank that only operates one subsidiary are discussed in the stand-alone cases. A bank that operates both subsidiaries must raise two units of financing. It chooses a financing structure that maximizes the profits of its initial owners, which are given by

$$\pi^0(S, \mathbf{F}^0) = (1-q)\max\{\pi^1(S, \mathbf{F}^0, nl), 0\} \\ + q\max\{\pi^1(S, \mathbf{F}^0, l), 0\} - \frac{1}{\phi}\max\{2 - D^0, 0\} \quad (36)$$

which is analogous to MPOE case.

The regulator will force the banks to continue its low profit subsidiary when it enters resolution following liquidity shock. This is not privately optimal and hence the bank

[12] We do not consider the case $\max P(S, \mu) < 2$, because it implies that the banks will never be able to finance the initial investment required to operate 2 subsidiaries.

has an incentive to avoid resolution. It then trades of this incentive with its incentive to reduce its reliance on mispriced equity financing outside of resolution. Thus two possible corner solutions describe the bank's optimal date 0 financing.

If the bank can avoid resolution with and without a liquidity shock then its date 0 debt is safe and the market value D^0 is given by its face value. While avoiding resolution, the bank still has an incentive to minimize its mispriced equity financing. To do so it maximizes the face value of its debt subject to Condition (35), which yields

$$F^0 = P(H, m) - 1.$$

If the bank is resolved following a liquidity shock then the market value of the bank's debt satisfies

$$D^0 = (1 - q)F^0 + qC(S)$$

As before the bank minimizes its equity financing, which will be achieved when the bank exclusively relies on debt financing, such that $D^0 = 2$. In this case we denote the face value of the SPOE's debt by $F^0(S)$, which is given by

$$F^0(S) \equiv \frac{2 - qC(S)}{1 - q} \tag{37}$$

Hence we obtain the following Lemma.

Lemma 11. *For an SPOE that operates both subsidiaries either of the following two date 0 financing structures is optimal*

1. *Choose a face value $F^0 = P(H, m) - 1$ and avoid resolution following a liquidity shock.*
2. *Rely only on debt financing with a face value $F^0(S)$ and resolve both subsidiaries following a liquidity shock.*

6.5. Choice of corporate structure.

The bank will only operate both subsidiaries if its initial owners obtain higher profits than when it operates only the high profit subsidiary. When at $t = 0$ financing is raised such that the bank avoids resolution following a liquidity its debt financing is limited to $P(H, m) - 1 < 1$ and hence, the bank must finance the low profit subsidiary with equity financing. This is not profitable because the financing costs exceed the value of the unlevered equity $\phi V(L, m) < P(L, m) < 1$. Hence, we show in the Appendix that if the bank chooses capital structure that avoids resolution, it can never make higher profits than if it only operates the high profit subsidiary.

If the bank does not avoid resolution following a liquidity shock then it optimally relies only on debt financing and the face value is given by Expression (37). The bank profits are then determined by its optimal monitoring decisions outside of resolution. Substituting $F^0(S)$ for I^1 in Expression (34) yields

$$(1 - \phi)(\frac{2 - qC(S)}{1 - q} - \bar{D}(H, n) > P(H, m) - P(H, n) \tag{38}$$

Hence, if the bank operates both subsidiaries, then outside of resolution it will monitor only the low profit subsidiary if and only if Conditions (33) and (38) are satisfied.

When the bank will monitor both subsidiaries in the absence of a liquidity shock, we show in the Appendix that it is profitable to operate both subsidiaries if and only if

$$(1-q)V(L,m) - 1 \geq q(C(H) - C(S)) + \frac{1-\phi}{\phi}(2 - qC(S) - (1-q)\bar{D}(H,m)) \quad (39)$$

The left-hand-side of this expression denotes the net present value that the low profit subsidiary's operation creates for the initial owners. Because the bank gets resolved following liquidity shock the subsidiary's cash flows only accrue to equity holder with probability $1-q$. The expected cost of investment in the low profit subsidiary is 1 because the equity holders will not pay for the additional investment following a liquidity shock. The first part of the right-hand-side is the increase in the banks financing cost due to the lower value of debt in resolution when the regulator operates both subsidiaries. The second part is the increase in cost of equity financing at date 1.

When the bank in the absence of a liquidity shock will monitor only the low profit subsidiary, we show in the Appendix that it is profitable to operate both subsidiaries if and only if

$$\begin{aligned}(1-q)V(L,m) - 1 + (1-q)(V(H,n) - V(H,m)) \geq q(C(H) - C(S)) \\ + \frac{1-\phi}{\phi}\Big(\max\{2 - qC(S) - (1-q)(\bar{D}(H,n) + \bar{D}(L,m)), 0\} \\ - \max\{1 - qC(H) - (1-q)\bar{D}(H,m), 0\}\Big) \quad (40)\end{aligned}$$

The additional term on the left-hand-side accounts for the decrease in the high profit subsidiary's cash flows when it engages in risk shifting. The difference on the right hand side accounts for the increased debt capacity that allows for less equity financing at date 1. Because the bank's choice of monitoring maximizes its profits we obtain the following Proposition.

Proposition 2. *The bank will operate both subsidiaries if and only if Condition (39) or (40) is satisfied. In this case the bank's profits are given by*

$$\pi^0(S) = V(H,\mu) + V(L,\mu) - \frac{2 - qC(S)}{1-q} - \frac{1-\phi}{\phi}\max\{\frac{2 - qC(S)}{1-q} - \bar{D}(S,\mu), 0\} \quad (41)$$

where $\mu = nm$ if and only if Conditions (33) and (38) hold, and otherwise $\mu = mm$.

7. Comparing MPE and SPE

7.1. The Bank's Preferences

From the initial owners point of view an MPOE dominates an SPOE. There are two reasons for this. First, the lack of limited liability of the banks' subsidiaries increases the risk shifting incentives for the high profits subsidiary, which can result in lower expected cash flows and higher financing costs due to a lower debt capacity.

Second, SPOE allows the regulator to operate the low profit subsidiary in resolution following liquidity shock. This is costly for he banks creditors because the low profit subsidiaries pledgeable income is too low to finance its continuation following a liquidity shock. Hence, the regulator will need to free up debt capacity of the high profit subsidiary at the cost of the bank's date 0 creditors. Since debt is fairly priced this cost will be ultimately borne by the bank's initial owners. Formally comparing the profit functions (25) an (41) then yields the following result.

