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Elisa Luciano
University of Torino

Clas Wihlborg
Chapman University, wihlborg@chapman.edu

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Financial Synergies and Systemic Risk in the Organization of Bank Affiliates*

Elisa Luciano
University of Torino and Collegio Carlo Alberto, Italy

Clas Wihlborg
Chapman University, USA

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Abstract

We analyze theoretically banks' choice of organizational structures in branches, subsidiaries or stand-alone banks, in the presence of public bailouts and default costs. These structures are characterized by different arrangements for internal rescue of affiliates against default. The cost of debt and leverage are endogenous. For moderate bailout probabilities, subsidiary structures, wherein the two entities provide mutual internal rescue under limited liability, have the highest group value, but also the highest risk taking as measured by leverage and expected loss. We explore the effect of constraints on leverage and policy implications. The conflict of interests between regulators, who minimize systemic risk, and banks, who maximize their own value, is mitigated when capital requirements are effective.

KEYWORDS: bank organization, bank risk, financial synergies, endogenous leverage in banking, default costs, bailouts

JEL classification numbers: G210, G32, G33

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1 Introduction

The international debate on banking regulation after the financial crisis 2007-2009 covers a variety of regulatory proposals in addition to capital requirements. These proposals include separation or "ring-fencing" of traditional commercial banking from other financial services and special resolution procedures for banks and other financial institutions. The motivation for the new regulatory initiatives seems to be concerns about the effectiveness of capital requirements to reduce risk-taking in the presence of strong incentives to exploit an implicit subsidy to debt-financing. This subsidy is generated by explicit and implicit protection of banks' creditors against losses from bank failures. There is a large literature on effects of capital requirements but there is little analysis of the impact of regulation of organizational structures such as ring-fencing on banks' incentives to take risk with potential systemic consequences.

In this paper we analyze value and risk effects of a multi-affiliate banking group's organizational choice between branch and subsidiary structures. The group may also choose to divest affiliates to create stand-alone banks. The banking group's choices with respect to organizational structure are analyzed in the presence and absence of capital regulation in the form of an effective constraint on leverage in each affiliate or the whole group. The group value of each organizational structure depends on the financial synergies that the bank can exploit within the structure. These synergies arise in the presence of default costs, taxes and a probability of state bailout. Systemic risk effects of the organizational choice are analyzed with the purpose to identify conditions that give rise to a conflict of interest between the banking group's value objective and a regulator's objective to minimize systemic risk. The interest rate on bank debt, as well as leverage in each affiliate, is endogenous in the absence of leverage constraints while only the interest rate is endogenous when capital requirements are imposed.

An affiliate is defined by its separate distribution of returns on assets, which may be more or less correlated with the distribution of another affiliate. Our multi-affiliate banking group may have affiliates in more than one country or it may be a conglomerate bank with, for example, a traditional commercial bank affiliate and an investment bank affiliate. Organizational structures are defined within our model by the degree of separation or ring-fencing of the capital base of each affiliate, which depends on internal arrangements for support of an insolvent affiliate from other affiliates. On the one extreme there is a branch structure wherein the affiliates have a joint capital base.[1]This means that the affiliates support each other through internal asset transfers till the point of joint default. On the other extreme the affiliates are separated as stand-alone banks with their own capital bases. In this case assets in one entity cannot be used to support the other entity.[2]

[1]Traditionally universal banks were financial conglomerates supplying a variety of financial services in addition to deposit taking and direct lending within one legal entity. More recently the different activities within conglomerates are often organized in subsidiaries under a Bank Holding Company in the US as well as in Europe. These banking groups are often strongly integrated both operationally and financially (Alexander, 2015).

[2]Our stand-alone banks may either be completely independent banks with different owners or financially completely independent subsidiaries with common ownership.

In between the two extremes there are subsidiary structures wherein each affiliate is a separate legal entity with limited liability but there are opportunities for support from one affiliate to another. As a result of the limited liability for each legally separate affiliate the support from one affiliate to another is constrained by the supporting affiliate's capital. Unlike in the branch structure, each affiliate can default without dragging other affiliates into default.[3] We distinguish between subsidiary structures with "mutual rescue" and subsidiary structures with "one-way rescue." In the former structure, each affiliate within a banking group supports another affiliate that has exhausted its capital but the support ends before the supporting affiliate defaults. In the one-way rescue structure, support goes only one way from, for example, a parent to a subsidiary.[4]

Value differences among organizational structures exist because the internal rescue arrangements among affiliates with or without limited liability affect the banking group's ability to reduce default costs, and the ability to exploit benefits from a tax shield and a probability of state bailouts. Capital requirements also affect the benefits from these sources of financial synergies.

A regulator's concern with systemic risk in different organizational structures is captured by a comparison of the expected losses of the creditors of the banking group. If the structure that maximizes group value contributes the most to systemic risk there is a potential conflict between the objectives of the bank and the objectives of the regulator. We show that the conflict of interest between the regulator's objective of minimizing systemic risk and the banking group's objective is mitigated when capital requirements are effective. One policy implication is that restrictions on organizational choice can serve as a substitute for capital requirements or be used as a complement to capital requirements when banking groups are able to evade these requirements.[5] The literature indicates that capital requirements are neither completely effective nor completely ineffective.[6]

A preview of our main results with respect to value and risk effects of organizational choice is as follows. With endogenous leverage subsidiary structures, and particularly those providing mutual rescue, have the highest group values, but also the highest risk taking, as measured by leverage and expected losses as long as default cost, probability of bailout and tax parameters are the same across affiliates, Branch structures as well as stand-alone banks contribute less to systemic risk, but have also smaller value to shareholders.

The value advantage of the subsidiary structures remains when a binding and identical

[3]Internal rescue arrangements depend on the financing and allocation of equity among affiliates within a group, and can take the form of explicit guarantees of a subsidiary's debt or a bank holding company's responsibility for several subsidiaries' debt. Internal insurance may also be more informal. For example, a parent firm facing distress can sell subsidiaries' assets in order to save itself or, if a subsidiary is facing distress, the parent can transfer assets to protect the bank's brand name. Debt financing of equity in a subsidiary (double leverage) can also be viewed as an internal rescue arrangement since losses of the subsidiary are transferred to the parent.

[4]At present, organizational structures like bank-holding companies (BHCs) in the US are usually characterized by strong integration of subsidiaries operationally as well as financially (Carmassi and Herring, 2015). There are also BHCs with relatively independent subsidiaries that are able to default individually without threatening all entities under a BHC's control.

[5]There is evidence that banks are able to manipulate risk-weighting schemes as they are specified in the Basel Accords (see , for example, Blundell-Wignall and Roulet, 2013).

[6]See, for example, Blum (1999) and Hovakimian and Kane (2001).

leverage constraint is imposed on each affiliate as long as the probability of state bailout is low or moderate. At relatively high probabilities of state bailout the stand-alone banks obtain the highest value, followed by subsidiaries with one-way rescue, subidiaries with mutual rescue and branch structures that offer unlimited internal rescue.

We also allow probabilities of state bailouts to differ across affiliates in different countries or affiliates supplying different kinds of services. The most striking result in this case is that the value disadvantage of the branch structure diminishes while its contribution to systemic risk becomes the highest.

The analysis proceeds as follows: related literature is reviewed in section 2. The basic model for valuation of stand-alone banks is set up in section 3. The trade-off between default costs, on the one hand, and the put option value of limited liability, the likelihood of a government bailout and the tax shield from deposits, on the other, is formulated. In section 4 the bank expands by adding an affiliate as a subsidiary or a branch. Their coinsurance or internal rescue features are formulated in this section. Analytical results for the group values of subsidiary, branch and stand-alone organizations are derived in section 5 with constrained leverage. The notion of debt diversity also emerges here when leverage is unconstrained. Numerical analysis of optimally levered banks follows in section 6. Systemic risk is introduced in section 7, where we show how the trade-off between increasing the group value and reducing the expected loss depends on the organizational structure and on the regulatory constraints that can be imposed. In section 8 we summarize results, discuss implications for current reform proposals and further research.

2 Background Literature

The theoretical analysis of risk and efficiency in bank organizations in this paper is related to several strands of literature. An important strand includes perfect-information theoretical models of banking groups, which have to organize themselves as branches versus subsidiaries. Within this strand, Dell'Ariccia and Marquez (2010), for instance, analyze theoretically the choice between branches and subsidiaries in banking. They model the choice as a trade-off between benefits of limited liability for a subsidiary and protection against political risk (of expropriation) in a branch. The international dimension inherent in their set-up is not our main focus. That is why we will not have political risk.

Financial synergies play an important role also in Freixas, Loranth and Morrison (2007), which considers a financial conglomerate wherein activities are risky to different degrees. The activities can be conducted in an integrated entity subject to one liability constraint– a branch bank in our terminology–or within a holding company structure with financially independent subsidiaries. These would be stand-alone banks in our setting, but - differently from our stand-alone banks - they would be able to shift assets with different risk between themselves. The paper also considers stand-alone, independently owned financial institutions without ability to transfer assets between them. In our model risk can be shifted between subsidiaries only through increased leverage in one entity while asset transfers occur only if subsidiries rescue each other. A general result we have in common with Freixas *et al.* (2007) is that optimal capital requirements must be differentiated across different organizational structures as well as different costs of default and state bailout schemes.

Another important strand includes theoretical models where organizations in branches or subsidiaries differ in transmission of information. Kahn and Winton (2004) emphasize moral hazard incentives to shift risk to debt-holders who cannot observe the riskiness of the different activities within a financial conglomerate. Since the debt-holders know that they do not have risk-information, the financial institution can reduce its cost of funding by separating the financing of high-risk and low-risk activities into different entities with different leverage. In our model debt-holders know the risk characteristics of assets so that risk is reflected in interest rates. Benefits of subsidiary structures occur only as a result of internal insurance arrangements, which are not present in Kahn and Winton.[7]

There is a third relevant strand of literature, that studies financial synergies arising as a result of the merger of two firms, which are not banks. Leland (2007) and Banal-Estanol, Ottaviani and Winton (2013) show that when two stand-alone firms are merged into one legal entity the new firm cannot take advantage of limited liability but it can benefit from reduced default costs. Banal-Estanol *et al.* (2013) restrict the analysis to debt financing and the effects of the merger of two firms on default costs, while the merged firm re-optimizes leverage in the Leland (2007) paper. The paper also considers tax-effects of the endogenous choice between debt and equity. In this case, the merged firm always benefit from reduced default costs while with fixed leverage a 'contamination effect' within the merged organization can cause the default costs to rise above the default costs of the separately financed firms. Limited internal insurance between subsidiaries is not considered in these papers. Luciano and Nicodano (2014) expands on the analysis in Leland (2007) and considers that a parent plus a subsidiary, which can be rescued by the parent, can economize on default costs relative to the merged firm. These papers also endogenize both leverage and the interest rate on debt. They focus on the organizational choice as a trade-off between default costs and tax-savings from debt financing. We depart from the model in Luciano and Nicodano (2014) because an essential feauture of banks in comparison with other corporates is the presence of public bailout. Furthermore, we extend their analysis to mutual rescue and stand-alone entities.

The last strand comprehends the empirical literature. Our rescues take the form of asset transfers and, as we will see, implied risk transfer. The empirical examination of asset transfers in Cerutti, Dell'Ariccia and Martinez Peria (2007) already motivated Dell'Ariccia and Marquez (2010). Cross-border flows are documented empirically by Cetorelli and Goldberg (2012). Jeon, Olivero and wuW (2013) study the transmission of shocks generated by such flows. Ongena, Popov and Udell (2013) analyze empirically how cross-border banks shift risk between countries with different regulation. Another piece of empirical literature with bearing on our model is Gropp and Heider (2010), which shows that the traditional determinants of capital structure in non-financial firms carry over to banks. The paper argues that mispriced deposit insurance and capital requirements are less important. Tsesmelidakis and Merton (2012), on the other hand, reveals evidence from bond yields for 74 US banks, 2007-2011, that the implicit subsidy to bondholders and shareholders of banks considered 'too big to fail' amounted to \$353bn. The authors use a typical corporate-finance model inspired by Merton's (1974) equity and debt valuation. Our approach to determine endoge-

[7] Financial dependence among subsidiaries may arise as a result of intra-corporate lending as well. The basis for intra-corporate lending is usually internal information advantages or internal tax arbitrage. See, for example, Gertner, Scharfstein and Stein (1994), and Shin and Stulz (1998). In our model financial interdependence depends only on internal rescue arrangements since lenders are fully informed.

nous leverage in banks is based on the same valuation principles. Last, let us mention that the presence and effects of rescues, or internal insurance within banking groups, which is the main mechanism behing our model, has been documented empirically by Bradley and Jones (2008) and Ashcraft (2004).

