Complex financial institutions and systemic risk

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Abstract

The objective of this paper is to identify the bank organizational structures that generate substantial systemic risk and to explain why banks have incentives for creating them. We seek the explanation in a bank's incentive to exploit financial synergies by choosing an organizational structure that maximizes the benefits the bank can derive from an interest tax shield, reduced default cost and the possibility of a state bailout in the presence of limited liability for legally separate entities. In both a calibrated and some stressed scenarios, we show that subsidiaries generate the highest value and the highest systemic risk. Complexity exacerbates the incentive to lever up in subsidiary structures. It blows up expected losses without having a comparable effect on value. The main sources of complexity in this paper are differences in asset risk and size across bank affiliates in different countries or with different financial activities. We also provide a perspective on current reform efforts with respect to the organization of banks..
KEYWORDS: bank organization, bank risk, bank complexity, financial synergies, endogenous leverage in banking, default costs, bailouts
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The basic organizational problem for a bank adding an affiliate is the choice between operating the affiliate as a stand alone bank, a separately incorporated subsidiary or as a legally integrated division without its own capital. The latter organizational choice is called a branch in the following. Affiliates within a branch structure rely on a common capital base and they draw on this capital until they default jointly. At the other extreme, banks acting as stand alones in our terminology have separate equity, debt and they do not offer each other rescue in case of default. In between branch and stand-alone structures banks may form subsidiary structures wherein each affiliate has its own capital base and owners have limited liability. This does not necessarily mean that the subsidaries are financially independent because within a group structure one or more subsidiaries can support another one to avoid its default. In a nutshell, different organizational structures provide different internal guarantees againts default of one entity: in a subsidiary structure in our teminology the potential

[1]Since operational synergies are not incorporated in the model, policy implications of the analysis here may have to be modified to take such synergies into account.

for rescue goes together with limited contamination relative to a branch structure wherein branches offer unconditional rescue and suffer from unlimited contamination.[2] In reality, these basic distinctions - which correspond to different abilities to exploit financial synergies - are not exactly reflected in the legal organization of complex financial institutions. We return to a discussion of the several facets of complexity but what is most relevant to our description is that it entails heterogeneity in activities, or asset size and return profile. This heterogeneity characterizes banks operating across borders and banks supplying other financial services than traditional commercial banks.

We show in a companion paper (Luciano and Wihlborg, 2015) that, thanks to their different abilities to face default of one entity, different organizational structures have different incentives to lever up, even when they have the same size, volatility of returns, default costs, tax rate. That has an impact on the value to their shareholders. Because of the different optimal levels of debt, different organizations produce also different expected losses to debt holders. We will associate these expected losses with systemic risk below.

This paper shows that complexity arising from different sizes and return distributions of affiliates exacerbates the incentive to lever up in subsidiary structures that produce the greatest value and the greatest systemic risk even in the absence of complexity. Thus, we rationalize the fact that complexity is harmful to the financial system and potentially dangerous, and we quantify the effect of complexity in a calibrated model of banks. Shareholders, in the search for value maximization, have an incentive to choose parent-subsidiary organiza-

[2] Internal default insurance arrangements 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 off subsidiaries in order to save itself or, if a subsidiary is facing distress, the parent can transfer assets to protect the bank's brand name. The presence and effect of rescues, or internal insurance within banking groups, have been studied empirically by Bradley and Jones (2008), as well as by Ashcraft (2004) for the US.

tions, and to lever them up so that systemic risk is much much higher than when complexity does not exist. To anticipate our policy conclusions, we provide examples of capital requirements, ring-fencing measures and insolvency procedures that are not effective in reducing systemic risk, both with and without complexity.

The structure of the paper is as follows: in Section 1 we review some background literature on organizational choices of banks and complexity. In Section 2 we elicit the model developed in Luciano and Wihlborg (2015). In Section 3 we summarize some of its basic properties of the model for the value/systemic risk of banks, by analyzing a calibrated base-case and some stressed scenarios. Effects of complexity as described by size and volatility differences on bank value and systemic risk of different organizational structures are analyzed in Section 4. In Section 5 we discuss the impact of some current reform efforts on value and systemic risk. Section 6 concludes.