Proposition 3. *The initial owners' profits are higher with MPOE than with SPOE.*

7.2. Welfare

As opposed to the initial owners' profits there is no clear welfare ranking between the two resolution regimes. An MPOE bank that operates both subsidiaries creates the following NPV

$$(1-q)(V(H,m)+V(L,m))+q(V(H,m)-1)-2 \tag{42}$$

The first term of this expression are the cash flows in the absence of liquidity shock, the second term are the net cash flows when the bank is hit by a liquidity shock and shuts down the low profit subsidiary, and the last term is the initial investment.

The NPV of an SPOE bank depends on whether it engages in risk shifting outside of resolution. If not, and it monitors both subsidiaries in the absence of liquidity shock, the NPV is given by

$$(1-q)(V(H,m)+V(L,m))+q(V(H,m)+V(L,m)-2)-2$$

The only difference compared to the MPOE is in the second term which accounts for the continuation of both subsidiaries following a liquidity shock. (Note that when the bank will monitor both subsidiaries outside of resolution the regulator can always ensure that the bank monitors both subsidiary following resolution.)

If the SPOE bank outside of resolution engages in risk shifting the NPV is given by

$$(1-q)(V(H,n)+V(L,m))+q(V(H,\mu_H^R)+V(L,\mu_L^R)-2)-2 \tag{43}$$

In this case the expected cash flows of the high profit subsidiary in the absence of a liquidity shock are only $V(H,n)$. In addition the regulator can only ensure that the bank monitors both subsidiaries following a liquidity shock and resolution if $P(S,mm) \geq 2$. In this case the regulator will ensure $\mu^R = mm$ and otherwise $\mu^R = nm$.

If an SPOE bank enters resolution the regulator's decision to continuation the low profit subsidiary is efficient. Hence, an SPOE that operates and monitors both subsidiaries will create higher welfare than an MPOE.

This changes when either the SPOE will not operate both subsidiaries or engage in risk shifting outside of resolution. First, because the SPOE's profits are lower it is possible that an SPOE would not be willing to operate both subsidiary while an MPOE would. This happens when

$$\pi^0(M, F^0(M)) \geq \pi^0(H, F^0(H)) > \pi^0(S, F^0(S)) \tag{44}$$

in which case the welfare of MPOE is higher. The relevant conditions that determine when these inequalities are referenced in Propositions 1 and 2.

Second, even if an SPOE operates both subsidiaries it sometimes engages in risk shifting outside of resolution. Comparing Expressions (42) and (43) one can show that the welfare generated by MPOE is higher if and only if

$$(1-q)(V(H,m) - V(H,n) > q(V(L,m) - 1) \\ - q \begin{cases} V(Hm) - V(H,n) & P(S,mm) \geq 2 \\ 0 & P(S,mm) < 2 \end{cases} \tag{45}$$

The left-hand-side of this condition is the difference in expected cash flows outside of resolution and the right-hand-side is the difference in the expected cash flows in resolution following a liquidity shock. Summarizing this discussion we obtain the following Proposition.

Proposition 4. *An MPOE bank creates a higher expected NPV than an SPOE bank if and only if Condition (44) holds or Conditions (33), (38), and (45) hold.*

8. Discussion

8.1. Required Bail-in

When banks optimally choose their date 0 capital structure they enter resolution. In resolution the regulator then expropriates the bank's equity holders and date 0 creditors. The difference between the face value of the bank's debts and the value of their claims following resolution is given by $F^0 - C(c^0)$, where c^0 denotes the banks corporate structure and resolution regime at date 0. Hence, the regulator needs the ability to reduce the creditors claims by a share

$$\frac{F^0 - C(c^0)}{F^0}$$

of the bank's date 0 debt's face value. Since $C(M) > C(S)$ it follows that for any given face value F^0 the share of bail-inable debt is higher with SPOE than MPOE. The reason is that with SPOE the regulator ensures the efficient continuation of the low profit subsidiary, which lacks the pledgeable income to operate as stand-alone banks. To do so the regulator needs to impose additional losses on the SPOE's creditors, resulting in larger bail-in. If conversely the share of bailable debt would be $\frac{F^0 - C(M)}{F^0}$, then the regulator could not continue the low profit unit following a liquidity shock, destroying the SPOE's benefits.

8.2. Bail-outs

When the regulator fails to ensure the efficient continuation of a banks subsidiaries following a liquidity shock this could be remedied by providing public funds in a bail-out. This will not be optimal however when the shadow cost of public funds is high. First, consider the case of an MPOE. In order to continue the low profit subsidiary following a liquidity shock the regulator would need to inject public funds $1 - P(L, m)$, which generates a surplus of $V(L, m) - 1$. Hence, providing a public bail-out for the resolution of an MPOE will be inefficient if and only if the shadow cost of public funds θ satisfies

$$\theta(1 - P(L, m)) > V(L, m) - 1$$

Second, in case of an SPOE the regulator fails to implement the efficient monitoring of both subsidiaries if $P(S, mm) < 2$. In this case the regulator need to provide public funds $2 - P(S, mm)$ and generates and additional surplus of $V(S, mm) - V(S, nm)$. Hence, providing such a public bail-out for the resolution of an SPOE will be inefficient if and only if the shadow cost of public funds θ satisfies

$$\theta(2 - P(S, mm)) > V(S, mm) - V(S, nm)$$

9. Resilience

To analyze banks' resilience following a liquidity shock we consider less severe liquidity shocks that only require an additional investment of $\rho < 1$ to continue each subsidiary. We analyze how a bank's resolution regime affects a banking group's ability to withstand such a liquidity shock given the bank's optimal date 0 financing choices. We call a bank resilient if following a liquidity no part of the banking group enters resolution and all operating subsidiaries continue their operations. The second part of this definition excludes SPOE banks who may find it profitable to shut down their low profit subsidiary without defaulting on any of their debts rather than enter resolution.[13]

9.1. Stand alone high profit subsidiary

If at $t = 1$ a stand alone bank is hit by a liquidity shock of size ρ it will avoid resolution if and only if

$$P(H, m) \geq F^0 + \rho. \tag{46}$$

In this case the bank's profits are given by the profit function (9), where $I^1 = F^0 + \rho$. In resolution the regulator will continue the bank's operations since $\rho < 1$. If the bank enters resolution creditors claims will thus be worth

$$C^{\rho}(H) = P(H, m) - \rho.$$

[13] We have discussed this case at the beginning of in Section 6.3.