3 The stand-alone bank

This section models a single and then two stand-alone (SA) bank using as a starting point the structural model of Merton (1974) and introducing default costs, taxes and the possibility of public (also called "governmental" below) bailout in default. These factors create an incentive to adjust leverage so as to exploit lower taxes and the possibility of bailout, and to reduce default costs.[8]

For the sake of simplicity, consider two points in time only, $t = 0, T$, and classify bank liabilities into deposits[9] and equity. Both deposits and equity are evaluated at fair value, D_0 and E_0, under the assumption that investors are risk-neutral or arbitrages are ruled out.[10] The face value of deposits is denoted by F. D_0 is the expected value of their final payoff, discounted. This means that the rate on deposits is endogenous, and competitively determined.[11] $F - D_0$ is the capital gain to debt holders.

To simplify, we label as "loans" all the bank assets.[12] The initial value of loans is denoted as L_0. The value of loans at time T is a non-negative random variable - which we take to be continuous - denoted as $L(T)$. At time T the bank collects the value of loans $L(T)$, net of corporate taxes. The tax rate is $k > 0$, but there is a tax shield on passive interest rates, $F - D_0$. Thereby, the bank's total cash flows are:

$$\bar{L}(T) = (1 - k)L(T) + k(F - D_0), \tag{1}$$

These cash flows are distributed to bond and equity holders according to absolute priority: depositors receive F, either if there is no default, which means that the asset value $\bar{L}(T)$ is greater than F, or if it is smaller but the government bails out the bank's creditors.[13] There is a probability π that this occurs. If there is no bailout, they receive the asset value, net of default costs. The latter are proportional to total cash flows, $\alpha\bar{L}(T)$. The value to be

[8]The main distinguishing characteristic of a bank relative to any corporation for from the point of view of financial synergies is the existence of a positive probability of a bailout by the government. A second important characteristic of a bank for our purposes is the potential systemic consequences of a bank's default.

[9]Deposits represent customer as well as interbank net deposits, borrowing from the Central Bank and issued bonds.

[10]This assumption is discussed in Merton (1974) and is adopted in both Leland (2007) and Luciano and Nicodano (2014).

[11]This is accomplished by imposing a zero profit condition. Thereby we capture the long-term incentives to choose a particular internal insurance arrangement although we lose the ability to analyze short term effects of imperfect competition.

[12]We disregard interbank claims and consider as a unique entity proper loans and securities. In doing that we have in mind mainly commercial banks.

[13]Here and in the sequel we disregard the case of equality between asset value and face value of debt, thanks to the hypothesis of continuity of loans as a random variable. The event of equality has indeed zero probability.

distributed to depositors becomes the sum of what equity holders pay to debt holders, out of $\bar{L}(T)$, what they receive from the government in case of bailout, less default costs if there is no bailout :

$$\min(F, \bar{L}(T)) + (F - \bar{L}(T))1_{\{\bar{L}(T)<F,B\}} - \alpha \bar{L}(T)1_{\{\bar{L}(T)<F,\bar{B}\}}, \tag{2}$$

where $1_{\{E\}}$ is the default indicator of event E, which is equal to one if and only if E occurs, B is the event of bailout, $\bar{B}$ the event of no bailout. The value of debt is the expectation of such payoff, discounted at the riskless rate r:

$$D_0 = \exp(-rT)\times$$

$$\times \left\{ \mathbb{E}\min(F, \bar{L}(T)) + \pi\mathbb{E}\max(F - \bar{L}(T), 0) - \alpha(1-\pi)\mathbb{E}\left[\bar{L}(T)\mathbf{1}_{\{\bar{L}(T)<F\}}\right] \right\} \tag{3}$$

where π is the probability of bailout, given that default occurred. Following Merton (1974), it is easy to argue that the first term is the difference between the face value of deposits discounted and a put on loans, with strike F. The second term is the so-called "default put": a put option on L, with strike F, which is paid with probability π. The third represents expected default costs. Collecting the put terms, we have

$$D_0 = \exp(-rT) \left\{ \begin{array}{c} F - (1-\pi)\mathbb{E}\max(0, F - \bar{L}(T)) \\ -\alpha(1-\pi)\mathbb{E}\left[\bar{L}(T)\mathbf{1}_{\{\bar{L}(T)<F\}}\right] \end{array} \right\} \tag{4}$$

It follows from absolute priority that the payoff to equity at T is $\max\left[\bar{L}(T) - F, 0\right]$. Equity holders are long a call on loans' net value, with strike F. E_0 is then

$$E_0 = \exp(-rT)\mathbb{E}\max\left[\bar{L}(T) - F, 0\right]. \tag{5}$$

The value of one stand-alone bank V_{SA}, namely the sum of debt and equity, can be proven to be equal to the unlevered value L_0, plus the bailout put minus expected default costs:

$$V_{SA} = D_0 + E_0 =$$

$$= \bar{L}_0 + \underbrace{\exp(-rT)\pi\mathbb{E}\max(0, F - \bar{L}(T))}_{\text{bailout put}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\bar{L}(T)\mathbf{1}_{\{\bar{L}(T)<F\}}\right]}_{\text{default costs}}. \tag{6}$$

The bank chooses the (non-negative) face value of deposits in order to maximize V_{SA}, since this represents also E_0 and the deposits that equity holders cash in at time 0, namely D_0.[14][15]

Stand-alone banks are defined here as entities that commit to no rescue. If we have two stand-alone banks, their total value - which we denote as GV_{SA} - is the sum of their values, $2V_{SA}$. Leverage would be chosen independently by each entity.

[14]If ever there are no default costs, no taxes and no bailout, the bank value $D_0 + E_0$ reduces to the initial loan value L_0: an irrelevance property of the Modigliani-Miller type holds in this case since leverage does not affect the bank value.

[15]It should be clear from the payoffs to debt and equity - both in this case and the ones to follow - that we could equally well have taken deposits as given and solved for the amount of loans.

4 A bank with two affiliates

We model a bank with two affiliates – that we call a home bank and a subsidiary or a branch – by specifying its financial synergies, which are affected by coinsurance between the affiliates in case of default.

The loans of the home bank, subsidiary and branch are

$$\bar{L}_i(T) = (1-k)L_i(T) + k(F_i - D_{0i}),\ i = h, s, b \tag{7}$$

To compare the different structures, we set gross–of-tax loans in branches equal (in distribution) to those in subsidiaries $L_b(T) = L_s(T)$. For technical tractability, we also introduce the following assumption:

Assumption 1. *The joint density of $L_h(T)$ and $L_b(T) = L_s(T)$ has non-null density over the whole positive orthant of R^2.*[16]

The overall group value with two affiliates is

$$GV_j = D_{0h} + E_{0h} + D_{0a} + E_{0a} \tag{8}$$

where we have $a = s, b$, depending on whether we are in the subsidiary or branch structure, and $j = MR$ for the mutual rescue structure, OWR for the one-way-rescue structure, BR for the branch structure. Rescue consists of providing the defaulted subsidiary with assets at T. By specifying when rescue occurs and how much asset transfer it entails, we obtain the group value in different organizations.

4.1 Rescue in the subsidiary organization

When two banks organize themselves in being a home bank and its subsidiary, they remain two separate legal entities. If rescue is conditional on not endangering the safety of the home bank and vice versa, we have mutual insurance. If ever the insurance works only from the home to the subsidiary or vice versa, we have one-way insurance. In principle, debt in different affiliates could have different seniority. It might well happen, for instance, that debt of the subsidiary is divided into a senior and a junior tranche, and the parent committs to rescue only the senior part, not the junior. And viceversa. The model below is meant to represent the situation resulting from given, crystalized seniority, possibly different across affiliates, but uniform within each affiliate. If the debt of each affiliate is stratified into different seniority levels, and not all of them are guaranteed, the model has to be changed accordingly.[17]

[16] The Gaussian distribution on loan log-returns introduced later satisfies this hypothesis, which is needed only in order to simplify the discussion and avoid having events of null probability, as well as perfectly correlated returns (positively and negatively).

[17] If only a fraction b_i of the debt of affiliate i is guaranteed, because of its seniority, only that fraction will be rescued, and the formulas from (9) to (12) below must contain $b_i(F - \bar{L}_i)$ instead of $F - \bar{L}_i$. Different specifications of b_i for different affiliates can be envisaged.

4.1.1 Mutual rescue

Rescue of the subsidiary means that the home bank using its surplus, $\bar{L}_h(T) - F_h$, pays that part of the subsidiary deposits that are not covered by the subsidiary's own assets, $F_s - \bar{L}_s(T)$. The home-bank can do this without facing default if its surplus is greater than the amount needed for rescue, $\bar{L}_h(T) - F_h > F_s - \bar{L}_s(T)$. The rescue occurs if and only if the home bank is not in default ($\bar{L}_h(T) > F_h$), the subsidiary is in default ($\bar{L}_s(T) < F_s$) and rescuing the subsidiary does not drive the home bank into default. Since the first condition is always satisfied when the last is, the conditions can be reduced to the event

$$R_s \triangleq \begin{cases} \bar{L}_s(T) < F_s \\ \bar{L}_h(T) - F_h > F_s - \bar{L}_s(T) \end{cases} \tag{9}$$

The subsidiary is not rescued if it is in default and the home bank does not have enough assets to cover the subsidiary's shortage of assets relative to the face value of debt:

$$Q_s \triangleq \begin{cases} \bar{L}_s(T) < F_s \\ \bar{L}_h(T) - F_h < F_s - \bar{L}_s(T) \end{cases} \tag{10}$$

Symmetrically, rescue of the home bank by the subsidiary takes place when the latter is not in default and is not endangered by the rescue itself:

$$R_h \triangleq \begin{cases} \bar{L}_h(T) < F_h \\ \bar{L}_s(T) - F_s > F_h - \bar{L}_h(T) \end{cases} \tag{11}$$

and default of the home bank takes place if the subsidiary is endangered:

$$Q_h \triangleq \begin{cases} \bar{L}_h(T) < F_h \\ \bar{L}_s(T) - F_s < F_h - \bar{L}_h(T) \end{cases} \tag{12}$$

If Q_s or Q_h hold true, there is room for state bailout of the defaulted bank, which occurs with probability π.[18] We assume that government intervention is independent of survivorship of any affiliate, while we do not assume independency of the loans of the affiliates.

It follows that the payoff to depositors of the subsidiary (home) is the payoff to a stand alone bank (denoted as "value without bailout and rescue" below), augmented by $F_i - \bar{L}_i(T)$, $i = s, h$, the minimum support to avoid default when rescue or bailout take place. Default costs are paid only if there is default, no internal rescue and no bailout. That gives as debt

[18] In all the structures, we assume that the government can enforce rescue by threatening the bank: if rescue does not occur ex post when due, the government does not intervene to bailout the bank in case rescue is still not enough. Our model is indeed a perfect, symmetric information one, in which the behavior of the bank is perfectly observable by the government. On top of that, specific legislation makes rescue enforcable by law: this is the case of the US "source of strenght" provision.

value:

$$D_{0i} = \underbrace{\exp(-rT)\left[F_i - \mathbb{E}\max(0, F_i - \bar{L}_i(T))\right]}_{\text{value without bailout and rescue}} + \underbrace{\exp(-rT)\mathbb{E}\left\{\left[F_i - \bar{L}_i(T)\right]\mathbf{1}_{\{R_i\}}\right\}}_{\text{rescue}} + \underbrace{\pi\exp(-rT)\mathbb{E}\left\{\max(F_i - \bar{L}_i(T), 0)\mathbf{1}_{\{Q_i\}}\right\}}_{\text{government bailout}} \underbrace{- \exp(-rT)(1-\pi)\alpha\mathbb{E}\left[\bar{L}_i(T)\mathbf{1}_{\{Q_i\}}\right]}_{\text{default costs}} \quad (13)$$

Since the assets for rescue of the subsidiary (home) come from the home (subsidiary) bank, rescue diminishes the equity value of the latter bank in comparison with the stand-alone case (5). For $i, j = s, h, i \neq j$:

$$E_{0i} = \exp(-rT)\mathbb{E}\max\left[\bar{L}_i(T) - F_i, 0\right] - \exp(-rT)\mathbb{E}\left\{\left[F_j - \bar{L}_j(T)\right]\mathbf{1}_{\{R_j\}}\right\},$$

In the mutual rescue structure the home bank chooses how many deposits to raise directly and through its subsidiary in order to maximize the overall value, which can be written as the sum of the asset values $\bar{L}_h + \bar{L}_s$ plus the bailout puts, minus their default costs,which are paid only in the absence of rescue by the other group member and in the absence of state bailout:[19]

$$GV_{MR} = \bar{L}_{h0} + \underbrace{\pi\exp(-rT)\mathbb{E}\max\left\{0, F_h - \bar{L}_h(T))\mathbf{1}_{\{Q_h\}}\right\}}_{\text{government bailout home}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home}} + \bar{L}_{s0} + + \underbrace{\pi\exp(-rT)\mathbb{E}\left\{\max(F_s - \bar{L}_s(T), 0)\mathbf{1}_{\{Q_s\}})\right\}}_{\text{government bailout subsidiary}} \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[\bar{L}_s(T)\mathbf{1}_{\{Q_s\}}\right]}_{\text{default cost subsidiary}}. \quad (14)$$

where $\bar{L}_{i0} = (1-k)L_i(0) + \exp(-rT)\ k_s(F_i - D_{0i}), i = h, s.$

4.1.2 Unilateral rescue

Assume now that, in the subsidiary case, rescue is unilateral and can go only from the home to the subsidiary. This means that the payoffs to the equity holders of the subsidiary and to depositors of the home bank are as in the stand-alone case. Their fair values are:

$$E_{0s} = \exp(-rT)\mathbb{E}\max\left[\bar{L}_s(T) - F_s, 0\right] \quad (15)$$