1 Background literature

There is a strand of literature in corporate finance on financial synergies arising as a result of the merger of two firms. Leland (2007) and Banal-Estanol, Ottaviani and Winton (2012) 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. 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 paper. 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. They focus on the organizational choice as a trade-off between default costs and tax-savings from debt financing.

An important difference between the models proposed for corporations and banks is that the latter, especially when they become too big or to complex to fail, can benefit from government bailouts of debt holders, in particular. Another difference of relevance for the discussion of systemic risk is that a large share of a bank's liabilities may be held by other banks and financial institutions. Therefore, a bank's failure may result in contagion within the financial system, which then propates to the whole economy. This characteristic of banks is often viewed as the rationale for government bailouts of banks in distress.

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.This is a property often associared with complexity. 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. Thereby the financial conglomerate becomes more transparent endogenously.

Financial synergies play an important role also in Freixas, Loranth and Morrison (2007)[3], which considers a conglomerate bank 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

[3]There are a number of papers considering agency costs and governance problems associated with different organizational structures. These costs or benefits can be viewed as negative or positive operational synergies. See, for example, Boot and Schmeits (2000). Chemmanur and John (1996), Harr and Rønde (2006) and Kahn and Winton (2004). Agency problems also play a role in models of capital regulation and leverage when monitoring efforts are endogenized. Acharya, Mehran and Thakor (2013) analyze how capital regulation affect both risk-shifting and monitoring incentives.

our stand-alone banks - they would be able to shift assets with different risk between themselves. Thereby they incorporate one aspect of complex financial institutions. In our model risk is shifted between subsidiaries through one way or mutual rescue-arrangements. These arrangements cause differences in the degree of financial interdependence among affiliates.

Dell'Ariccia and Marquez (2010) 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 bank with a subsidiary in the presence of economic risk and protection against political risk (of expropriation) in a branch organization. There are no rescues among subsidiaries, however.

Most of the literature that compares organizational structures in banks focuses on the extremes of financially independent subsidiaries and merged financially integrated entities that we call branches. Two exceptions in the literature are Castiglionesi and Wagner (2012), who analyze efficiency properties of interbank insurance against liquidity problems, and Luciano and Wihlborg (2015), who compare the value of banks which create financial synergies through one-way as well as mutual insurance against default, relative to a branch structure on one side and stand-alone banks on the other.

Luciano and Wihlborg (2015) set up a theoretical model for comparing stand-alone banks, holding-subsidiaries and branch structures. They study exogenous leverage first. They then endogenize it and show that, as long as default cost, probability of bailout and tax parameters are similar across affiliates, subsidiary structures, and particularly those providing mutual internal insurance under limited liability, have the highest private group values, but also the highest risk taking, as measured by leverage, expected default costs and discounted losses.

Moving to complexity, there is little explicit modelling; partly because there are so many dimension to complexity. It is often viewed as one aspect of 'too big to fail' since complex banks are generally also large and it is generally presumed that the systemic consequences of a bank's failure is increasing both in size and complexity. Most papers on complexity focus on bank characteristics that increase the systemic consequences of a bank's failure at a given size. Interconnectedness, lack of correspondence between functional and legal organization, operations in several countries with different legal and regulatory frameworks, and operations in several financial areas subject to different regulations are often identified as factors increasing complexity and the systemic consequences of a bank's failure. Barth and Wihlborg (2015) review the literature on complexity and provide data on its different dimensions. Carmassi and Herring (2015) analyze how different aspects of complexity may enhance systemic risk. They also refer to a number of possible reasons for becoming too complex such as economies of scale and scope, regulation and tax rules.