If at $t = 0$ a bank is financed such that it avoid resolution following a liquidity shock, the market value of its date 0 debt is given by $D^0 = F^0$ and if it enters resolution following a liquidity shock its market value is given by

$$D^0 = (1 - q)F^0 + q(P(H, m) - \rho).$$

The profits of the banks initial owners are given by Expression (10) where π^1 is given by Expression (9) and $I^1 = F^0 + \mathbb{I}_\lambda \rho$. Substituting into Expression (10) shows that the initial owners profits are strictly increasing in F^0 if and only if

$$F^0 < \bar{D}(H, m) \wedge D^0 < 1.$$

The first condition follows from the fact that increasing F^0 only decreases the bank's use of equity financing if there is free debt capacity at $t = 0$. The second condition follows from the the fact that the bank's never needs to raise more funding than it needs to finance its investment.

If the bank avoids resolution $D^0 = F^0$. It thus follows from Condition (46) that it is optimal for the bank to avoid resolution following a liquidity shock if

$$P(H, m) - \rho \geq \bar{D}(H, m) \vee P(H, m) - \rho \geq 1$$

Since $\bar{D}(H, m) > 1$ the bank's debt capacity will never constrain the bank's ability to rely on debt financing in the absence of liquidity shock. Hence, it is strictly optimal to finance the bank's initial investment entirely with debt. It follows that a bank is resilient to liquidity shocks if the remaining pledgeable income exceeds the size of the liquidity shock, which yields the following Lemma.

Lemma 12. *A stand alone high profit bank optimally avoids resolution following a liquidity shock ρ if and only if*

$$\rho \leq P(H, m) - 1$$

9.2. MPOE

The bank's decisions to avoid resolution of its subsidiaries are analogous to the conditions in Section 5.3. Following a liquidity shock an MPOE bank group will avoid resolution if and only if it can profitably operate both subsidiaries

$$P(H, m) + P(L, m) \geq F^0 + 2\rho. \tag{47}$$

and it is less profitable to default on the debt of one subsidiary i and only operate the other subsidiary i^c

$$V(i, m) - F_i^0 - \mathbb{I}_\lambda \rho \geq \frac{1 - \phi}{\phi}[\max\{F^0 + 2\mathbb{I}_\lambda \rho - \bar{D}(H, m) - \bar{D}(L, m), 0\} - \max\{F_{i^c}^0 + F_J^0 + \mathbb{I}_\lambda \rho - \bar{D}(i^c, m), 0\}]. \tag{48}$$

When subsidiary i enters resolution the regulator always prefers to continue the subsidiary because the NPV is positive. The regulator can raise sufficient financing to operate the subsidiary if and only if $P(i, m) \geq \rho$. Hence, creditor's claims on a subsidiary i that enters resolution will be worth

$$C^{\rho}(i) = \max\{P(i, m) - \rho, 0\}$$

Using the same argument as in Section 5.4 it is optimal to choose a financing structure that minimize the bank's use of equity financing. We are going to focus on the case where the bank's date 1 debt capacity will limit the amount of debt financing that the bank can raise to finance its investments

Assumption 5. *The debt capacities satisfy* $\bar{D}(H, m) + \bar{D}(L, m) < 2$.

Since $D^0 \leq F^0$ this assumption implies that that the bank will optimally use its entire date 1 debt capacity,

$$F^0 \geq \bar{D}(H, m) + \bar{D}(L, m)$$

Hence, the lowest debt level that allows the banks to use its entire debt capacity satisfies (47) if and only if

$$2\rho \leq P(H, m) + P(L, m) - \bar{D}(H, m) - \bar{D}(L, m) \tag{49}$$

A bank's resilience thus positively depends on the income it does not pledge as debt. Since an MPOE always maximizes the amount of debt financing it uses at date 1, its resilience decreases in the debt capacity.

When Condition (49) is satisfied then Condition (48) can be rewritten as

$$V(i, m) - F_i^0 - \mathbb{I}_{\lambda}\rho < \frac{1-\phi}{\phi}[F^0 + 2\mathbb{I}_{\lambda}\rho - \bar{D}(H, m) - \bar{D}(L, m) - \max\{F_{i^c}^0 + F_J^0 + \mathbb{I}_{\lambda}\rho - \bar{D}(i^c, m), 0\}].$$

For a constant level of $F^0 = \bar{D}(H, m) + \bar{D}(L, m)$ this condition is least binding when the entire date 0 debt is issued by the holding company such that $F_J^0 = F^0$, because it minimizes the bank's incentives to default on the debt of single subsidiary. Substituting this debt structure back into the condition yields $\rho \leq P(i, m)$. Clearly this constraint will be more binding for the low profit subsidiary

$$\rho \leq P(L, m) \tag{50}$$

Hence, the low profit subsidiary's pledgeable income must be higher than the required reinvestment in case of liquidity. There are no financing synergies when a liquidity shock occurs, because the entire debt capacity of the firm will be used to repay the maturing debt F^0.

Choosing $F_J^0 = F^0$ will be optimal because it ensures that the bank always uses the maximum amount of debt financing to repay the maturing debt. We thus obtain the following Lemma.

Lemma 13. *It is optimal for an MPOE bank to avoid the resolution of both subsidiaries following a liquidity shock ρ if and only if Conditions (49) and (50) are satisfied.*

If $P(H, m) < \bar{D}(H, m) + \bar{D}(L, m)$ then only condition (49) is binding for $\rho > 0$.

9.3. SPOE

We focus on the case when the bank will engage in risk shifting if its financing need is high enough and again assume that the bank's debt capacity will limit its debt financing.

Assumption 6. *The debt capacities satisfy condition (33) and* $\bar{D}(H,n) + \bar{D}(L,m) < 2$.

This assumption implies that when a bank operates both subsidiaries it will engage in risk shifting when its pledgeable income is not too much larger than its financing need. Hence, the bank can avoid resolution if and only if F^0 is smaller or equal than

$$\max\{P(H,n) + P(L,m) - 2\rho, P(H,m) - \rho\}. \tag{51}$$

The first component of the maximum term describes the solvency constraint of a bank that operates both subsidiaries and engages in risk shifting and the second component describes the solvency constraint of a bank that only operates the high profit subsidiary.