[19] Rescue payments cancel out because they are paid by one stakeholder (equity owners of one affiliate) to debt holders of the other.

$$D_{0h} = \exp(-rT)\times$$
$$\times\left[F_h - (1-\pi)\mathbb{E}\max(0, F_h - \bar{L}_h(T)) - \alpha(1-\pi)\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\left\{\bar{L}_h(T)<F_h\right\}}\right]\right]. \tag{16}$$

The formulas for the subsidiary debt and home-bank equity of the mutual case remain in force, since their payoffs are not affected. The overall value of the subsidiary organization with unilateral insurance, GV_{OWR}, is the sum of the asset values, $\bar{L}_{h0} + \bar{L}_{s0}$, plus the bailout puts for each bank, minus their default costs:

$$\begin{array}{c} GV_{OWR} = \\ \bar{L}_{h0} + \underbrace{\pi\exp(-rT)\mathbb{E}\max(0, F_h - \bar{L}_h(T))}_{\text{government bailout home}} + \\ \underbrace{-\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\left\{\bar{L}_h(T)<F_h\right\}}\right]}_{\text{default cost home}} \\ +\bar{L}_{s0}+ \\ \underbrace{+\pi\exp(-rT)\mathbb{E}\left\{\max(F_s - \bar{L}_s(T), 0)\mathbf{1}_{\{Q_s\}}\right\}+}_{\text{government bailout subsidiary}} \\ \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[\bar{L}_s(T)\mathbf{1}_{\{Q_s\}}\right]}_{\text{default cost subsidiary}} \end{array}. \tag{17}$$

A similar decomposition of value can be obtained if rescue goes only from the subsidiary to the home bank. Here we assume that the direction of support is the one elicited above.

4.2 Rescue in the branch organization

The branch case is different from the mutual subsidiary case because there is no more limited liability of one bank versus the other, although analytically we treat the two entities as separate since they have separate return distributions. In the branch case, insolvency for the whole bank organization is the only possibility: either both the home and the branch default, or none does. Rescue is mutual but not conditional on survivorship of the entity coming to rescue. So, support from the home bank to the branch is offered whenever

$$R_b \triangleq \left\{\begin{array}{l} \bar{L}_h(T) > F_h \\ \bar{L}_b(T) < F_b \end{array}\right. \tag{18}$$

while support in the other direction occurs when

$$R_h' \triangleq \left\{\begin{array}{l} \bar{L}_h(T) < F_h \\ \bar{L}_b(T) > F_b \end{array}\right. \tag{19}$$

These events substitute for R_s, R_b. The transfer in the two events is

$$\min\left(\bar{L}_h(T) - F_h, F_b - \bar{L}_b(T)\right),$$
$$\min\left(\bar{L}_b(T) - F_b, F_h - \bar{L}_h(T)\right).$$

As in the parent-subsidiary case, the transfer is the minimum of the difference between the face value of debt of one affiliate and its own cash flows, and the extra-cash-flows of the guarantor. These extra-cash-flows do not necessarily cover the losses. So, the whole bank defaults when either the home or the branch is insolvent, and its affiliate does not have enough cash flows to rescue, namely when either R_b and $\bar{L}_h(T) - F_h < F_b - \bar{L}_b(T)$ are true, or R'_h and $\bar{L}_b(T) - F_b < F_h - \bar{L}_h(T)$ are. In these cases, there is the possibility of government bailout, with probability π. The event in which bailout of the branch may occur is

$$Q_b \triangleq \begin{cases} \bar{L}_b(T) < F_b \\ \bar{L}_h(T) - F_h < F_b - \bar{L}_b(T) \end{cases} \tag{20}$$

The event in which bailout of the home bank may occur is

$$Q'_h \triangleq \begin{cases} \bar{L}_h(T) < F_h \\ F_h - \bar{L}_h(T) > \bar{L}_b(T) - F_b \end{cases} \tag{21}$$

If the government does not bailout there are default costs. The home bank can maximize the overall value by choosing how many deposits to raise directly and through its branch. The separate value of debt and equity for the affiliates is given in Appendix A. The overall group value is given again by the sum of the asset values $\bar{L}_h + \bar{L}_b$ plus the government bailout puts minus their default costs:

$$\begin{gathered} GV_{BR} = \\ \bar{L}_{h0} + \underbrace{\pi \exp(-rT)\mathbb{E}\max\left\{0, F_h - \bar{L}_h(T))\mathbf{1}_{\{Q'_h\}}\right\}}_{\text{government bailout home}} + \\ -\underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\left[\bar{L}_h(T) + \max(0, \bar{L}_b(T) - F_b)\right]\mathbf{1}_{\{Q'_h\}}\right]}_{\text{default cost home}} + \\ +\bar{L}_{b0} + \\ +\underbrace{\pi \exp(-rT)\mathbb{E}\left\{\max(F_b - \bar{L}_b(T), 0)\mathbf{1}_{\{Q_b\}})\right\}}_{\text{government bailout branch}} + \\ \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[\left[\bar{L}_b(T) + \max(0, \bar{L}_h(T) - F_h)\right]\mathbf{1}_{\{Q_b\}}\right]}_{\text{default cost branch}} \end{gathered} \tag{22}$$

In the branch case the overall bank defaults when total assets are less than total debt in face value: $\bar{L}_h(T) + \bar{L}_b(T) < F_h + F_b$. In the subsidiary case there will be situations when the same condition holds but one subsidiary does not default because it can abandon the rescue before defaulting. This happens when $\bar{L}_h(T) - F_h < F_s - \bar{L}_s(T)$. In this way the subsidiary organization can save on default costs relative to the branch structure. For this reason, we expect that the lack of limited liability on the branch level affects branch structures negatively relative to subsidiary structures, exactly as the Sarig effect deprives mergers of value. See Sarig (1985), Leland (2007), Balan-Estanol *et al.* (2012). But this intuition could fail with endogenous leverage. Therefore, we distinguish between the exogenous and endogenous cases below.

5 Comparing group values of organizations; analytical results

In this section we compare the different organizational structures when cash flows from loans (in distribution), as well as other parameters, are the same. In section 5.1 we perform the comparison analytically assuming that the level of deposits is the same in different organizational structures. This case represents what we call constrained leverage. Equality of deposits in face value can indeed be interpreted as a form of equal capital requirements for all entities. The tax rate k is set to zero, to focus on the role of state bailouts and default costs. In section 5.2 we endogenize leverage as well and show that even when the tax rate is zero the bank can benefit from differentiating leverage across affiliates if it chooses a one-way rescue structure. Such "debt diversity" in the presence of a positive tax rate is explored further in the numerical analysis in section 6.[20]

5.1 Constrained leverage in all organizations

In a nutshell this section proves a basic feature of the model: subsidiary structures with high levels of rescue/coinsurance have higher value for moderate bailout probabilities, while structures with low levels of rescue/coinsurance have higher values for high bailout probabilities.

Introduce the following

Assumption 2. *Let the affiliates have the same size, i.e. the same initial value and distribution of final loans ($L_{h0} = L_{a0}, L_h(T) = L_a(T), a = s, b$ in distribution), the same positive leverage ($F_h = F_a > 0, a = s, b$). No taxes are paid ($k = 0$).*

If we compare the one-way and the mutual rescue structures, we can conclude that

Proposition 5.1. *Under Assumption 2, unilateral conditional rescues in subsidiary-home-bank organizations are strictly worse than mutual conditional rescues, if $\alpha > 0$ and $\pi = 0$, while they are better when $\pi = 1$ and $\alpha > 0$ or $\alpha = 0$. If $\alpha > 0$, there is a positive bailout probability π^* above which unilateral rescue becomes better than mutual. Last, they have equal value in a neighborhood of $\alpha = \pi = 0$.*

So, independently of how many deposits are collected in the affiliate, if there is no bailout but default is dissipative ($\alpha > 0$ and $\pi = 0$), it is better to provide mutual rescue in case one affiliate becomes insolvent, instead of leaving it alone. Mutual rescue saves on default costs in the absence of state bailouts. When there is external bailout with certainty or when default is not dissipative ($\pi = 1$ and $\alpha > 0$ or $\alpha = 0$), mutual rescue is not a rational strategy. Above a given likelihood of state bailout (π^*), mutual rescue is not any more rational if default is dissipative ($\alpha > 0$). Instead, the group value is enhanced if internal rescues are limited to go one way. .

If we compare the branch and the subsidiary with mutual rescue organizations, we get the following:

[20] Proofs of Propositions are in Appendix B.

Proposition 5.2. *Under Assumption 2, the subsidiary organization (with mutual rescue) is strictly preferable to the branch, for every* $\alpha > 0$, *when* $0 \leq \pi < 1$; *when* $\alpha = 0$ *or* $\alpha > 0$ *and* $\pi = 1$, *they have equal value.*

The Proposition states that in all cases of dissipative default costs and some degree of uncertainty about the bailout, the bank will prefer the subsidiary organization even when there is commitment to mutual rescue.

Putting together Propositions 5.1 and 5.2, it is easy to assess the following:

Corollary 5.1. *Under Assumption 2, if* $\alpha > 0$, *there exists a bailout probability* π^* *above which the subsidiary organization with unilateral rescue is strictly preferred to the subsidiary with mutual rescue, which in turn is preferred or equivalent to the branch organization.*

The comparison between two stand alone banks and the same banks (in terms of assets) once they become affiliated within a group with one way or mutual insurance is quite straightforward too. It can be demonstrated that:

Proposition 5.3. *Under Assumption 2, organizing a bank as a stand-alone entity provides greater value than organizing it as a subsidiary - with unilateral or mutual rescue - if default is not dissipative and there is a positive probability of bailout* ($\alpha = 0$ *and* $\pi > 0$) *or, for any level of default costs, if the probability of bailout is one* ($\alpha \geq 0$, $\pi = 1$). *The value of the subsidiary organization is greater when default is dissipative but the probability of bailout is null* ($\alpha > 0$ *and* $\pi = 0$). *Under dissipative default costs, there is a positive bailout probability* π^{**} *above which stand alone banks are more valuable than subsidiaries with one-way rescue. The stand alone organization becomes more valuable than subsidiaries with mutual rescue when* $\pi = \pi^{***}$, *where* $\pi^{***} \leq \max(\pi^*, \pi^{**})$.

The visual representation of Propositions 1-4 for the case when $\alpha > 0$ is in Figure 1.

Insert here Figure 1

In the Figure the value $GVj, j = OWR, MR, BR, SA$, is on the vertical axis while the probability of bailout, π, increases along the horizontal axis. The Figure illustrates the pairwise comparisons in the Propositions. The interSection points $\pi^{**} < \pi^{***} < \pi^*$, may also be ordered as $\pi < \pi^{***} < \pi^{**}$. The general pattern is not affected by the order of these intersection points.

The shaded area for the value of the branch structure, GV_{BR}, reflects that we cannot order its value relative to the stand alone banks and the subsidiary with one way rescue for relatively low values of the bailout probability, π, when there are positive default costs. We know that when $\alpha = 0$ and $\pi = 0$ all organizational structures have the same value. Combining Propositions 1 and 2 we can say that when ($\alpha > 0$ and $\pi = 0$) the mutual rescue subsidiary structure is strictly more valuable than any of the other organizations but we cannot rank the branch organization relative to the one way rescue subsidiary and the stand-alone organizations. As the bailout probability increases when there are positive default costs the value of the stand-alone stucture increases faster than the value of the one-way rescue subsidiary organization, which increases faster than the mutual rescue subsidiary organization. At very high bailout probabilities the ordering of these three organizational structures have been reversed. The ambiguity for the value of the branch structure relative to the one-way rescue subsidiary structure and the two stand-alones can be understood in terms of coinsurance and contamination as a result of unlimited rescue in the branch structure. Banal-Estanol *et al.* (2013) show how a branch structure in comparison with two stand-alone banks provides coinsurance that reduces default costs. However, contamination is also possible because large losses in one affiliate can drag the whole branch structure into default as a result of the unlimited coinsurance. This contamination effect does not occur in subsidiary structures and stand-alone banks under limited liability. Within our framework subsidiary structures have the advantage relative to stand-alone banks that they benefit from coinsurance gains in terms of default costs.[21]

Since the comparisons in this section are based on the assumption that the face value of debt, F, is the same in each affiliate, value differences between structures are explained by differences in the interest rate on deposits, which reflect expected default costs and bailout expectations. Default costs are different across organizations even with the same leverage because of the differences in rescue. The value of the bailout put also kicks in differently because the inability to survive based on the group coinsurance is different across rescue arrangements, even for the same leverage.