The Financial Stability Board (FSB) uses 'complexity' as one important factor affecting systemic risk and the designation of some banks as G-SIBs (Global Systemically Important Banks). The G-SIB designation is based on interconnectedness, substitutability within the financial institution infrastructure, cross-jurisdictional activity, activity in OTC derivatives and trading activity in addition to size.

There are few theoretical treatments of complexity. Gai et al (2011) develop a network model to study the interplay between complexity, concentration of liabilities and financial system linkages in response to shocks that may cause systemic effects. Complexity is captured by factors increasing intra-financial activities such as a bank's involvement in securitization, and the number of interbank unsecured borrowing and lending links. One result of their analysis is that intra-financial system activity increases the systemic effects of shocks.

In this paper we do not describe complexity on the bank level but we argue that differences in size and return distributions of assets across countries and financial activities are important sources of complexity and systemic risk. We show that different organizational structures differ in terms of value, leverage and systemic risk.

2 The model

This Section models first a single or stand-alone (SA) bank using as a starting point the structural model of Merton (1974) and introducing default costs, taxes and the possibility of external (Governmental) bailout in default. Then it extends the model to banking groups.

2.1 The stand-alone bank

The bank produces a fixed amount of loans at time 0. It may obtain leverage by issuing deposits or debt with an endogenous, competitively determined interest rate. We argue that this creates an incentive to raise leverage so as to exploit lower taxes and the possibility of bailout, and a disincentive determined by default costs.

For the sake of simplicity, consider two points in time only, $t = 0, T$, and classify bank liabilities into deposits and equity. Deposits represent customer as well as interbank net deposits, borrowing from the Central Bank and issued bonds. Equity represents capital and reserves. In order to model deposits in a simple way, we assume that they take the form of zero-coupon debt. They can be withdrawn at maturity[4] T. Both debt and equity - and as a

[4]Structural models of the type we are going to build have proven to be quite resilient to the possibility of liabilities' repayment when the actual value of assets goes under a covenant level. This is why we do not introduce the hypothesis of a "bank run" when the value of deposits falls below a given threshold before T.

consequence the whole firm - are evaluated at fair value, i.e. under the risk neutral measure. Let their fair values be D_0 and E_0. The face value of deposits is denoted by F, and the interest rate accruing on them is the one which indeed makes D_0 their fair value, i.e. the expected value of their final payoff, discounted. $F - D_0$ is the total amount of interests paid by the bank.

To simplify, we label as "loans" all the bank assets. We disregard interbank claims and consider as a unique entity proper loans and securities. In doing that we have in mind mainly commercial banks. The initial value of loans is denoted as $L_0 \in \mathbb{R}$. The value of loans at time T is a non-negative random variable - which we take to be continuous, for simplicity - denoted as $L(T)$. Loans can be traded at any time between 0 and T, and the market for loans is efficient (no transaction costs, no indivisibility). 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 cash flows at T, net of taxes, are[5] $\bar{L}(T) \triangleq (1-k)L(T) + k(F - D_0)$,

Standard absolute priority holds: the cash flows $\bar{L}(T)$ are distributed to depositors and equity holders as follows: depositors receive F, either if this is greater or equal than the asset value $\bar{L}(T)$, or if it is smaller, $\bar{L}(T) < F$ and the government bails the bank out. There is a probability π that this occurs.[6] If $\bar{L}(T) < F$ and there is no bailout, default is assumed to be

[5] Recall that $\triangleq$ means "equal by definition".

[6] Freixas *et al.* (2007) specifies two kinds of debt; insured deposits and non-insured loan funding. We assume here that all deposits are guaranteed with a certain probability because, in the current economic environment, implicit insurance of creditors of all types seems to be the rule rather than the exception. The implicit guarantees cannot be certain, however. This is why we add a parameter π. Last, we do not model explicitly a price for deposit insurance. However, if deposit insurance is paid as a percentage of the face value of deposits, dF, charged to debt holders, if they receive the whole face value, or as a percentage of their recovery, $d\bar{L}$, and does not enter the tax shield, all the results below still hold, provided that the reader reinterprets F as $(1-d)F$.