When the bank enters resolution then analogous to Section 6.3 the regulator will choose financing structure such that the monitoring decision of the high profit subsidiary is given by

$$r_H = \begin{cases} m & P(H,m) + P(L,m) \geq 2\rho \\ n & \text{otherwise} \end{cases}$$

Upon resolution the payoff of the bank's creditors is thus given by $P(S, r_H m) - 2\rho$.

We will first analyze the incentives of a bank that avoids resolution to continue both subsidiaries following a liquidity shock.

Lemma 14. *An SPOE bank that chooses an optimal debt structure that avoids resolution will operate both subsidiaries following a liquidity shock if and only if*

$$P(L,m) - (P(H,m) - P(H,n)) \geq \rho. \tag{52}$$

Intuitively this condition state that the increase in the banks pledgeable income from operating the low profit subsidiary must be larger than the cost of continuing the low profit subsidiary. The increase in the pledgeable income must take into account the inefficient risk taking that ensues when the SPOE bank operates both subsidiaries.

In a second step we will now analyze a banks incentives to choose $\mathbf{F}^0$ such that it avoids resolution following a liquidity shock when condition (52) is satisfied. The bank has an incentive to avoid resolution when the regulator upon resolution chooses a financing structure that implements different monitoring decisions than the privately optimal ones.

Lemma 15. *It is optimal for an SPOE bank to avoid the resolution and continue both subsidiaries following a liquidity shock if and only if condition (52) holds and*

$$q(P(H,n) + P(L,m) - P(S, r_H)) \\ \geq (1-\phi)\Big(2\rho + \bar{D}(H,n) + \bar{D}(L,m) - P(H,n) - P(L,m)\Big) \tag{53}$$

This condition results from comparing the profits of bank when it does or does not avoid resolution following liquidity shock of size ρ. The left-hand-side of this expression describes the gains from avoiding the regulator implementing a different monitoring decision after resolution, which reduces the bank's pledgeable. The right-hand-side of this expression describes the potential costs of avoiding resolution.

The bank will avoid resolution when the associated increase in financing costs is sufficiently small. When the bank needs to forgo debt financing at date 0 in order to avoid resolution following liquidity shock, then the right-hand side is positive. When the bank can withstand a liquidity shock even when its pledges its entire date 1 debt capacity as date 0 debt, then avoiding resolution is not costly. In this case the right-hand side is negative and the condition will always be satisfied.

9.4. Comparing MPOE and SPOE

The relative resilience of MPOE and SPOE banks is ambiguous. First, consider banks' incentives to choose debt levels that allow them to continue both subsidiaries following a liquidity shock such that Conditions (49) and (53) are satisfied. An SPOE has greater incentives to avoid resolution when the regulator will change its monitoring decisions in resolution. But when the SPOE exhausts its ability to raise debt financing at date 1 the remaining free pledgeable income is lower than for an MPOE, because the high profit subsidiary will engage in risk shifting and $P(H, n) = \bar{D}(H, n) = V(H, n)$.

Second, consider the banks incentive to continue the low profit subsidiary following a liquidity shock such that conditions (50) and (52) are satisfied. Operating the low profit subsidiary with an SPOE leads to risk shifting of the high profit subsidiary. Hence, the SPOE is more likely to shut down its low profit subsidiary following a liquidity shock. The MPOE's ability to default only of the debt of its low profit subsidiary does not matter when the bank chooses an optimal debt structure that maximizes resilience. The reason is that debt is fairly priced and its price internalizes any expected default. The relative importance of these effects determines whether in equilibrium an SPOE or an MPOE will be able to continue both subsidiaries.

10. Conclusions

This paper addresses the potential costs and benefits of the MPOE and the SPOE bank resolution regimes. The SPOE allows for socially efficient continuation of banking units following liquidity shocks that would be closed down under the MPOE. Moreover, the SPOE provides banks with stronger incentives to choose capital structures that avoid resolution following liquidity shocks. These advantages can explain why most regulators in practices seem to favor the SPOE resolution.

However, we also document some potential drawbacks of the SPOE resolution. The SPOE resolution reduces the monitoring incentives of low risk units, which reduces the bank's expected payoffs and pledgeable income. The reduction of pledgeable income can prevent the formation of efficient banking groups and reduces bank's ability to avoid resolution. These drawbacks question regulators' apparent preference for the SPOE resolution plans.

A. Proofs^

A.1. General Results

Let c^t denote a bank's choice of corporate structure and resolution regime at date t.

Lemma 16. *If for two monitoring decisions μ and μ' $P(c^1, \mu) > V(c^1, \mu')$, then the expected date 1 profits satisfy*

$$\pi^1(c^1, \mu; c^0, \mathbf{F}^0, \lambda) > \pi^1(c^1, \mu'; c^0, \mathbf{F}^0, \lambda) \forall F^0, \lambda$$

Proof. From the definition of $P(c^1, \mu)$ it follows that $V(c^1, \mu) \geq P(c^1, \mu)$. Since the the expected cash flow is higher with monitoring μ than μ' the profits with monitoring μ' can only be higher if the financing cost with monitoring μ would be sufficiently higher.

The financing costs associated with μ can only be higher than for μ' if $\bar{D}(c^1, \mu) < \bar{D}(c^1, \mu')$ and $I^1 > \bar{D}(c^1, \mu)$. In this case the profits associated with μ are

$$\pi^1(c^1, \mu; c^0, \mathbf{F}^0, \lambda) = V(c^1, \mu) - \bar{D}(c^1, \mu) - \frac{1}{\phi}(I^1 - \bar{D}(c^1, \mu))$$
$$= \frac{1}{\phi}(P(c^1, \mu) - I^1)$$

and the profits of associated with μ' satisfy

$$\pi^1(c^1, \mu'; c^0, \mathbf{F}^0, \lambda) \leq V(c^1, \mu) - I^1$$

The Lemma then follows from $P(c^1, \mu) > V(c^1, \mu')$ and $\phi < 1$. □

A.2. High-profit single-unit bank

Proof of Lemma 1. When the bank chooses not to monitor its loans then then it follows from Expression (4) that the equity holders' profits are

$$V(H, n) - I^1.$$

Cleary for $\bar{D}(H, m) \geq I^1$ it follows from Expression (6) that equity holders profits are higher with monitoring because $V(H, m) > V(H, n)$. For $\bar{D}(H, m) < I^1$ it follows from Expressions (4) and (7) that the equity holders profits with monitoring is given by

$$\frac{1}{\phi}(P(H, m) - I^1)$$

It then follows from Assumption 2, Expression (5), and $\phi < 1$ that

$$\frac{1}{\phi}(P(H, m) - I^1) > \frac{1}{\phi}(P(H, n) - I^1) = \frac{1}{\phi}(V(H, n) - I^1) > V(H, n) - I^1.$$