5.2 Unconstrained leverage

In this section we derive one analytical result with respect to endogenous leverage in different organizational structures, when the tax rate is still null, the deposit interest rate remains endogenous, and parameters and loan distributions across affiliates remain the same. We establish conditions for "debt diversity" in the sense that the bank chooses different leverage for the two affiliates. Debt diversity is of concern since it affects the affiliates' default and, thereby, expected default costs and the expected value of bailouts. Debt diversity will be explored more fully in section 6 where the tax rate is positive.

The one organizational structure that is naturally asymmetric with respect to rescue policy is the subsidiary organization with one-way internal rescue. Intuitively, its value can be increased by moving deposits from the non-insured affiliate to the internally insured affiliate. Thereby, the subsidiary-structure with one-way rescue achieves "debt diversity."

For simplicity, let the loans of the two affiliates be independent. The following Proposition, the proof of which is in Appendix A:

Proposition 5.4. *Let $k = 0, \alpha > 0, 0 < \pi < 1$. Two banks with independent loans, which are optimally levered and decide to set up a one-way rescue structure, create debt diversity at the margin. The potentially rescued affiliate is more levered than the rescuing affiliate and the group's overall value is greater than the value of two stand-alone banks.*

In the next section we will see that debt diversity arises as a result of the interest tax shield as well as default costs.[22]

[21]The value differences between the various organizations can be split into coinsurance gains and risk contamination, where the coinsurance gains are the reductions in default costs or the higher bailout revenues due to rescue, while risk contamination is the increase in default costs due to the fact that one entity can drag the other into default.

[22]Luciano and Nicodano (2014) obtained this result for the one-way rescue case, with no bailout.

6 Numerical analysis with endogenous leverage

In order to fully analyze the role of endogenous leverage we apply a numerical method for finding the face value of debt that maximizes group value.[23] In section 6.1 we choose a Gaussian distribution for returns on loans G and we specify a number of numerical cases; each case represents a set of values for tax rate, bailout probability and default costs. The numerical optimization procedure is applied in section 6.2 under the assumption that parameter values are the same across the two affiliates. The optimized market values for debt and equity, the value of the bailout put, expected default costs and consequently the group value of the bank will be calculated for each organizational structure. In section 6.3 the bailout probabilities differ for the two affiliates.

We find that the analytical Propositions in section 5 with exogenous leverage are robust to endogenization of leverage as long as the probability of state bailout is moderate and the same for the two affiliates. The subsidiary structure with mutual rescue is the structure of choice with both exogenous and endogenous leverage. Under the same condition, the result that the subsidiary structure with one-way rescue is more valuable than the stand-alone structure is robust. We can not rank the branch structure relative to the one-way rescue structure and the stand alone structure with exogenous leverage, but with endogenous leverage both the subsidiary structures are preferred to the branch structure, which has greater value than the stand-alone structure. This result with endogenous leverage reflects the subsidiary structures' ability to take advantage of debt diversity.[24] We see below that a high bailout probability for all affiliates induces all the structures to push leverage as far as possible with the result that we cannot clearly rank their relative values.Even if the high bailout probability applies only to one affiliate, the other affiliate that may enjoy rescue also increases its leverage.

6.1 Financial synergies and group values

The maximization problems to be solved are obtained by introducing Gaussian returns in expression (17) for the unilateral rescue case for subsidiaries, expression (14) for the mutual rescue case for subsidiaries and expression (22) for the branch case. We write the final asset or loan value as $L(T) = L_0 \exp(Y)$; log returns on loans Y have mean $\mu = (r - \sigma^2/2)T$ and variance $\sigma^2 T$. The initial value of the loans from each entity is normalized to $L_0 = 100$. Using Leland's (2007) parametrization, which was calibrated to non-financial BBB firms, we assume that the time horizon is five years, $T = 5$, the instantaneous riskless rate is 5%,the correlation between asset returns in the two affiliates is 0.2. In order to tailor the parameter

[23] The optimization procedure works as follows: for each level of debt of the two affiliates, we compute the fair value of debt as a fixed point, determine equity and value; we perform the computation over a grid of possible leverages, making sure that we capture the global maximum, if it exists.

[24] It can be noted that had we not excluded perfect correlation between returns on assets (Assumption 2), the subsidiary structure with mutual rescue, the branch structure and two stand alone banks become identical, when assets have correlation 1. In this case there are no benefits of differentiating leverage within these three organizational structures, which are symmetric with respect to rescue policy. Also, there are no diversification benefits with respect to default costs. As a result internal rescue policies cannot affect group values for these organizational structures if there is perfect correlation and bailout probabilities and default costs are the same.

choice to financial firms, we set $\sigma = 5\%$ per year. This asset volatility is taken from a seminal paper for financial intermediaries (Marcus and Shaked, 1984). We take the conservative 5% parameter in comparison to the most recent parameter for non-financial firms obtained by Schaefer and Straebulaev (2008) to reflect the discrepancy between financial and non financial firms illustrated in Marcus and Shaked,1984.

To compare financial synergies in different organizational structures when leverage is optimally chosen we vary the tax rate, k, as well as default costs, α, and the probability of bailout, π. If not stated otherwise, these parameters are the same across affiliates.[25]

In the base case in Table 1, the parameter k is 5%, π is 5% and α is 15%. These initial values are relatively low. A low tax rate can be rationalized on the grounds that the effective tax rate is rarely as high as the nominal corporate tax rate. The default cost parameter is initially set slightly below the 20 percent used by Leland (2007).

The state bailout probability is difficult to assess. Our starting point is 5% under the risk-neutral measure. The probability represents an average across types of debt with different seniority and explicit or implicit insurance coverage. The Figure is consistent with the relatively small difference in ratings (1-3 notches) between so called stand-alone ratings and ratings incorporating the likelihood of government support for unsecured bank debt as reported in Schich and Kim (2012).

There is a wide range of estimates of probabilities of state bailouts. Dam and Koetter (2012) estimate the probability as high as around 60 percent based on the frequency of bailouts of insolvent banks. Brandao Marques *et al.* (2013) use implicit estimates of probabilities based on ratings of "stand-alone" banks relative to ratings incorporating the likelihood of government support, They find that the probability was near zero through 2006. then it jumped to around 40% during the crisis. We experiment with different probabilities below.

In Tables 1-4, for each set of parameters we show the face value of deposits, F, the market value of deposits, D_0, leverage defined as the market value of debt relative to the market value of equity, D_0/E_0, default costs for each affiliate, the group value of the bailout put and the group value, $GV = D_0 + E_0$.

The case of a zero tax rate is not included in the numerical cases below because the optimal leverage with $k = 0$ tends to go to either zero or infinity. In conventional capital structure analysis the optimal leverage is the result of a trade-off between the interest tax shield and expected default costs. In our analysis bailout adds a second benefit from leverage. Under the assumption that the tax rate is positive there is an interior solution for leverage as a result of the non-linear relationship between the tax rate and the benefit of the tax shield.

Insert here Tables 1-4

In Table 1 we present the base case with relatively low values for all parameters. A first observation is that the subsidiary structures with one-way as well as mutual rescue choose to shift most of the deposits to one subsidiary. This "debt diversity," which we established analytically for unilateral rescue structures above for k=0 appears for mutual

[25]The numerical cases analyzed below are robust to the choice of other levels of volatility (equal across affiliates) and correlation.

rescue structures as well when $k > 0$. Tax benefits of debt can be maximized by concentrating leverage to one of the subsidiaries. The mutual rescue structure can take advantage of the interest tax shield by imitating unilateral rescue by pushing leverage high in one affiliate while keeping the leverage and, therefore, the need for rescue low in the other affiliate.

The stand-alone banks are by definition not able to take advantage of debt diversity. The branch structure chooses some debt diversity - something that we could not establish analytically - but much less than the subsidiary structure because the branch structure is more sensitive to increasing default costs.

A second observation in the first panel is that the subsidiary structure with mutual rescue has the highest group value, and that both the subsidiary structures have higher GVs than the branch and the stand-alone structures. The subsidiary structures are best able to take advantage of financial synergies by adjusting leverage. The default costs of the mutual rescue structure are higher than the costs for the one-way structure but this difference is more than offset by the higher value of the bailout put for the mutual rescue case. The differences between the different structures are small at these parameter values.

In Table 2 we push the default costs from 15% to 25%. The GVs become smaller but the comparisons among the different structures remain unchanged. In Table 3 we raise the tax rate to 10 percent while other parameters remain the same as in Table 2. The GVs fall as a result of the higher tax rate on the asset return but in order to compare financial synergies we deduct the tax rate times the value of the assets (200) in the last two rows in the different panels. These rows in Table 3 in comparison to Table 2 show that financial synergies increase as a result of the greater tax benefit from debt financing. The pattern of the results does not change, however. The subsidiary with mutual rescue remains the most valuable ahead of the one-way rescue structure, the branch structure and the two stand-alones.

The probability of state bailouts is increased in Table 4. The power of this parameter on the choice of leverage is substantial. If we increase the probability to 10 percent we do not obtain an interior optimum face value below 500 for any affiliate. For this reason we increase the probability to 7 percent in Table 4. Even so there is no interior optimum face value below 500 unless we also increase the default cost parameter to 50 percent as we have done in Table 4.[26] It can be seen that GVs remain similar in magnitude to those with default costs of 25 percent when the bailout probability is increased to 7 percent. As noted, the power of the bailout probability for choice of leverage can be explained by its indirect impact on reduced default costs in combination with its direct impact on the value of the bailout put.

The higher bailout probability in Table 4 does not affect the comparisons among the structures qualitatively. The GV of the mutual rescue structure remains the most valuable ahead of the one way and the branch structures. The value of the bailout put for the mutual structure, in particular, increases relative to the previous cases.

[26]If we increase the volatility to 20 percent, which may be realistic in times of crisis, we obtain interior solutions even at a 40 percent probability of bailout.

6.2 Differentiating probabilities of state bailouts

In this section we increase the probability of bailout of the home affiliate to 50% while the probability for the other affilate remains at 5%. We limit the differentiation of parameters to this case since changes in the bailout probability has the most powerful impact on leverage.

Insert here Table 5

Table 5 shows how the face values of debt in the affiliates, the values of the affilates and the group values (GVs) are affected by the increase in the probability. We stop the search for an optimum when the face value in an affiliate reaches 301. Thus, it is possible that the optimal face value would be even higher when the reported value in the Table is 301. In this cases the bank chooses to push debt financing to an extreme.

The two subsidiary structures (OWR and MR) and the stand-alone structure (2SA) behave in the same way with respect to the debt levels in the two affiliates. The 50 % probability of bailouts provide incentives to push debt very high in the home affiliate. The group values in these structures turn out to be the same. In other words, the differences in rescue arrangements do not affect the relative values of these three structures.

The branch structure behaves in a very different way. It pushes the debt level to extremes in both affiliates. The difference between the bailout probabilities does not affect the distribution of debt between the affiliates in this structure charaterized by joint default. There is no gain from differentiation since the two branch affilates rescue each other till both default. Another way of stating this is that in a branch structure the whole group takes advantage of a high probability of bailout for one of the affiliates by creating high leveraage in both affilates. Nevertheless, the group value for the branch structure remains below the group values for the other structures, which can benefit from limited liability for each affilate. In the next section we analyze additional aspect of risk-taking for the different structures.

7 Incorporating systemic risk: Is there a trade-off between bank value and expected loss?

We have so far focused on a value maximizing bank's choice of its organizational structure. From a regulatory point of view it is necessary to consider possible externalities of a bank's activities. Most observers consider contagion effects of a bank's default a negative externality that banks' do not incorporate in decisions with respect to risk. Contagion from a bank's default in the form of an increase in the default risk of other financial institutions is a source of systemic risk. In practice the systemic effect of a bank's default would depend on the magnitude of the losses to creditors as well as the structure of its liabilities to households, firms and other financial institutions. Interconnectedness with other financial institutions is one aspect that generally is thought to increase systemic risk.

The systemic effects of a bank's default in our framework can be expressed as

$$K \times DEL = K(F \exp(-rT) - D_0)$$

where $F \exp(-rT) - D_0$ is the discounted expected loss (DEL) to creditors, namely the difference between the present value of the bank's debt as a safe asset $F \exp(-rT)$ and its actual no-arbitrage value D_0. The exact expressions for the different organizations are given in Appendix C. K represents bank-specific factors affecting the systemic impact of a loss of a particular size. The bigger is the interbank exposure of a bank, the bigger K will be, because, for a given loss, its impact on the system will be bigger. In what follows, to compare different organizational forms, we assume that K is equal across them, namely their interbank exposure is the same, and we focus the analysis on how the expected loss depends on the organizational structure. The reader can well realize that, for the same expected loss, if K is greater for a given affiliate, its final impact on the system will be emphasized. So, intervank exposure works as a multiplier.