costly. For the sake of simplicity, we take default costs to be proportional to total cash flows at T, $\alpha\bar{L}(T)$. The value to be distributed to depositors becomes the sum of what equity holders pay to debt holders and, in case of default, what they receive from the government in case of bailout, less default costs if there is no bailout :

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

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:

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

$$\times \left\{ \mathbb{E} \min(F, \bar{L}(T)) + \pi\mathbb{E} \max(F - \bar{L}(T), 0) - \alpha(1-\pi)\mathbb{E}\left[\bar{L}(T)\mathbf{1}_{\{\bar{L}(T)<F\}}\right]\right\} \tag{2}$$

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 (price) on loans, with strike F. The second term is the so-called "default put": (the price of) 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

$$D_0 = \exp(-rT) \left\{ \begin{array}{c} F - (1-\pi)\mathbb{E} \max(0, F - \bar{L}(T)) \\ -\alpha(1-\pi)\mathbb{E}\left[\bar{L}(T)\mathbf{1}_{\{\bar{L}(T)<F\}}\right] \end{array} \right\} \tag{3}$$

The payoffs to equity holders of the bank at T are $\max\left[\bar{L}(T) - F, 0\right]$. Equity holders are long a call on loans' net value, with strike F. The equity value at time 0, E_0, is then

$$E_0 = \exp(-rT)\mathbb{E}\max\left[\bar{L}(T) - F, 0\right]. \tag{4}$$

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

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

$$= \bar{L}_0 + \underbrace{\exp(-rT)\pi\mathbb{E}\max(0, F - \bar{L}(T))}_{\text{bailout put}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\bar{L}(T)\mathbf{1}_{\{\bar{L}(T)<F\}}\right]}_{\text{default costs}}. \tag{5}$$

Bank managers choose the (non-negative) face value of deposits in order to maximize V_{SA}, which represents funds to managers disposal at time 0 comprehensive of dividends in E_0 and the deposits that equity holders cash in at time 0, in D_0.[7] Since bankruptcy costs and benefits from bailouts accrue to depositors, and therefore determine D_0, they are taken into account when choosing F.[8]

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.

Stand-alone banks are defined here as entities that commit to no rescue. If we have two stand-alone banks, their total value is simply be the sum of their values $2V_{SA}$. In the

[7] 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.

[8] Note also that the benefit of the bailout put is here revealed as a higher D_0 for a fixed F (lower deposit rate) while higher bankruptcy costs reduce D_0 (increase the deposit rate). A smaller difference between D_0 and F implies lower costs of leverage.

following when we compare the value of two entities in different organizational structures we set $2V_{SA} = GV_{SA}$ Their optimal face values of deposits would simply be the ones which maximize each affiliate's value separately. Leverage would be chosen independently by each affiliate.

2.2 A bank with two affiliates

In this section we derive expressions for the value of a bank with two affiliates as in Luciano and Wihlborg (2013). The value depends on internal insurance (or rescue) arrangements. The two affiliates are called home bank and either a subsidiary or a branch depending on internal insurance arrangements. These arrangements affect the ability of the bank to exploit sources of financial synergies. The two affiliates can be part of a cross-border bank or they can be producing different financial services as parts of a conglomerate bank organization.

In the following financial synergies exist as a result of default costs, interest tax shields and a positive probability of bailout by the state of any separate legal entity enjoying limited liability. If the home bank organizes its affiliate as a branch the two entities do not separately enjoy limited liability, they default together and they are bailed-out together. The two entities provide internal guarantees for each other as long as there is capital in the bank as a whole. This distinguishes them from parent-subsidiaries, which can default separately. Indeed, if the bank organizes the affiliated activity in a subsidiary both entities enjoy limited liability. They can default and be bailed out individually. Two types of subsidiary organization are considered. In one there is a mutual insurance or mutual rescue. Each affiliate rescues the other affiliate conditional on the survival of the rescuing entity. In the other, which is a subcase of the former, the home bank offers one-way insurance for the subsidiary (or the other way around). It intervenes in order to recapitalize (rescue) the subsidiary if ever the latter is unable to pay back its depositors, provided that rescuing the subsidiary does not trigger the home bank's default.