□

A.3. MPOE

Proof of Lemma 4. If the MPE only operates only one subsdiary it becomes a stand alone bank and hence, Lemma 1 and equivalent arguments for a low profit subsidiary imply that the bank will monitor that subsidiary

If the MPE operates both subsidiaries, then monitoring both subsidiaries maximizes the expected cash flows. Hence the equity holder's profits from another monitoring decision $\mu' \neq mm$ can only be higher if this results in lower funding costs. Such lower funding costs are only possible if $\bar{D}(M, mm) < \bar{D}(M, \mu')$ and $I^1 > \bar{D}(M, mm)$. In this cases the profits associated with monitoring both subsidiaries are given by

$$\begin{aligned}\pi^1(M, mm; M, \mathbf{F}^0, \lambda) &= V(H,m)+V(L,m)-\bar{D}(H,m)-\bar{D}(L,m)-\frac{1}{\phi}(I^1-\bar{D}(H,m)-\bar{D}(L,m)) \\ &= \frac{1}{\phi}(P(H,m)+P(L,m)-I^1)\end{aligned}$$

If the MPE does not monitor both subsidiaries ($\mu' \neq mm$) equity holder's profits satisfy

$$\pi^1(M, \mu'; M, \mathbf{F}^0, \lambda) = \begin{cases} V(H,\mu'_H)+V(L,\mu'_L)-I^1 & \bar{D}(H,\mu'_H)+\bar{D}(L,\mu'_H) \geq I^1 \\ \frac{1}{\phi}(P(H,\mu'_1)+P(L,\mu'_L)-I^1) & \bar{D}(H,\mu'_H)+\bar{D}(L,\mu'_H) < I^1 \end{cases}$$

If $\bar{D}(H, \mu'_H) + \bar{D}(L, \mu'_L) \geq I^1$, then monitoring both subsidiaries maximizes the equity holder's profits if

$$\frac{1}{\phi}(P(H,m)+P(L,m)-I^1) \geq V(H,\mu'_H)+V(L,\mu'_L)-I^1$$

Rearrangement of terms then yields

$$P(H,m)+P(L,m)-P(H,\mu'_H)-P(L,\mu'_L) \geq (1-\phi)(I^1-\bar{D}(H,\mu'_H)-\bar{D}(L,\mu'_L))$$

The left-hand-side of this condition is always positive because monitoring maximizes the pledgeable income of both subsidiaries. The right hand side of this condition is always negative because $\bar{D}(H, \mu'_1) + \bar{D}(L, \mu'_1) \geq I^1$, and hence, the condition will always be satisfied.

If $\bar{D}(H, \mu'_H) + \bar{D}(L, \mu'_L) < I^1$, then monitoring both subsidiaries maximizes the equity holder's profits if

$$\frac{1}{\phi}(P(H,m)+P(L,m)-I^1) \geq \frac{1}{\phi}(P(H,\mu'_1)+P(L,\mu'_L)-I^1)$$

This Condition is always satisfied because monitoring maximizes the pledgeable income of both subsidiaries □

Proof of Proposition 1. Since $\pi^0(L) < 0$ the MPOE will operate both subsidiaries if and only if $\pi^0(M) \geq \pi^0(H)$. From Lemma 7 it follows that the initial owners' profit of an MPOE that operates both subsidiaries is given by

$$\pi^0(M) = (1-q)(V(H,m)+V(L,m)-F^0(M)-\frac{1-\phi}{\phi}\max\{F^0(M)-\bar{D}(H,m)-\bar{D}(L,m),0\})$$

where

$$F^0(M) \equiv \frac{2 - q(P(H,m) - 1)}{1 - q}$$

and the profit of a stand alone high profit subsidiary creates profits

$$\pi^0(H) = (1-q)(V(H,m) - F^0(H) - \frac{1-\phi}{\phi}\max\{F^0(H) - \bar{D}(H,m), 0\})$$

where

$$F^0(H) \equiv \frac{1 - q(P(H,m) - 1)}{1 - q}$$

Because $\pi^0(H) \leq (1-q)(V(H,m) - F^0(H))$ it follows that an MPE conglomerate will operate both subsidiaries if

$$\pi^0(M) > (1-q)(V(H,m) - F^0(H))$$

Rearrangement of term then yields Condition (27) and the if part of the Lemma.

To prove the only if part remember that $P(L,m) < 1 \Rightarrow \bar{D}(L,m) < 1$. Hence, if $F^0(H) > \bar{D}(H,m)$, $F^0(M) > \bar{D}(H,m) + \bar{D}(L,m)$ and

$$\pi^0(M) = \pi^0(H) + (1-q)(V(L,m) - \frac{1}{1-q} - \frac{1-\phi}{\phi}(\frac{1}{1-q} - \bar{D}(L,m)) < \pi^0(H)$$

where the inequality follows from $P(L,m) < 1$. It follows that the MPOE will operate both subsidiary only if $F^0(H) > \bar{D}(H,m)$, in which case Condition (27) determines whether operating the low profit subsidiary is profitable. □

Proof of Lemma 8 . From Lemma 5 it follows that if the bank resolves a subsidiary if it is not hit by a liquidity shock then it will it will also resolve that subsidiary following a liquidity shock.

Consider the different possible cases. First, if absent a liquidity shock, the bank resolves all subsidiaries it operates, then it always resolves the entire bank. Hence, the initial owners profits are 0. Clearly this cannot be optimal because the bank can make positive profits if it only operates the high profit subsidiary.