We begin the analysis in section 7.1 with a comparison of the expected losses in different organizational structures in the numerical cases with unconstrained leverage presented in section 6. Thereafter, we turn to expected losses with constrained leverage in section 7.2. The results show that the subsidiary structure with mutual rescue has the highest expected loss when leverage is unconstrained and, if leverage is constrained, at a relatively high bailout probability. At a relatively low bailout probability this structure has the lowest expected loss. A high bailout probability in one affiliate causes the highest expected loss in the branch structure. A general result is that a leverage constraint mitigates the conflict of interest between the bank's and the regulator's objectives.

7.1 Unconstrained leverage

Table 6, lines 1 to 4, shows the expected losses in the different organizational structures when debt is endogenized under the same assumptions about parameters as in Tables 1-4. For the subsidiary structures, (OWR and MR) there is one column for each affiliate. The expected losses for the whole groups are shown on separate lines in each case. These lines shows the sum of the two affiliates' expected losses. In the branch structure (BR) only the total expected loss is relevant since the affilates cannot default separately. The expected losses of the stand-alone banks (SA) are shown individually as well as jointly.

Insert here Table 6

Comparing the expected losses of legal entities it can be seen that the home subsidiary in the mutual rescue case has the highest expected loss in each of the first four cases wherein parameters are equal across the affilates. The home (rescuing) subsidiary in the one-way rescue case has the second highest expected loss. The branch bank has a lower expected loss than any one of the subsidiary banks in spite of its larger size. One reason for this result is that the branch bank exploits debt diversity to a lesser extent than the subsidiary structures.

It can be observed that the expected losses in the subsidiary structures occur almost entirely in one of the subsidiaries. Thus, it does not make a difference for the comparisons if we consider the sum of the expected losses in subsidiaries or the expected loss of the most leveraged subsidiary.

The stand-alone banks individually face a slightly lower expected loss than the branch bank while the sum of the expected losses of two stand-alone banks is approximately the same as the expected loss of the branch bank. The expected losses for the subsidiary structures are mostly substantially higher than the expected losses of the branch and the stand-alone banks. The exception occurs when the default cost parameter is at the highest level in case 4 where the subsidiary structure with one-way rescue has a relatively low expected loss as well.

The data in Table 6 for expected losses can now be combined with the data for group values in Tables 1-4 to illustrate in figures how group values and expected losses depend on the organizational structure for each set of parameters. Figures 2 and 3 show the bank values (GV) vertically and the Expected losses (DEL) horizontally for the firt four cases with equal parameters in Table 5.

The base case (1) with relatively low parameter values for the tax effect, default costs and probability of bailout is shown in Figure 2. The branch bank almost dominates the stand-alone banks since the GV for the BR structure is higher at very similar DELs. By organizing the bank in subsidiaries it can increase its value but at the expense of systemic risk as shown by the higher DEL values for the one-way rescue structure and the mutual rescue structure. The subsidiary structures are able to exploit debt diversity and the probability of bailouts at the expense of systemic risk.

Insert here Figure 2

Figures 3 a-c shows other cases with unconstrained leverage. In Figure 3a the default cost parameter has been raised to 10 percent from 5 percent. The pattern from the base case remains. The tax rate is increased to 10 percent in Figure 3b. The pattern remains similar but the expected losses of the OWR and MR subsidiary structures are higher than in the base case because incentives to diversify debt to take advantage of the interest tax shield are higher.

Insert here Figure 3

Both the default cost parameter and the probability of bailout have been raised in Figure 3c relative to the base case. The higher default costs discourage leverage in all the structures. The mutual rescue case still stands out with the highest expected loss and highest value while the other three structures are similar in terms of both value and expected loss. The one-way rescue structure (OWR) has higher value than the branch (BR) and the stand-alone (SA) structures. Thus, if the regulator would want to constrain expected losses, it would prevent mutual rescue, in particular. In more practical terms this would imply strict ring-fencing of the capital in one subsidiary.

The conflict between bank group value (GV) and expected loss (DEL) can be described as a trade-off between these variables from a regulatory point of view. In Figures 2, 3a and 3b the differences in group values are small relative to the differences in expected loss. This means that the costs for the bank of being constrained to organize itself as a branch bank or two stand-alone banks to keep the expected loss low are relatively small. However, when we raise the default costs and the bailout probability in Figure 3c the differences in values are greater relative to the differences in expected loss. Thus, the cost to the bank of not being able to form the mutual rescue structure relative to the benefit to the regulator of reducing the expected loss is relatively high when default costs and probability of bailout are relatively high.

Figure 3d shows that the above results are not robust to the insertion of specific, targeted constraints on leverage. In this case, all organizational forms are forced to lever as much as it is optimal for a branch organization (81 and 108). This compelling constraint is the only one able to challenge the natural tendency of mutual guarantees to be more valued but also more risky: the suboptimality of leverage for the SA makes the couple of SA banks more risky, while the low diversity of debt makes MR and OWR less risky than in the other cases of Figure 3.

We turn now to the case of differential probabilities of bailout. This case was presented in Table 5 and the expected losses in this case are shown in Table 6, line (5). The subsidiary structures and the stand alone structure push leverage very high in the home entity that benefits from the 50% probability of bailouts. The group values and the expected losses are the same in these structures. The group value for the branch structure is slightly lower in Table 5 b but the expected loss is much higher in this structure than in the other three. This result is consistent with the observation from Table 5 that the branch structure increases its leverage substantially in both affilates when one of them enjoys a high probability of bailout. As a result the branch structures contribution to systemic risk becomes the greatest.

In this case with differentiated probabilities of bailouts there is not necessarily a conflict of interest between the regulator's objective to minimize systemic risk and the bank's objective to maximize group value unless the branch structure enjoys operational synergies, which we have not incorporated in the analysis.

7.2 Constrained leverage

To explore the possibility that the conflict of interest between the bank and the regulator is absent or alleviated with constrained leverage, we compare analytically expected losses of the organizational structures when the face values of all affiliates are the same. The analytical results for expected losses can be compared with the comparison of group values in Figure 1 and the Propositions in section 5. This is done in Appendix C below.

A result proved in section 5 and shown in Figure 1 was that for positive default costs and relatively low values for the probability of bailout ($\pi < \pi^{**}$ in the case of the figure)

$$GV_{MR} > GV_{OWR} > GV_{SA}$$

Appendix C shows that

$$\begin{aligned} DEL_{MR} &< DEL_{SA} \\ DEL_{OWR} &< DEL_{SA} \end{aligned}$$

This means that for low values of the probability of bailout there is no conflict of interest between the bank and the regulator, as far as MR or OWR versus SA are concerned, since the former have greater value and smaller loss than the latter. The only conclusion we can draw with respect to comparisons with the branch structure is that if $GV_{BR} > GV_{SA}$ then

$DEL_{BR} < DEL_{SA}$. In this case the systemic risk of the stand-alone banks is clearly the highest while the group value is the lowest.

For relatively high values of the probability of bailout instead ($\pi > \pi^*$ in the case of the figure) we know from section 5 that

$$GV_{SA} > GV_{OWR} > GV_{MR}$$

Appendix C shows that

$$\begin{aligned} DEL_{SA} &< DEL_{MR} \\ DEL_{OWR} &< DEL_{MR} \end{aligned}$$

so that there is no conflict of interest between the bank and the regulator, as far as SA and MR are concerned. The former have greater value and smaller loss than the others. No conclusion can be drawn when comparing BR and other structures.

The general result of this analysis is that the objective of the bank to maximize value and the regulator's objective to minimize systemic risk are consistent in several cases when both the parameters and the face value of debt constraint are the same for the two affiliates. Thus, the conflict of interest between the bank and the regulator that we observed with unconstrained leverage is mitigated.

8 Summary, policy implications and further research

It can be assumed that banks like most corporations choose organizational structures with the objective of maximizing value. Bank regulators, on the other hand, are primarily concerned with systemic risk of bank failures. We have analyzed how banks can exploit financial synergies through organizational choices with consequences for systemic risk in a model that allows for an endogenous interest rate on bank debt and endogenous leverage. The organizational choices differ in their ability to exploit financial synergies generated by a probability of state bailouts, reduced default costs and tax benefits from debt financing. In comparison with existing literature on value effects of multi-affiliate banks' choices, we include a greater variety of organizational structures characterized by different internal arrangements for rescue of an insolvent affiliate.

Value and risk effects of the choice of organizational structure have been analyzed with endogenous leverage and interest rates as well as with a constraint on the face value of debt relative to assets. This constraint can be thought of as a capital requirement on each affiliate.

Although capital requirements constitute the key regulatory instrument to reduce systemic risk, the analysis with endogenous leverage remains relevant since there is strong evidence that capital requirements are not completely effective.[27]

The subsidiary structure with limited liability and the possibility of mutual rescue is value maximizing and, therefore, chosen by shareholders if leverage can be chosen optimally. The subsidiary structure with one-way rescue is also more valuable than the branch and the stand-alone structures. The value advantage of the subsidiary structure with mutual recue

[27] See the corresponding footnote above.

holds in the presence of effective capital requirements as well, if the probability of state bailouts is low or moderate.

The two subsidiary structures with internal rescue arrangements also generate the highest systemic risk with endogenous leverage as long as the probability of bailout is the same for each affiliate. Both the probability of a state bailout and the ability to differentiate leverage across affiliates contribute to this result. It implies that there is a conflict between the bank's objective to maximize the value of financial synergies and the regulator's objective to minimize systemic risk. The regulator would prefer stand-alone banks without rescue arrangements while the banks would prefer the subsidiary structures; in particular the one with mutual rescue.

The conflict of interest between the regulator's and the bank's objectives is mitigated or eliminated when the regulator can impose constraints on leverage through effective and equal capital requirements across affiliates. At a low probability of state bailout the subsidiary structures are preferred over stand-alone banks while the stand-alone banks are preferred over subsidiaries with mutual rescue if the probability of bailout is high.

With endogenous leverage is that the systemic risk associated with a branch structure increases greatly relative to the other structures when the probability of bailout differs between affiliates. The reason is that the branch structures with unlimited internal rescue have incentives to push leverage high in both affiliates based on a high probability of bailout in only one of the affiliates. Although the branch structure is not the bank's value maximizing choice based on financial synergies alone, this result has relevance because a bank may choose a branch structure to exploit operational sysnergies.

Many large banks are organized as bank holding companies across countries and financial services. These structures are consistent with mutual rescue arrangements when they are financially integrated as they often are.[28] The financial integration among subsidiaries within these holding companies suggests that they can adjust leverage across subsidiaries as well as rescue arrangements. If so, they are also sources of systemic risk. This observation rationalizes the proposed reforms of bank organizations in the form of ring-fencing of capital within subsidiary structures. On the other hand, if capital requirements are effective and similar across affiliates, ring-fencing that creates stand-alone banks from a financial point of view lies in the interest of both banks and regulators only if the probability of state bailouts is high.

Carmassi and Herring (2015) and Alexander (2015) have noted that large bank holding companies with many subsidiaries sometimes are de facto branch structures and similar to traditional universla banks. The branch like organization of legally separated subsidiaries is explained by a strong operational integration with the implication that the subsidiries cannot default individually.[29] As noted above the branch organization, wherein all affiliates default jointly, has strong incentives to create high leverage in the whole organization and, thereby, systemic risk if only one affiliate has a high probability of bailout. In this case the regulatory authority has an incentive to separate the affilates to reduce sytemic risk although

[28] Carmassi and Herring (2015) provide examples of Bank Holding Companies with more or less financially integrated structures.

[29] Carmassi and Herring (2013) for instance notes that high default costs in the Lehman Brothers insolvency in 2008 was caused by the close integration of subsidiaries, which enabled Lehman to book assets in ways that obscured the true values of the different subsidiaries.

the private value of the bank will be reduced.

The thrust of organizational reform efforts in the US, UK and the EU is to ring-fence traditional commercial banking financially as well as operationally. The proposed reforms appear to imply requirements for one-way rescue of commercial banking subsidiaries from subsidiaries conducting investment banking and other non-traditional financial activities while rescue in the opposite direction would not be permitted. Our analysis shows that such ring-fencing many times does not reduce systemic risk relative to branch organizations and stand alone banks if the bank subsidiaries can choose leverage. With effective capital requirements the effects on systemic risk depends on the probability of state-bailouts.

Both the US and the EU have implemented reforms with the objective of reducing the probability of bailouts of large as well as small banks. These reforms[30] have not been put to the test and their credibility has been questioned by many observers (Barth and Wihlborg, 2015). There are indications that the probability of bailout has declined as noted in Schich and Kim (2012) but there is little doubt that the probability of bailout for large financial institutions remains substantial.

The analysis in this paper can be extended in several directions.