It lies in the interest of a bank that chooses its value maximizing organizational structure to signal its internal rescue policy to market participants as noted in the introduction. It cannot commit the same way to the government that may bailout the bank and it would seem to be in the bank's interest to avoid rescue costs if it expects to be bailed out. 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.[9] Our model is indeed a perfect, symmetric information one, in which the behavior of the bank is perfectly observable by the government.

To keep the discussion simple, we assume that the tax rate, k, is equal across the affiliates of the bank, so that the final value of net-of-taxes loans of the home bank, subsidiary and branch are $\bar{L}_i(T) = (1-k)L_i(T) + k(F_i - D_{0i}),\ i = h, s, b$.

Later on, in order 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, which rules out perfect positive and negative correlation:

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.[10]

[9] On top of that, specific legislation makes rescue enforcable by law: this is the case of the US "source of strenght" provision.

[10] 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

The overall group value with two affiliates is

$$GV_j = D_{0h} + E_{0h} + D_{0a} + E_{0a} \tag{6}$$

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.

2.2.1 Mutual rescue in the subsidiary organization

When two banks organize themselves in being a home bank and its subsidiary, they remain two separate legal entities, but the home bank offers insurance against default of the subsidiary and vice versa in the mutual rescue case.The insurance consists of providing the subsidiary with assets at T, if the affiliate is in default, conditional on not endangering the safety of the home bank and vice versa.

Rescue of the subsidiary occurs if and only if the home bank is not in default or distress ($\bar{L}_h(T) > F_h$), the subsidiary is in default - i.e. its asset value is below the default level ($\bar{L}_s(T) < F_s$) and rescuing the subsidiary does not drive the home bank into default. Rescue means that, using its surplus $\bar{L}_h(T) - F_h$, the home bank pays that part of the subsidiary deposits that are not covered by its 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, $\bar{L}_h(T) -$

correlated returns (positively and negatively).

$F_h > F_s - \bar{L}_s(T)$. The conditions can be reduced to the event

$$R \triangleq \begin{cases} \bar{L}_s(T) < F_s \\ \bar{L}_h(T) - F_h > F_s - \bar{L}_s(T) \end{cases} \tag{7}$$

Instead the subsidiary defaults if the following event occurs:

$$Q \triangleq \begin{cases} \bar{L}_s(T) < F_s \\ \bar{L}_h(T) - F_h < F_s - \bar{L}_s(T) \end{cases} \tag{8}$$

The state bails out the subsidiary with probability π.

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

$$R' \triangleq \begin{cases} \bar{L}_h(T) < F_h \\ \bar{L}_s(T) - F_s > F_h - \bar{L}_h(T) \end{cases} \tag{9}$$

If this rescue of the home bank does not take place the following default event occurs:

$$Q' \triangleq \begin{cases} \bar{L}_h(T) < F_h \\ \bar{L}_s(T) - F_s < F_h - \bar{L}_h(T) \end{cases} \tag{10}$$

If Q' holds true, there is room for state bailout of the home bank, which occurs with probability π.

For given face value of deposits and initial loans of the home bank and subsidiary, the payoff to depositors of the subsidiary is the payoff to a stand alone bank, augmented by the conditional home-bank support $F_s - \bar{L}_s(T)$ when rescue occurs. Since bailout comes after rescue by the home bank, the subsidiary debt before rescue and bailout is the one we obtained in the stand alone case. Default costs are paid only if there is default, no rescue and no bailout. We have:

$$
\begin{aligned}
D_{0s} &= +\underbrace{\exp(-rT)\left[F_s - \mathbb{E}\max(0, F_s - \bar{L}_s(T))\right]}_{\text{value without bailout and rescue}} + \\
&\quad +\underbrace{\exp(-rT)\mathbb{E}\left\{\left[F_s - \bar{L}_s(T)\right]\mathbf{1}_{\{R\}}\right\}}_{\text{rescue}} + \\
&\quad +\underbrace{\pi\exp(-rT)\mathbb{E}\left\{\max(F_s - \bar{L}_s(T), 0)\mathbf{1}_{\{Q\}}\right\}}_{\text{government bailout}} \\
&\quad \underbrace{-\exp(-rT)(1-\pi)\alpha\mathbb{E}\left[\bar{L}_s(T)\mathbf{1}_{\{Q\}}\right]}_{\text{default costs}}
\end{aligned}
\tag{11}
$$

Since the assets for rescue come from the home bank, rescue diminishes the equity value of the home-bank in comparison with (**??**). The equity value of the home bank becomes

$$
\begin{aligned}
E_{0h} &= \exp(-rT)\mathbb{E}\max\left[\bar{L}_h(T) - F_h, 0\right] \\
&\quad -\exp(-rT)\mathbb{E}\left\{\left[F_s - \bar{L}_s(T)\right]\mathbf{1}_{\{R\}}\right\},
\end{aligned}
$$

where the first term represents the home bank equity without a subsidiary.

Rescue of the home bank by the subsidiary affects the payoffs to the debt holders of the home bank positively since it entails a transfer to them if the event R' is true, as follows:

$$\begin{aligned} D_{0h} &= +\underbrace{\exp(-rT)\left[F_h - \mathbb{E}\max(0, F_h - \bar{L}_h(T))\right]}_{\text{value without bailout and rescue}} + \\ &\quad +\underbrace{\exp(-rT)\mathbb{E}\left\{\left[F_h - \bar{L}_h(T)\right]\mathbf{1}_{\{R'\}}\right\}}_{\text{rescue received}} + \\ &\quad +\underbrace{\pi\exp(-rT)\mathbb{E}\left\{\max(F_h - \bar{L}_h(T), 0)\mathbf{1}_{\{Q'\}}\right\}}_{\text{government bailout}} \\ &\quad \underbrace{-\exp(-rT)(1-\pi)\alpha\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\{Q'\}}\right]}_{\text{default costs}}, \end{aligned} \tag{12}$$

Symmetrically, equity holders of the subsidiary are deprived of part of their cash flows if the rescue event R' is true:

$$\begin{aligned} E_{0s} &= \exp(-rT)\mathbb{E}\max\left[\bar{L}_s(T) - F_s, 0\right] \\ &\quad -\exp(-rT)\mathbb{E}\left\{\left[F_h - \bar{L}_h(T)\right]\mathbf{1}_{\{R'\}}\right\}, \end{aligned}$$

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, GV_{MR}, which can be written as:

$$\begin{aligned} &\bar{L}_{h0} + \underbrace{\pi\exp(-rT)\mathbb{E}\max\left\{0, F_h - \bar{L}_h(T))\mathbf{1}_{\{Q'\}}\right\}}_{\text{government bailout home}} - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\{Q'\}}\right]}_{\text{default cost home}} \\ &+\bar{L}_{s0}+ \\ &+\underbrace{\pi\exp(-rT)\mathbb{E}\left\{\max(F_s - \bar{L}_s(T), 0)\mathbf{1}_{\{Q\}})\right\}}_{\text{government bailout subsidiary}} \\ &\underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[\bar{L}_s(T)\mathbf{1}_{\{Q\}}\right]}_{\text{default cost subsidiary}} . \end{aligned} \tag{13}$$

where $\bar{L}_{i0} = (1-k)L_i(0) + \exp(-rT)\ k_s(F_i - D_{0i}), i = h, s$. This formulation says that the home-bank plus subsidiary value is given by 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.. Rescue payments cancel out because they are paid by one stakeholder (equity owners of one affiliate) to debt holders of the other. The group value can be split as in the stand-alone case even though the events of default and bailout are different.