Second, consider a bank that resolves its low profit subsidiary but not its high profit subsidiary in the absence of a liquidity shock. Sine the low profit subsidiary doe not continue its operation following a liquidity shock the market value of its debt is given by

$$D_L^0 = qP(L,m)$$

and the face values of the other debt claims must satisfy

$$F_H^0 + F_J^0 \leq P(H,m).$$

The profit of the bank's initial owner is then given by

$$(1-q)(V(H,m)-\max\{F_H^0+F_J^0,\frac{1}{\phi}(F_H^0+F_J^0-(1-\phi)\bar{D}(H,m)\})$$
$$+q\max\{V(H,m)-\max\{F_H^0+F_J^0+1,\frac{1}{\phi}(F_H^0+F_J^0+1-(1-\phi)\bar{D}(H,m))\},0\}$$
$$-\frac{1}{\phi}(2-D^0)$$

Suppose now that the bank issues debt $F_L^0 = P(L,m)$, which implies that the low profit subsidiary does not get resolved if there is no liquidity shock. However, the market values of all debt claims remain unchanged and equity holders still never receive payouts from the low profit subsidiary. Hence the initial owners' profits remain unchanged.

Third, consider a bank that resolves its high profit subsidiary but not its low profit subsidiary in the absence of a liquidity shock. Since the high profit subsidiary continues its operation even even in case of a liquidity shock the market value of its debt is given by

$$D_H^0 = P(H,m) - q$$

and the face values of the other debt claims must satisfy

$$F_L^0 + F_J^0 \leq P(L,m)$$

The profit of the bank's initial owner is then given by

$$(1-q)(V(L,m)-\max\{F_L^0+F_J^0,\frac{1}{\phi}(F_L^0+F_J^0-(1-\phi)\bar{D}(L,m))\})-\frac{1}{\phi}(2-D^0)$$

Similarly to before issuing debt $F_H^0 = P(H,m)$ implies that the high profit subsidiary does not get resolved if there is no liquidity shock but does not change the market values of all debt claims. Hence the initial owners' profits remain unchanged.

It follows that it is weakly optimal to choose a date 0 financing structure such that the bank will continue both subsidiaries in the absence of a liquidity shock. □

A.4. SPOE

Proof of Lemma 9. If Condition (29) is satisfied the the debt is safe, which yields first case of Expression (31).

If Condition (29) is not satisfied and Condition (30) is satisfied the market value of the banks debt is $(1-p_B)F^1$. If Condition (30) is not satisfied the bank cna pledge its entire cash flows as debt. Together this yields the second case of Expression (31). □

Proof of Lemma 10. Clearly the bank will not monitor the high profit subsidiary if and only if

$$\pi^1(S,nm;S,\mathbf{F}^0,\lambda) > \pi^1(S,mm;S,\mathbf{F}^0,\lambda)$$

Substituting Expression 31 for $\bar{D}(S, mm)$ and $\bar{D}(S, nm)$ and rearrangement of terms, yields

$$\frac{1-\phi}{\phi}(\max\{I^1(r^1; S, \mathbf{F}^0, \lambda) - \bar{D}(H, m), 0\} - \max\{I^1(r^1; S, \mathbf{F}^0, \lambda) - \bar{D}(H, n) - \bar{D}(L, m), 0\}) > V(H, m) - V(H, n) \quad (54)$$

Since $V(H, m) - V(H, n) > 0$, Condition (54) is satisfied if and only if either

$$I^1 > \bar{D}(H, n) + \bar{D}(L, m)$$

and

$$\frac{1-\phi}{\phi}(\bar{D}(H, n) + \bar{D}(L, m) - \bar{D}(H, m), 0\}) > V(H, m) - V(H, n)$$

or

$$I^1 \leq \bar{D}(H, n) + \bar{D}(L, m)$$

and

$$\frac{1-\phi}{\phi}(I^1 - \bar{D}(H, m)) > V(H, m) - V(H, n)$$

The first two Conditions can be rewritten as

$$\frac{1-\phi}{\phi}(I^1 - \bar{D}(H, m)) > \frac{1-\phi}{\phi}(\bar{D}(H, n) + \bar{D}(L, m) - \bar{D}(H, m)) > V(H, m) - V(H, n)$$

and the last two Conditions can be rewritten as

$$\frac{1-\phi}{\phi}(\bar{D}(H, n) + \bar{D}(L, m) - \bar{D}(H, m)) \geq \frac{1-\phi}{\phi}(I^1 - \bar{D}(H, m)) > V(H, m) - V(H, n)$$

These Condition's are satisfied if and only if

$$\frac{1-\phi}{\phi}(\bar{D}(H, n) + \bar{D}(L, m) - \bar{D}(H, m)) > V(H, m) - V(H, n)$$

and

$$\frac{1-\phi}{\phi}(I^1 - \bar{D}(H, m)) > V(H, m) - V(H, n)$$

It follows that Condition (54) is satisfied if and only if the Conditions of the Lemma are satisfied. □

Proof of Lemma 11. We separately prove the Lemma's two parts.

Part 1: From Condition (35) it follows that the bank avoids resolution if and only if $F^0 \leq P(H; S, \mathbf{F}^0, l) - 1$. In this case all its debts $\mathbf{F}^0$ are save debt and the initial owners' profits are given by

$$\pi^0(S, \mathbf{F}^0) = (1-q)\pi^1(S, F^0, nl) + q\pi^1(S, F^0, l) - \frac{1}{\phi}(2 - F^0)$$

Substituting for the profit functions and simple algebra shows that this expression is increasing in F^0 and hence, it is optimal to choose $F^0 = P(H) - 1$.

Part 2: We only need to consider debt levels $F^0 > P(H; S, \mathbf{F}^0, l) - 1$. It this case the the bank will enter resolution following a liquidity shock and hence and hence, the value of the bank initial debt satisfies

$$D^0 = (1-q)F^0 + qC(S) \tag{55}$$

The initial owners' profits are then given by

$$\pi^0(S, \mathbf{F}^0) = (1-q)\pi^1(S, F^0, nl) - \frac{1}{\phi}(2 - D^0)$$

Substituting for the profit functions and simple algebra[14] shows that this expression is increasing in F^0 and hence, it is optimal to choose $D^0 = 2$. Expression (37) then follows from substituting $D^0 = 2$ into Expression (55). □

Proof of Proposition 2. The bank will operate both subsidiaries if and only if higher profit than when it operates only the high profit subsidiary. We will now consider three possibly cases

Case 1. An SPOE bank that operates both subsidiaries and finances such that it avoids resolution following a liquidity shock. From Lemma 11 it follows that $F^0 = P(H, m) - 1$. Since, $P(H) \geq P(S)$ it follows that $\pi^1(S, F^0, l) = 0$ and the initial owners' profits are given by

$$\pi^0(S, \mathbf{F}^0) = (1-q)\pi^1(S, F^0, nl) - \frac{1}{\phi}(3 - P(H))$$

Consider the following relationship

$$\begin{aligned}\pi^0(S, F^0) &\leq (1-q)(V(H, m) - V(L, m) - (P(H) - 1)) - \frac{1}{\phi}(3 - P(H)) \\ &< (1-q)(V(H, m) - V(L, m)) - \frac{1}{\phi}2 < (1-q)V(H, m) - \frac{1}{\phi} < \pi^0(H)\end{aligned}$$

The first inequality follows from Assumption 1 and the construction of π^0, the second inequality follows from $(1-q) < \frac{1}{\phi}$, the third inequality follows from $P(L, m) < 1$, and the last inequality again follows from the construction of π^0. It follows that it is never optimal to operate both subsidiaries and avoid resolution because initial owners' profits are higher when they operate only the high profit subsidiary.