First, debt can be tranched in different seniority levels, that can be guaranteed or non-guaranteed. For any specific organizational form, the interplay between seniority and guarantees from other affiliates can be specified,[31] and possibly optimized to minimize default probability or maximize group value.

Second, the assumption that the parameters describing default costs, tax rates and return volatility are the same for the two affiliates should be relaxed. An obvious extension of the analysis would be to consider differences in parameter values to capture the complexity of cross-border banks and banks involved in a variety of financial services. A first attempt in this direction is in Luciano and Wihlborg (2016).

Last but not least, for a given expected loss, we argued above that the greater the interbank exposure, the greater the systemic impact of that loss. The model built in this paper parametrizes interbank exposure, since the focus of the study is on the internal (parent-subsidiary versus branch) rescue mechanism and its effect, through endogenous leverage, on value and risk taking. However, a future extension could model that exposure explicitly, optimize it too, and see whether different organizations should take different interbank exposures.

[30] We are referring to the Orderly Liquidation procedures in the Dodd-Frank Act and the Single Resolution Mechanism in the EU.

[31] We anticipated on that in footnote 17.

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9 Appendix A: Values to stakeholders, branch case

This Appendix reports the values of debt and equity of the branch and its home bank. Payoffs to equity and bond holders resemble the subsidiary cases, whenever rescue or bailout occurs. They differ when insolvency occurs, because insolvency is always joint, and default costs are paid on both the assets of the bank originally in default and the assets transferred from the other affiliate. We have the following expression for the branch debt:

$$\begin{aligned} D_{0b} &= +\underbrace{\exp(-rT)\left[F_b - \mathbb{E}\max(0, F_b - L_b(T))\right]}_{\text{value without bailout and rescue}} + \\ &\quad \underbrace{+\exp(-rT)\mathbb{E}\left\{\min\left(L_h(T) - F_h, F_b - L_b(T)\right)\mathbf{1}_{\{R_b\}}\right\}}_{\text{rescue received}} + \\ &\quad \underbrace{+\pi\exp(-rT)\mathbb{E}\left\{\max(F_b - L_b(T), 0)\mathbf{1}_{\{Q_b\}}\right\}}_{\text{government bailout}} + \\ &\quad \underbrace{-\exp(-rT)(1-\pi)\alpha\mathbb{E}\left[\left[L_b(T) + \max(0, L_h(T) - F_h)\right]\mathbf{1}_{\{Q_b\}}\right]}_{\text{default costs}}, \end{aligned}$$

The home-bank equity is

$$\begin{aligned} E_{0h} &= \exp(-rT)\mathbb{E}\max\left[L_h(T) - F_h, 0\right] \\ &\quad -\exp(-rT)\mathbb{E}\left\{\min\left(L_h(T) - F_h, F_b - L_b(T)\right)\mathbf{1}_{\{R_b\}}\right\}, \end{aligned}$$

The home-bank debt is

$$\begin{aligned} D_{0h} &= +\underbrace{\exp(-rT)\left[F_h - \mathbb{E}\max(0, F_h - L_h(T))\right]}_{\text{value without bailout and rescue}} + \\ &\quad \underbrace{+\exp(-rT)\mathbb{E}\left\{\min\left(L_b(T) - F_b, F_h - L_h(T)\right)\mathbf{1}_{\{R'_h\}}\right\}}_{\text{rescue received}} + \\ &\quad \underbrace{+\pi\exp(-rT)\mathbb{E}\left\{\max(F_h - L_h(T), 0)\mathbf{1}_{\{Q'_h\}}\right\}}_{\text{government bailout}} + \\ &\quad \underbrace{-\exp(-rT)(1-\pi)\alpha\mathbb{E}\left[\left[L_h(T) + \max(0, L_b(T) - F_b)\right]\mathbf{1}_{\{Q'_h\}}\right]}_{\text{default costs}}. \end{aligned}$$

The branch equity is

$$\begin{aligned} E_{0b} &= \exp(-rT)\mathbb{E}\max\left[L_b(T) - F_b, 0\right] \\ &\quad -\exp(-rT)\mathbb{E}\left\{\min\left(L_b(T) - F_b, F_h - L_h(T)\right)\mathbf{1}_{\{R'_h\}}\right\}, \end{aligned}$$

The sum gives GV_{BR}.

10 Appendix B: Comparing group value of organizations; analytical results

This Appendix proves Propositions 5.1, 5.2 and 5.3. There are no taxes ($k = 0$), so that $\bar{L}_i = L_i, i = s, h$, both at time 0 and at time T, in all states of the world.

We start from Proposition 5.1.

Proof. Let us compare the values of the unilateral subsidiary arrangement and the mutual one, when the home bank and the affiliate have the same and positive level of deposits, cash flows of the affiliates are equally distributed and $k = 0$. The values are given in the main text. The value of the unilateral arrangement is smaller than the mutual arrangement if and only if the bailout put net of default costs in the home bank - with no support form the affiliate - is smaller than when the subsidiary offers rescue, i.e.

$$\underbrace{\pi \exp(-rT)\mathbb{E}\max(0, F_h - L_h(T))}_{\text{government bailout home}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\left\{L_h(T)<F_h\right\}}\right]}_{\text{default cost home}} <$$

$$\underbrace{\pi \exp(-rT)\mathbb{E}\max\left\{(0, F_h - L_h(T))\mathbf{1}_{\{Q_h\}}\right\}}_{\text{government bailout home w/ mutual support}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home w/ mutual support}}. \quad (23)$$

The event Q_h is not empty, under Assumption 1. Whenever $0 < \pi < 1$, this makes the expectation which represents bailout on the left hand side greater than on the right hand side; the same for default costs (in absolute value), if $\alpha > 0, 0 \leq \pi < 1$. So, the difference on the left hand side can be greater, equal or smaller than the oneoin the right hand side. However, the overall inequality in (23) holds, for any positive value of α, if $\pi = 0$, while the opposite inequality holds for $\pi = 1$, and for any $\alpha > 0$, or $\alpha = 0$. The two sides are equal when $\alpha = \pi = 0$ and in a neighbourhood of it. Since the direction of the inequality (23) changes when π goes from 0 to 1 and α stays positive, and both its left and right-hand side are continuous in π, there is a positive bailout probability, which we call π^*, above which mutual guarantees become worse than unilateral. This concludes the proof. □

Consider now Proposition 5.2.

Proof. Since cash flows from loans L_s and L_b are the same (in distribution), $L_s = L_b$., call the common value of the latter L. Note that the bailout events coincide for the two organizations, i.e. the sets $Q_s = Q_b, Q_h = Q'_h$ coincide for the two organizations. Let us compare the values of the mutual subsidiary and the branch arrangement, which are respectively

$$GV_{MR} = L_{h0}$$
$$+\underbrace{\pi \exp(-rT)\mathbb{E}\max\left[(0, F_h - L_h(T))\mathbf{1}_{\{Q_h\}}\right]}_{\text{government bailout home}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home}}$$
$$+L_0+$$
$$+\underbrace{\pi \exp(-rT)\mathbb{E}\left[\max(F - L(T), 0)\mathbf{1}_{\{\ Q_s\}})\right]}_{\text{government bailout subsidiary}}$$
$$\underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[L(T)\mathbf{1}_{\{\ Q_s\}}\right]}_{\text{default cost subsidiary}},$$

and

$$GV_{BR} = L_{h0} + \underbrace{\pi \exp(-rT)\mathbb{E}\max\left[(0, F_h - L_h(T))\mathbf{1}_{\{\ Q_h\}}\right]}_{\text{government bailout home}} + \\ - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[[L_h(T) + \max(0, L(T) - F)]\,\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home}} + \\ + L_0 + \\ + \underbrace{\pi\exp(-rT)\mathbb{E}\left[\max(F - L(T), 0)\mathbf{1}_{\{Q_s\}})\right]}_{\text{government bailout branch}} + \\ \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[[L(T) + \max(0, L_h(T) - F_h)]\,\mathbf{1}_{\{\ Q_s\}}\right]}_{\text{default cost branch}} \tag{24}$$

The former is greater than the latter if and only if

$$- \underbrace{\alpha(1-\pi)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home s}} \\ \underbrace{-(1-\pi)\alpha\mathbb{E}\left[L(T)\mathbf{1}_{\{\ Q_s\}}\right]}_{\text{default cost subsidiary}} > \\ - \underbrace{\alpha(1-\pi)\mathbb{E}\left[[L_h(T) + \max(0, L(T) - F)]\,\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home b}} + \\ \underbrace{-(1-\pi)\alpha\mathbb{E}\left[[L(T) + \max(0, L_h(T) - F_h)]\,\mathbf{1}_{\{Q_s\}}\right]}_{\text{default cost branch}}.$$

In the subsidiary case, default costs are paid only on the home or the subsidiary cash flows. In the branch case, they also affect the asset transfers from the affiliate ($\max(0, L(T)-F)$) or from the home bank ($\max(0, L_h(T)-F_h)$). As a consequence, default costs in the subsidiary organization are smaller (in absolute value) than default costs in the branch organization, for positive values of α and $0 \leq \pi < 1$, and the previous inequality is satisfied. It follows that the subsidiary organization is more valuable than the branch. When $\alpha = 0$, or $\pi = 1, \alpha > 0$, the two become the same. This concludes the proof. □

Last, let us prove Proposition 5.3, which compares two SA banks with a unilateral and mutual-rescue organization, with no taxes ($k = 0$).

Proof. Let us compare the values of the stand alone and unilateral subsidiary arrangement. The home bank has the same deposits (in distribution) in both cases. If we already name the two affiliates "home" and "subsidiary" when they are stand-alone banks, the values of the two arrangements are respectively

$$GV_{2SA} = L_{h0} \\ + \underbrace{\pi\exp(-rT)\mathbb{E}\max(0, F_h - L_h(T))}_{\text{government bailout home as SA}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{L_h(T)<F_h\}}\right]}_{\text{default cost home as SA}} \\ + L_{s0} + \\ + \underbrace{\pi\exp(-rT)\mathbb{E}\left\{\max(F_s - L_s(T), 0)\right\}}_{\text{government bailout subsidiary as SA}} \\ \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[L_s(T)\mathbf{1}_{\{L_s(T)<F_s\}}\right]}_{\text{default cost subsidiary as SA}}, \tag{25}$$

and

$$\begin{aligned} & GV_{OWR} = L_{h0} \\ & +\underbrace{\pi \exp(-rT)\mathbb{E}\max(0, F_h - L_h(T))}_{\text{government bailout home}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{L_h(T)<F_h\}}\right]}_{\text{default cost home}} \\ & +L_{s0}+ \\ & +\underbrace{\pi \exp(-rT)\mathbb{E}\left\{\max(F_s - L_s(T), 0)\mathbf{1}_{\{\ Qs\}})\right\}}_{\text{government bailout subsidiary}} \\ & \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[L_s(T)\mathbf{1}_{\{\ Qs\}}\right]}_{\text{default cost subsidiary}}. \end{aligned} \tag{26}$$

The difference in value between the SA arrangement and the unilaterally-guaranteed group is

$$\begin{aligned} & (GV_{2SA} - GV_{OWR})\exp(rT) \\ & = + \underbrace{\pi\mathbb{E}\left\{\max(F_s - L_s(T), 0)\right\}}_{\text{government bailout subsidiary as SA}} - \underbrace{\pi\mathbb{E}\left\{\max(F_s - L_s(T), 0)\mathbf{1}_{\{Q_s\}})\right\}}_{\text{government bailout subsidiary}} \\ & \underbrace{-(1-\pi)\alpha\mathbb{E}\left[L_s(T)\mathbf{1}_{\{L_s(T)<F_s\}}\right]}_{\text{default cost subsidiary as SA}} + \underbrace{(1-\pi)\alpha\mathbb{E}\left[L_s(T)\mathbf{1}_{\{\ Q_s\}}\right]}_{\text{default cost subsidiary}}. \end{aligned} \tag{27}$$

Since the returns on loans satisfy Assumption 1, Q_s is not empty. It is also a subset of $L_s(T) < F_s$. This means that, in absolute value, both the bailout put and default costs are smaller in the unilateral case than in the SA one. Since they show up with different signs, the trade-off between them depends on the parameters α and π. If $\alpha = 0$ and $\pi > 0$, only the first two terms in the above expression are non-null, and the value of the SA is greater than the value of a unilateral insurance. The same situation arises when $\pi = 1, \alpha \geq 0$. If $\pi = 0$ and $\alpha > 0$, only the last two terms in the above expression are non-null, and the value of the SA is smaller than the value of a unilateral insurance. Because of continuity of the above expression, it follows that there is a π^{**} above which the SA value becomes greater than the unilateral one. Let us now compare the SA value, given above, and mutual value, i.e.