2.2.2 One-way rescue in the subsidiary organization

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:

$$E_{0s} = \exp(-rT)\mathbb{E}\max\left[\bar{L}_s(T) - F_s, 0\right] \tag{14}$$

$$D_{0h} = \exp(-rT)\times$$

$$\times\left[F_h - (1-\pi)\mathbb{E}\max(0, F_h - \bar{L}_h(T)) - \alpha(1-\pi)\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\left\{\bar{L}_h(T)<F_h\right\}}\right]\right]. \tag{15}$$

The formulas for the subsidiary debt and home-bank equity of the mutual case remain in force, since their payoffs are not affected. It follows that the overall value of the subsidiary organization, with unilateral guarantee, GV_{OWR}, is

$$\begin{gathered}
\bar{L}_{h0} + \underbrace{\pi \exp(-rT)\mathbb{E}\max(0, F_h - \bar{L}_h(T))}_{\text{government bailout home}} + \\
-\underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\bar{L}_h(T)\mathbf{1}_{\left\{\bar{L}_h(T)<F_h\right\}}\right]}_{\text{default cost home}} \\
+\bar{L}_{s0} + \\
+\underbrace{\pi \exp(-rT)\mathbb{E}\left\{\max(F_s - \bar{L}_s(T), 0)\mathbf{1}_{\{Q\}})\right\} +}_{\text{government bailout subsidiary}} \\
\underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[\bar{L}_s(T)\mathbf{1}_{\{Q\}}\right]}_{\text{default cost subsidiary}}
\end{gathered} \quad . \tag{16}$$

The home bank plus subsidiary value, 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. Default costs are paid by the home bank as in the SA case; they are paid by the subsidiary only if there are no rescue and no state bailout. A similar decomposition of value can be obtained if rescue goes only from the subsidiary to the home bank.

2.2.3 Rescue in the branch organization

Consider now the branch case. 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 with equity assigned internally to them based on the volatility of each affiliates's return and the correlation between affiliate returns. 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. We expect this lack of limited liability to be a source of contamination that affects branches negatively relative to subsidiary structures, exactly as the Sarig effect deprives mergers of value (see Sarig (1985), Leland (2007), Balan-Estanol et al. (2012)). Rescue is mutual, but is not conditional on survivorship of the guarantor. So, support from the home bank to the branch is offered whenever.

$$R_b \triangleq \begin{cases} \bar{L}_h(T) > F_h \\ \bar{L}_b(T) < F_b \end{cases} \tag{17}$$

while support in the other direction occurs when

$$R'_b \triangleq \begin{cases} \bar{L}_h(T) < F_h \\ \bar{L}_b(T) > F_b \end{cases} \tag{18}$$

These events substitute for R, R'. The transfer in the two events is respectively

$$\min\left(\bar{L}_h(T) - F_h, F_b - \bar{L}_b(T)\right), \tag{19}$$

$$\min\left(\bar{L}_b(T) - F_b, F_h - \bar{L}_h(T)\right). \tag{20}$$

It does not necessarily cover the difference between the face value of debt of the guaranteed company and its own cash flows, but it is the minimum between that difference and the extra-cashflows of the guarantor. So, the whole bank defaults when either the home or the branch are insolvent, and their affiliate has not enough cash flows to rescue:

$$R_b \text{ and } \bar{L}_h(T) - F_h \quad < \quad F_b - \bar{L}_b(T) \tag{21}$$

$$R'_b \text{ and } \bar{L}_b(T) - F_b \quad < \quad F_h - \bar{L}_h(T) \tag{22}$$

In these cases, there is the possibility of government bailout. This happens when one affiliate is insolvent and the other entity is either insolvent or unable to rescue because the minimum above is $\bar{L}_h(T) - F_h$ or $\bar{L}_b(T) - F_b$. Whenever the state intervenes, there has been joint insolvency of the branch and home bank. If the state does not bailout there are default costs. The event in which bailout of the branch occurs is

$$Q_b \triangleq \begin{cases} \bar{L}_b(T) < F_b \\ \bar{L}_h(T) - F_h < F_b - \bar{L}_b(T) \end{cases} \tag{23}$$