Case 2. An SPOE bank that operates both subsidiaries, finances such that enters resolution following a liquidity shock, and monitors both subsidiaries outside of resolution. Such a bank has higher profits than if it only operates the high profit subsidiary if and only if

$$\pi^1(S, mm; S, \frac{2 - qC(S)}{1-q}, nl) \geq \pi^1(H, m; H, \frac{1 - qC(H)}{1-q}, nl)$$

[14]Note that $\partial\pi^1(c, \mu; M, \mathbf{F}^0, nl)/\partial F^0 \leq -\frac{1}{\phi}\forall c, \mu$.

This condition can be rewritten as

$$V(H,m)+V(L,m)-\frac{2-qC(S)}{1-q}-\frac{1-\phi}{\phi}\max\{\frac{2-qC(S)}{1-q}-\bar{D}(H,m),0\}$$
$$\geq V(H,m)-\frac{1-qC(H)}{1-q}-\frac{1-\phi}{\phi}\max\{\frac{1-qC(H)}{1-q}-\bar{D}(H,m),0\}$$

Since $\frac{2-qC(S)}{1-q}>2>\bar{D}(H,m)$ this condition is satisfied if and only if

$$V(L,m)-\frac{1}{\phi}\frac{2-qC(S)}{1-q}+\frac{1-\phi}{\phi}\bar{D}(H,m)$$
$$+\frac{1-qC(H)}{1-q}+\frac{1-\phi}{\phi}\max\{\frac{1-qC(H)}{1-q}-\bar{D}(H,m),0\}\geq 0$$

When $\frac{1-qC(H)}{1-q}>\bar{D}(H,m)$ this condition can be rewritten as

$$\phi V(L,m)\geq\frac{1+q(C(H)-C(S))}{1-q}\geq 0$$

which cannot hold because $C(H)>C(S)$ and $\phi V(L,m)<1$. When $\bar{D}(H,m)>\frac{1-qC(H)}{1-q}$ this condition can be rewritten as Condition (39). Since $\phi V(L,m)<1$ and $C(H)\geq C(S)$ Condition (39) will only be satisfied when $\bar{D}(H,m)>\frac{1-qC(H)}{1-q}$ which yields the first part of the Propostion.

Case 3. An SPOE bank that operates both subsidiaries, finances such that enters resolution following a liquidity shock, and only monitors the low profit subsidiary outside of resolution. Such a bank has higher profits than if it only operates the high profit subsidiary if and only if

$$\pi^1(S,nm;S,\frac{2-qC(S)}{1-q},nl)\geq\pi^1(H,m;H,\frac{1-qC(H)}{1-q},nl)$$

Substituting for π^1yields

$$V(S,nm)-\frac{2-qC(S)}{1-q}-\frac{1-\phi}{\phi}\max\{\frac{2-qC(S)}{1-q}-\bar{D}(S,nm),0\}$$
$$\geq V(H,m)-\frac{1-qC(H)}{1-q}-\frac{1-\phi}{\phi}\max\{\frac{1-qC(H)}{1-q}-\bar{D}(H,m),0\}$$

which can be rewritten as Condition (40).

Because the bank's choice of monitoring maximizes its profits it will operate both subsidiaries if either Condition (39) or (40) is satisfied. □

A.5. Comparing MPOE and SPOE

Proof of Proposition 3. Consider banking groups that operate both subsidiaries. The profit of an SPOE bank is given by $\pi^0(S,F^0(S))=\max_\mu(1-q)\pi^1(S,\mu,S,F^0(S),nl)$ and the profit of an MPOE bank is given by $\pi^0(M,F^0(M))=(1-q)\pi^1(M,mm,M,F^0(M),nl)$.

First, Consider an SPOE bank that monitors both subsidiaries in the absence of a liquidity shock. The profits in the absence of a liquidity shock satisfy

$$\begin{aligned}
&\pi^1(S, mm, S, F^0(S), nl) = \\
&\quad V(H,m) + V(L,m) - \frac{2 - qC(S)}{1-q} - \frac{1-\phi}{\phi}\max\{\frac{2-qC(S)}{1-q} - \bar{D}(H,m), 0\} \\
&\leq V(H,m) + V(L,m) - \frac{2-qC(H)}{1-q} - \frac{1-\phi}{\phi}\max\{\frac{2-qC(H)}{1-q} - \bar{D}(H,m) - \bar{D}(L,m), 0\} \\
&\qquad = \pi^1(M, mm, M, F^0(M), nl)
\end{aligned}$$

where the inequality follows from $C(H) > C(S)$ and $\bar{D}(L,m) \geq 0$. It follows that the profits of an MPOE bank are higher.

Second, consider an SPOE bank that only monitors low profit subsidiaries in the absence of a liquidity shock. For $F^0(M) \geq \bar{D}(H,m) + \bar{D}(L,m)$ the profits in the absence of a liquidity shock satisfy

$$\begin{aligned}
&\pi^1(S, nm, S, F^0(S), nl) = \\
&\quad V(S,nm) - \frac{2-qC(S)}{1-q} - \frac{1-\phi}{\phi}\max\{\frac{2-qC(S)}{1-q} - \bar{D}(S,nm), 0\} \\
&\quad \leq V(L,m) + V(H,n) - \frac{1}{\phi}\frac{2-qC(S)}{1-q} - \frac{1-\phi}{\phi}\bar{D}(S,nm) \\
&= \frac{1}{\phi}(P(L,m) + P(H,n) - \frac{2-qC(S)}{1-q}) \leq \frac{1}{\phi}(P(L,m) + P(H,m) - \frac{2-qC(H)}{1-q}) \\
&= V(H,m) + V(L,m) - \frac{2-qC(H)}{1-q} - \frac{1-\phi}{\phi}\max\{\frac{2-qC(H)}{1-q} - \bar{D}(H,m) - \bar{D}(L,m), 0\} \\
&\qquad = \pi^1(M, mm, M, F^0(M), nl)
\end{aligned}$$

where the second inequality follows from $C(H) > C(S)$ and $P(H,m) > P(H,n)$.