$$\begin{aligned} & GV_{MR} = L_{h0} \\ & +\underbrace{\pi \exp(-rT)\mathbb{E}\max\left\{(0, F_h - L_h(T))\mathbf{1}_{\{Q_h\}}\right\}}_{\text{government bailout home w/mutual support}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home w/mutual support}} \\ & +L_{s0}+ \\ & +\underbrace{\pi \exp(-rT)\mathbb{E}\left\{\max(F_s - L_s(T), 0)\mathbf{1}_{\{\ Q_s\}})\right\}}_{\text{government bailout subsidiary}} \\ & \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[L_s(T)\mathbf{1}_{\{\ Q_s\}}\right]}_{\text{default cost subsidiary}}. \end{aligned} \tag{28}$$

The difference is

$$(GV_{2SA} - GV_{MR})\exp(rT) =$$

$$\begin{aligned}&+\underbrace{\pi\mathbb{E}\max(0,F_h-L_h(T))}_{\text{government bailout home as SA}}-\underbrace{\pi\mathbb{E}\max\left\{(0,F_h-L_h(T))\mathbf{1}_{\{Q_h\}}\right\}}_{\text{government bailout home w/mutual support}}\\&-\underbrace{\alpha(1-\pi)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{L_h(T)<F_h\}}\right]}_{\text{default cost home as SA}}+\underbrace{\alpha(1-\pi)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home w/mutual support}}\\&+\underbrace{\pi\mathbb{E}\left\{\max(F_s-L_s(T),0)\right\}}_{\text{government bailout subsidiary as SA}}-\underbrace{\pi\mathbb{E}\left\{\max(F_s-L_s(T),0)\mathbf{1}_{\{\ Q_s\}})\right\}}_{\text{government bailout subsidiary}}\\&\underbrace{-(1-\pi)\alpha\mathbb{E}\left[L_s(T)\mathbf{1}_{\{L_s(T)<F_s\}}\right]}_{\text{default cost subsidiary as SA}}+\underbrace{(1-\pi)\alpha\mathbb{E}\left[L_s(T)\mathbf{1}_{\{\ Q_s\}}\right]}_{\text{default cost subsidiary}}.\end{aligned}\tag{29}$$

Since returns on loans satisfy Assumption 1, the event Q_h (in which the home is not rescued by its subsidiary) is not empty. Within each line the first term is greater than the second, in absolute value. As above, let us analyze the difference in value by changing α and π. If $\alpha = 0$ and $\pi > 0$, only the first and third line in the above expression are non-null, and the value of the SA is greater than the value of a mutual rescue. The same situation arises when $\pi = 1, \alpha \geq 0$. Since in these cases the difference between the unilateral and mutual arrangement is

$$+\underbrace{\pi\exp(-rT)\mathbb{E}\max(0,F_h-L_h(T))}_{\text{government bailout home as SA}}-\underbrace{\pi\exp(-rT)\mathbb{E}\max\left\{(0,F_h-L_h(T))\mathbf{1}_{\{Q_h\}}\right\}}_{\text{government bailout home w/mutual support}}>0,$$

we can see that the SA arrangement is preferable to the unilateral, which in turn is better than the mutual (as we knew from the corresponding Proposition). If $\pi = 0$ and $\alpha > 0$, only the second and fourth lines are non-null, and the value of the SA is smaller than the value of a mutual insurance. It was also smaller than the unilateral one in that case. The difference between the unilateral and mutual arrangement in this case is

$$-\underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{L_h(T)<F_h\}}\right]}_{\text{default cost home as SA}}+\underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[L_h(T)\mathbf{1}_{\{Q_h\}}\right]}_{\text{default cost home w/mutual support}}<0,$$

so that the stand alone value is smaller than the unilateral and the latter is smaller than the mutual (as we knew from Proposition 1). Because of continuity of the above expressions, there is a π^{***} above which the SA value becomes better than the mutual one, which is better than the branch. Using Proposition 2 and the comparison between the unilateral and stand alone, such π^{***} is smaller or equal than the maximum between π^* and π^{**}. This concludes the proof. □

11 Appendix C: *DEL*s

The aim of this Appendix is to study the relationship between the discounted expected loss and the group value for alternative structures, when Assumption 2 holds, the face value of debt is exogenously given and equal across affiliates, and $k = 0$. We call this relationship the frontier.

The discounted expected loss for a group:

$$DEL := 2F \exp(-rT) - (D_{0i} + D_{0j}), \tag{30}$$

where F is debt face value, equal for the two affiliates, D_{0i} D_{0j} are specified in each of organizational structure.

We consider the following alternative organizations:

- Stand alone banks, SA. In (30), $D_{0i} = D_{0j} = D_{0sa}$ represents debt value of the single stand alone bank.
- Mutual rescue, MR; here $D_{0i} = D_{0h}$ is the home debt value, while $D_{0j} = D_{0s}$ is the subsidiary debt value .
- Unilateral, OWR; here $D_{0i} = D_{0h}$ is the home debt value, while $D_{0j} = D_{0s}$ is the subsidiary debt value.
- Branch, BR; here $D_{0i} = D_{0h}$ is the home debt value, while $D_{0j} = D_{0b}$ is the branch debt value.

11.1 Two SA banks

The discounted expected loss for two SA banks is given by:

$$DEL = 2(F \exp(-rT) - D_{0sa}),$$

where D_{0sa} is debt value of the single bank affiliate.

Proposition 11.1. *Under Assumption 2, in the SA bank case, the group value, the discounted expected loss and the frontier are given in closed form as:*

$$GV_{SA} = 2(L_0 + \exp(-rT)\pi\mathbb{E}[\max(0, F - L(T))] - \alpha(1-\pi)\exp(-rT)\mathbb{E}[L(T)\mathbf{1}_{\{L(T)<F\}}]), \tag{31}$$

$$DEL_{SA} = 2\exp(-rT)(\mathbb{E}[\max(0, F - L(T))](1-\pi) + \alpha(1-\pi)\mathbb{E}[L(T)\mathbf{1}_{\{L(T)<F\}}]), \tag{32}$$

$$DEL_{SA} = 2(\exp(-rT)\mathbb{E}[\max(0, F - L(T))] + L_0) - GV_{SA}. \tag{33}$$

11.2 MR

In this case, the total (i.e., group) discounted expected loss is given by:

$$DEL = 2F\exp(-rT) - (D_{0h} + D_{0s}), \quad (34)$$

Debt values are given by D_{0h} (home debt value) and D_{0s} (subsidiary debt value) as given in the main text.

Proposition 11.2. *In the mutual rescue case, the group value, the discounted expected loss and the frontier are given in closed form as:*

$$\begin{aligned} GV_{MR} &= 2L_0 + \\ &+ \pi\exp(-rT)\mathbb{E}[\max(0, F - L_h(T))\mathbf{1}_{\{Q'\}}] - \alpha(1-\pi)\exp(-rT)\mathbb{E}[L_h(T)\mathbf{1}_{\{Q'\}}] \\ &+ \pi\exp(-rT)\mathbb{E}[\max(0, F - L_s(T))\mathbf{1}_{\{Q\}}] - \alpha(1-\pi)\exp(-rT)\mathbb{E}[L_s(T)\mathbf{1}_{\{Q\}}] \end{aligned} \quad (35)$$

$$\begin{aligned} DEL_{MR} &= \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \exp(-rT)\mathbb{E}[\max(0, F - L_s(T))]\right) \\ &- \exp(-rT)\left(\mathbb{E}[(F - L_h(T))\mathbf{1}_{\{R'\}}] + \mathbb{E}[(F - L_s(T))\mathbf{1}_{\{R\}}]\right) \\ &- \pi\exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))\mathbf{1}_{\{Q'\}}] + \mathbb{E}[\max(0, F - L_s(T))\mathbf{1}_{\{Q\}}]\right) \\ &+ \alpha(1-\pi)\exp(-rT)\left(\mathbb{E}[L_h(T)\mathbf{1}_{\{Q'\}}] + \mathbb{E}[L_s(T)\mathbf{1}_{\{Q\}}]\right) \end{aligned} \quad (36)$$

$$\begin{aligned} DEL_{MR} &= -GV_{MR} + 2L_0 \\ &+ \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \mathbb{E}[\max(0, F - L_s(T))]\right) \\ &- \exp(-rT)\left(\mathbb{E}[(F - L_h(T))\mathbf{1}_{\{R'\}}] + \mathbb{E}[(F - L_s(T))\mathbf{1}_{\{R\}}]\right), \end{aligned} \quad (37)$$

11.3 OWR

In this case, the total discounted expected loss is given by:

$$DEL = 2F\exp(-rT) - (D_{0h} + D_{0s}), \quad (38)$$

Debt values are given by D_{0h} (home debt value) and D_{0s} (subsidiary debt value) and their expressions are given in the main text.

Proposition 11.3. *In the unilateral case, the group value, the discounted expected loss and the frontier are given in closed form as:*

$$\begin{aligned} GV_{OWR} &= 2L_0 + \\ &+ \pi\exp(-rT)\mathbb{E}[\max(0, F - L_h(T))] - \alpha(1-\pi)\exp(-rT)\mathbb{E}[L_h(T)\mathbf{1}_{\{L_h(T)<F\}}] \\ &+ \pi\exp(-rT)\mathbb{E}[\max(0, F - L_s(T))\mathbf{1}_{\{Q_s\}}] - \alpha(1-\pi)\exp(-rT)\mathbb{E}[L_s(T)\mathbf{1}_{\{Q_s\}}] \end{aligned} \quad (39)$$

$$\begin{aligned} DEL_{OWR} &= \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \exp(-rT)\mathbb{E}[\max(0, F - L_s(T))]\right) \quad (40) \\ &- \exp(-rT)\mathbb{E}[(F - L_s(T))\mathbf{1}_{\{R\}}] \\ &- \pi \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \mathbb{E}[\max(0, F - L_s(T))\mathbf{1}_{\{Q_s\}}]\right) \\ &+ \alpha(1-\pi)\exp(-rT)\left(\mathbb{E}[L_h(T)\mathbf{1}_{\{L_h(T)<F\}}] + \mathbb{E}[L_s(T)\mathbf{1}_{\{Q_s\}}]\right) \end{aligned}$$

$$\begin{aligned} DEL_{OWR} &= -GV_{OWR} + 2L_0 \quad (41) \\ &+ \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \mathbb{E}[\max(0, F - L_s(T))]\right) \\ &- \exp(-rT)\mathbb{E}[(F - L_s(T))\mathbf{1}_{\{R_s\}}], \end{aligned}$$

11.4 BR

In this case, the total discounted expected loss is given by:

$$DEL = 2F\exp(-rT) - (D_{0h} + D_{0s}), \quad (42)$$

Debt values are given by D_{0h} (home debt value) and D_{0b} (branch debt value) as in the main text.

Proposition 11.4. *In the branch case, the group value, the discounted expected loss and the frontier are given in closed form as:*

$$\begin{aligned} GV_{BR} &= 2L_0 + \quad (43) \\ &+ \pi\exp(-rT)\mathbb{E}[\max(0, F - L_h(T))\mathbf{1}_{\{Q_h'\}}] \\ &- \alpha(1-\pi)\exp(-rT)\mathbb{E}[(L_h(T) + \max(0, L_b(T) - F))\mathbf{1}_{\{Q_h'\}}] \\ &+ \pi\exp(-rT)\mathbb{E}[\max(0, F - L_b(T))\mathbf{1}_{\{Q_b\}}] \\ &- \alpha(1-\pi)\exp(-rT)\mathbb{E}[(L_s(T) + \max(0, L_b(T) - F))\mathbf{1}_{\{Q_b\}}] \end{aligned}$$

$$\begin{aligned} DEL_{BR} &= \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \mathbb{E}[\max(0, F - L_b(T))]\right) \quad (44) \\ &- \exp(-rT)\mathbb{E}[\min(L_h(T) - F, F - L_b(T))\mathbf{1}_{\{R_b\}}] \\ &- \exp(-rT)\mathbb{E}[\min(L_b(T) - F, F - L_h(T))\mathbf{1}_{\{R_b'\}}] \\ &- \pi\exp(-rT)\left(\mathbb{E}[\max(0, F - L_b(T))\mathbf{1}_{\{Q_b\}}] + \mathbb{E}[\max(0, F - L_h(T))\mathbf{1}_{\{Q_h'\}}]\right) \\ &+ \alpha(1-\pi)\exp(-rT)\mathbb{E}[(L_b(T) + \max(0, L_h(T) - F))\mathbf{1}_{\{Q_b\}}] \\ &+ \alpha(1-\pi)\exp(-rT)\mathbb{E}[(L_h(T) + \max(0, L_b(T) - F))\mathbf{1}_{\{Q_h'\}}], \end{aligned}$$

$$\begin{aligned} DEL_{BR} &= -GV_{BR} + 2L_0 \\ &+ \exp(-rT)\left(\mathbb{E}[\max(0, F - L_h(T))] + \mathbb{E}[\max(0, F - L_s(T))]\right) \\ &- \exp(-rT)\mathbb{E}[\min(L_h(T) - F, F - L_b(T))\mathbf{1}_{\{R_b\}}] \\ &- \exp(-rT)\mathbb{E}[\min(L_b(T) - F, F - L_h(T))\mathbf{1}_{\{R_h{}'\}}], \end{aligned} \tag{45}$$

11.5 Comparison of losses and values across organizations

Using the above expressions, it is easy to show that below π^{**}

$$GV_{MR} > GV_{OWR} > GV_{SA}$$

and above π^*

$$GV_{SA} > GV_{OWR} > GV_{MR}$$

Using the relationship between values and losses, namely the frontier in the above theorems, one can show that below π^{**}

$$DEL_{MR} < DEL_{OWR} + \exp(-rT)E[(F - L_s(T))1_{\{R_s\}}] < DEL_{SA}$$

so that

$$DEL_{MR} < DEL_{SA}$$
$$DEL_{OWR} < DEL_{SA}$$

as stated in the text.