For $F^0(M) < \bar{D}(H,m) + \bar{D}(L,m)$ the profits in the absence of a liquidity shock satisfy

$$\begin{aligned}
&\pi^1(S, nm, S, F^0(S), nl) = \\
&\quad V(S,nm) - \frac{2-qC(S)}{1-q} - \frac{1-\phi}{\phi}\max\{\frac{2-qC(S)}{1-q} - \bar{D}(S,nm), 0\} \\
&\leq V(L,m) + V(H,n) - \frac{2-qC(S)}{1-q} \leq V(H,m) + V(L,m) - F^0(M) \\
&\qquad = \pi^1(M, mm, M, F^0(M), nl)
\end{aligned}$$

It follows that the profits of an MPOE bank are higher.

Because both types of banks make the same profits if they only operate a single subsidiary and choose their corporate structure to maximize their profits, the above arguments yield the Lemma. □

Proof of Proposition 4. From Assumption 1 and the optimal behavior of SPOE and MPOE it follows that both types of banks create a higher NPV when they operate both subsidiaries then when they only operate the high profit subsidiary. When Condition (44) is satisfied, then only an MPOE bank will operate both subsidiaries and hence an MPOE bank creates a higher NPV. Otherwise, both MPOE and SPOE banks operate either only the high profit subsidiary, in which case they create the same NPV, or both subsidiaries.

If the SPOE will monitor both subsidiaries in the absence of a liquidity shock, then it will create a higher NPV because the only difference to an MPOE is that it will operate both subsidiaries following a liquidity shock. This case occurs when Conditions (33) or (38) is violated.

If the SPOE will monitor only the low profit subsidiary in the absence of a liquidity shock (Conditions (33) and (38) are satisfied) then the difference between the NPVs of an SPOE and and MPOE bank yields Condition (45). □

A.6. Resilience

Proof of Lemma 14. If a bank does not enter resolution following a liquidity shock the profits of the bank's initial owners are given by

$$(1-q)\pi^1(S, \mathbf{F}^0, nl) + q \max \pi^1(S, \mathbf{F}^0, l) - \frac{1}{\phi}\max\{2 - F^0, 0\}.$$

Substituting for the profit functions π^1 shows that, since $\bar{D}(H,n) + \bar{D}(L,m) < 2$ and Condition (33) is satisfied, this expression is strictly increasing in F^0 if and only if $F^0 < \bar{D}(H,n) + \bar{D}(L,m)$.

We distinguish two cases. First, when $\bar{D}(H,n) + \bar{D}(L,m) \leq P(H,n) + P(L,m) - 2\rho$ then the bank will optimally choose a debt level

$$F^0 \in [\bar{D}(H,n) + \bar{D}(L,m), P(H,n) + P(L,m) - 2\rho].$$

Hence, it will not enter resolution and will engage in risk shifting if it operates both subsidiaries. If the bank operates both subsidiaries following a liquidity shock its profits are thus given by Expression (32), where $I^1 = F^0 + 2\rho$ and $\mu = nm$. If it shuts down the low profit subsidiary then its profits are given by Expression (9), where $I^1 = F^0 + \rho$. Comparing these profit functions shows that the bank will continue both subsidiaries if and only if Condition (52) is satisfied.

Second, when $\bar{D}(H,n) + \bar{D}(L,m) > P(H,n) + P(L,m) - 2\rho$ then a bank that avoids resolution can optimally choose $F^0 > P(H,n) + P(L,m) - 2\rho$ if and only if

$$P(H,n) + P(L,m) - 2\rho < P(H,m) - \rho$$

This Condition is is violated if and only if Condition (52) holds. Hence a bank that avoids resolution will choose $F^0 = P(H,n) + P(L,m) - 2\rho$ and continue both subsidiaries following a liquidity shock. □

Proof of Lemma 15. Consider a bank that does enter resolution following a liquidity shock. The initial owners of the bank make profits

$$(1-q)\max\{\pi^1(S, \mathbf{F}^0, nl), 0\} - \frac{1}{\phi}\max\{2 - D^0, 0\}.$$

where

$$D^0 = (1-q)F^0 + q(P(H, r_H) + P(L, m) - 2\rho)$$

and $r_H = r_H(S)$. Substituting for the profit functions π^1 shows that the initial owners' profit are strictly increasing in F^0 if and only if $F^0 \leq \bar{D}(H, n) + \bar{D}(L, m)$ and $D^0 \leq 2$. Since $D^0 \leq F^0$ and $\bar{D}(H, n) + \bar{D}(L, m) < 2$ the bank's minimum optimal debt level is given by

$$F^0 = \bar{D}(H, n) + \bar{D}(L, m).$$

It follows that for

$$\bar{D}(H, n) + \bar{D}(L, m) + 2\rho \leq P(H, n) + P(L, m) \tag{56}$$

the bank always finds it optimal to choose $\mathbf{F}^0$ such that it does not enter resolution following a liquidity shock.

If Condition 56 is not satisfied then the expected profit of bank that chooses $\mathbf{F}^0$ such that it enters resolution is given by

$$(1-q)(V(H, n) + V(L, m)) - 2 - q2\rho \\ - \frac{1-\phi}{\phi}\Big(2 - (1-q)(\bar{D}(H, n) + \bar{D}(L, m)) - q(P(S, r_H) - 2\rho)\Big)$$

The profits of a bank that avoids resolution and continues both subsidiaries following liquidity shock is given by

$$V(H, n) + V(L, m) - 2 - q2\rho - \frac{1-\phi}{\phi}\Big(2 + q2\rho - (P(H, n) + P(L, m) - 2\rho)\Big)$$

Comparing these expressions and simple algebra then yields that the bank will avoid resolution if and only if Condition (53) is satisfied. Since the right-hand-side of this expression is negative, this expression is always satisfied when Condition 56 is satisfied. □

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