Symmetrically, one can show from the previous expressions that beyond π^*

$$DEL_{SA} < DEL_{OWR} + \exp(-rT)E[(F - L_s(T))1_{\{R_s\}}] < DEL_{MR}$$

which implies

$$DEL_{SA} < DEL_{MR}$$
$$DEL_{OWR} < DEL_{MR}$$

as stated in the text.

Figure 1: Group value GV as a function of the probability of bailout π for default costs > 0, case $\pi^{**} < \pi^{*}$.

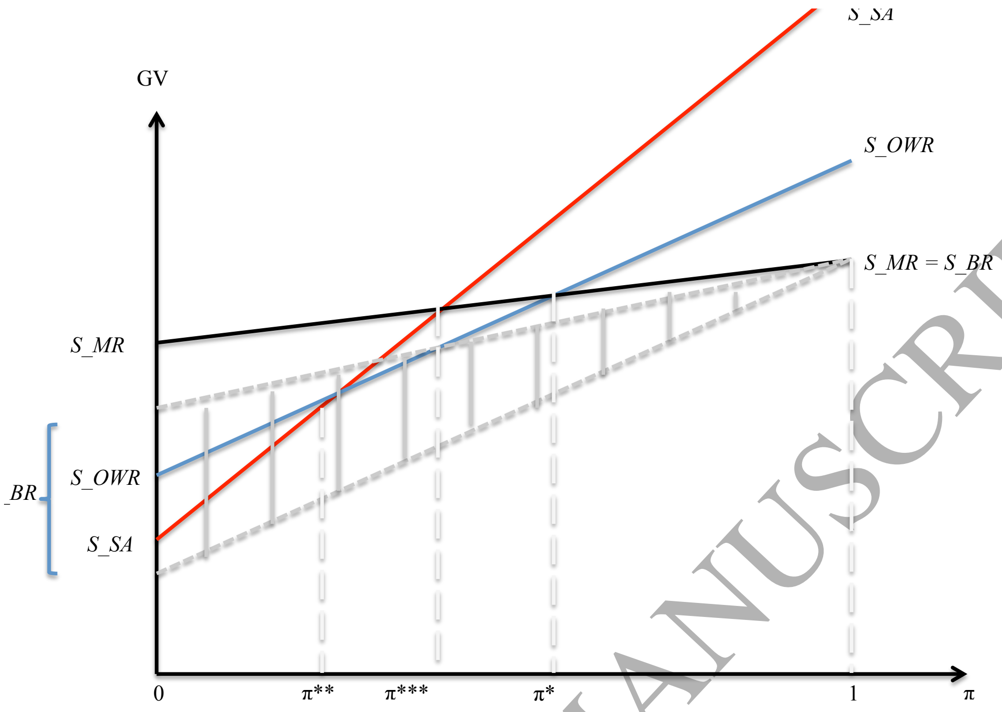

Figure 2: DEL and GV in the base case

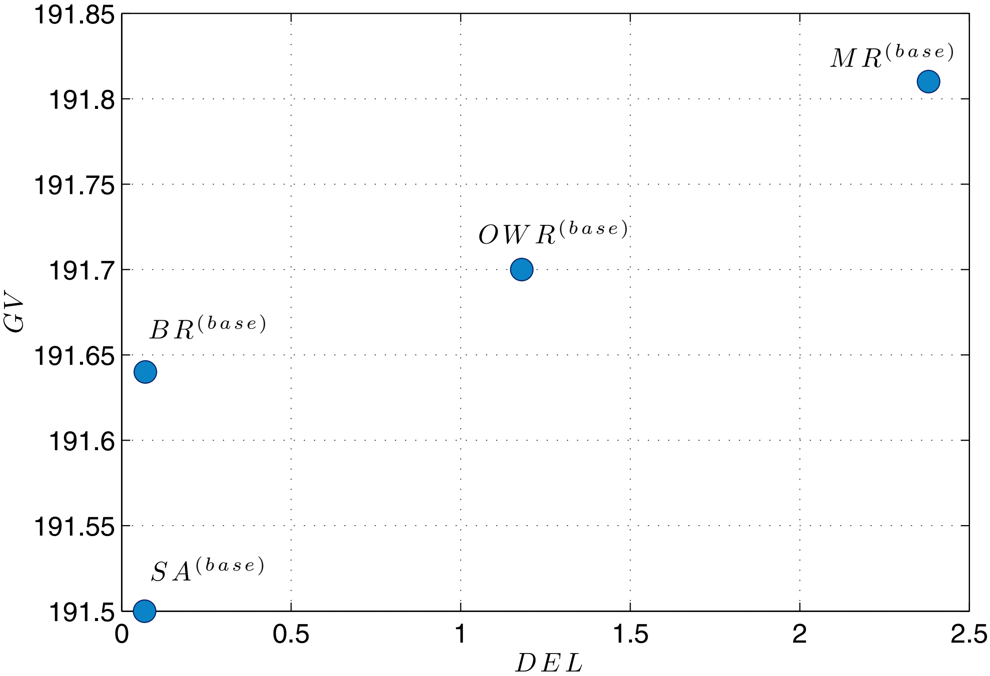

Figure 3: DEL and GV in the cases of Table 5, other than the base case.

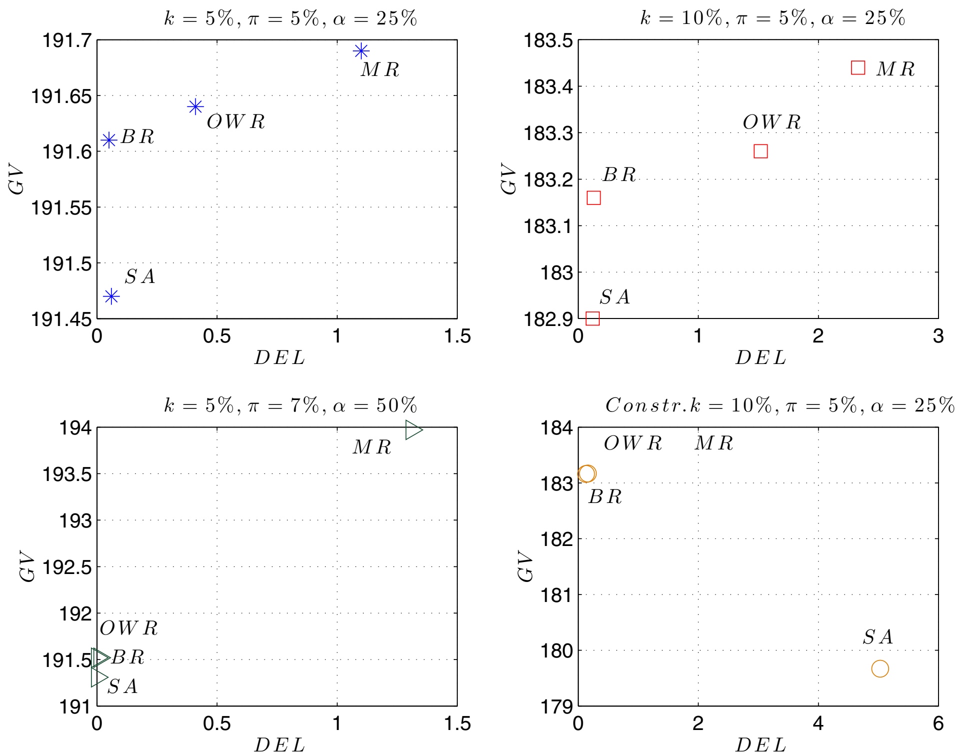

Table 1. Comparison of coinsurance arrangements with unconstrained leverage;
Base case with k=5%, π=5%, α=15%.
GV is group value. Highest GV in bold.

Panel 1. α=15%	Sub_OWR		Sub_MR		BR		2SA	
F	1	202	1	207	84	112	90	90
D_0	0.779	156.14	0.779	158.83	65.42	87.16	70.06	70.06
D_0/E_0	0.022	∞	0.024	∞	2.24	8.87	2.73	2.73
Def. costs	0	0.1502	0	0.3019	0.0018	0.0533	0.0276	0.0276
Bailout Put	0.055		0.223		0.001		0.0006	
GV	191.70		**191.81**		191.637		191.50	

Table 2. Comparison of coinsurance arrangements with unconstrained leverage;
Increasing default cost
k=5%, π=5%, α=25%. GV is group value. Highest GV in bold.

Panel 2. α=25%	Sub_OWR		Sub_MR		BR		2SA	
F	1	195	1	201	83	109	88	88
D_0	0.779	151.46	0,779	155.44	64.64	84.84	68.51	68.51
D_0/E_0	0.020	1.5m	0.022	∞	2.13	7.23	2.48	2.48
Def. costs	0	0.0803	0	0.2152	0.0016	0.0420	0.0239	0.0239
Bailout Put	0.0176		0.1239		0.005		0.0004	
GV	191.64		**191.69**		191.613		191.471	

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Table 3. Comparison of coinsurance arrangements with unconstrained leverage; Increasing the tax rate to k=10% for π=5%, α=25%.
GV is group value. Highest GV in bold.

. k=10% π=5% α=25%	Sub_OWR		Sub_MR		BR		2SA	
F	1	195	1	198	81	108	87	87
D_0	0.779	150.35	0.779	151.88	63.08	83.98	67.69	67.69
D_0/E_0	0.024	∞	0.025	∞	2.32	9.43	2.85	2.85
Def. costs	0	0.3017	0	0.4615	0.0036	0.1059	0.0566	0.0566
Bailout Put	0.0637		0.2959		0.0014		0.0005	
GV	183.26		**183.44**		183.158		182.90	

Table 4. Comparison of coinsurance arrangements with unconstrained leverage; Increasing probability of state bailouts, π, to 7%, for k=5%, α=50%.
GV is group value. Highest GV in bold

k=5% π=7% α=50%	Sub_OWR		Sub_MR		BR		2SA	
F	1	176	1	201	76	101	76	76
D_0	0.779	137.06	0.779	155.23	59.19	78.66	59.19	59.19
D_0/E_0	0.015	54.82	0.021	∞	1.62	4.53	1.62	1.62
Def costs	0	0.0024	0	0.4207	0	0.0027	0.0003	0.0003
Bailout Put	0.0004		2.60		0		0	
GV	191.523		**193.97**		191.522		191.31	

Table 5. Differentiating probabilities of state bailout**.** Comparison of coinsurance arrangements with unconstrained leverage. Home affiliate probability, $\pi_{H,}$ increased to 50% while sub affiliate probability. π_S is 5%, k=10%, α=25%.

k=10% π=5% α=25%	Sub_OWR		Sub_MR		BR		2SA	
F	301	90	301	90	301	301	301	90
D_0	159.92	70.06	159.92	70.06	94.91	159.92	159.92	70.06
Def. costs	7.52	0.03	14.32	0.03	7.54	14.66	7.54	0.03
Bailout Put	66.96	0	73.75	0	73.53		66.96	
GV	**255.67**		**255.67**		254.83		**255.67**	

Table 6. Expected loss for different parameters; $F\exp(-rT)-D_0$; r=0.05, T=5
Total expected loss is the sum of the expected losses for the two affiliates of the subsidiary and branch structures. In the case of the stand-alone banks the total expected loss refers to the sum of the expected losses of the two banks.

Parameter values	SUB_OWR		SUB_MR		BR		2SA	
	Ho-me	Sub	Ho-me	Sub	Home	Sub	Home	Sub
k=5%, π=5%, α=15%	0	1.18	**2.38**	0			0.03	0.03
Total Exp. Loss	1.18		2.38		0.07		0.06	
k=5%, π=5%, α=25%	0	0.41	**1.10**	0			0.03	0.03
Total Exp. Loss	0.41		1.10		0.05		0.06	
k=10% π =5% α=25%	0	1.52	**2.33**	0			0.06	0.06
Total Exp. Loss	1.52		2.33		0.13		0.12	
k=5% π =7% α=50%	0	0.01	**1.31**	0			0	0
Total Exp. Loss	0.01		1.31		0		0	
k=10% π_H=50% π_S=5% α=15%	74.5	0.034	74.5	0.034			74.50	0.03
Total Exp. Loss	74.53		74.53		**214.01**		74.53	