The event in which bailout of the home bank occurs is

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

The home bank can maximize the overall value by choosing how many deposits to raise directly and through its branch. The overall group value, GV_{BR}, can be written as:

$$\begin{gathered} \bar{L}_{h0} + \underbrace{\pi \exp(-rT)\mathbb{E}\max\left\{0, F_h - \bar{L}_h(T))\mathbf{1}_{\{Q_b'\}}\right\}}_{\text{government bailout home}} + \\ - \underbrace{\alpha(1-\pi)\exp(-rT)\mathbb{E}\left[\left[\bar{L}_h(T) + \max(0, \bar{L}_b(T) - F_b)\right]\mathbf{1}_{\{Q_b'\}}\right]}_{\text{default cost home}} + \\ +\bar{L}_{b0} + \\ + \underbrace{\pi \exp(-rT)\mathbb{E}\left\{\max(F_b - \bar{L}_b(T), 0)\mathbf{1}_{\{Q_b\}})\right\}}_{\text{government bailout branch}} + \\ \underbrace{-(1-\pi)\alpha\exp(-rT)\mathbb{E}\left[\left[\bar{L}_b(T) + \max(0, \bar{L}_h(T) - F_h)\right]\mathbf{1}_{\{Q_b\}}\right]}_{\text{default cost branch}} \end{gathered} \tag{24}$$

The home-bank plus branch 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.

Comparing the analytics of the branch case with the case of subsidiries with mutual resuce it can be observed that in the branch case bank defaults whenever $\bar{L}_h(T) + \bar{L}_b(T) < F_h + F_b$ while in the subsidiary case there will be situations when the same condition holds but one subsidiry 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 the subsidiary organization can save on default costs relative to the branch structure.

3 Analysis of value and systemic risk

In order to analyze the role of endogenous leverage we apply a numerical method for finding the face value of debt that maximizes the value to be distributed to the stakeholders of the bank. In sub-Section 3.1 we specify a distribution for returns on loans, G. A number of numerical cases are specified in sub-Section 3.2 where we compare optimized group values of different organizational structures at different values for the tax rate, the bailout probability and default costs. Then in sub-Section 3.3 we introduce the expected loss as a measure of the systemic risk of a bank with a particular structure.

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. The numerical cases analyzed below illustrate the typical behaviour of the different organizations. They are robust to the choice of other sets of parameters for volatility and correlation.

For each single bank, we assume that log returns on loans Y, defined by $L(T) = L_0 \exp(Y)$, are Gaussian with mean $\mu = (r - \sigma^2/2)T$ and variance $\sigma^2 T$. In each case the initial value of the loans from each entity is the same, $L_0 = 100$. The time horizon is set to five years, $T = 5$, and the instantaneous riskless rate is conventionally set to 5%. Up to this point, the calibration is taken from Leland (2007), which represented non-financial BBB firms. In order to tailor the parameter choice to financial firms, and in the absence of estimates of banks' assets (as opposite to equity) volatilities for recent periods, we set $\sigma =$ 5% per year. This is taken from the seminal paper for financial intermediaries of Marcus and Shaked (1984), and is below the fifth percentage of asset volatility for non-financial firms recently obtained by Schaefer and Straebulaev (2008). We take a conservative 5% parameter in comparison to the most recent parameter for non-financial firms to reflect the discrepancy between financial and non financial firms illustrated in the seminal paper. In all cases the correlation between asset returns in the two affiliates is 0.2, as in Leland. In order 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. To begin with these parameters are the same across affiliates in order to highlight how the different factors affect value and leverage.

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 state bailout probability is difficult to assess, even though 5% is consistent with estimates in Dam and Koetter (2012). The default cost parameter is initially set slightly below the 20 percent used by Leland

(2007).

In Tables 1-3 the banks maximize the private group value, GV, at different parameter values. 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 value of the bailout put for the group and the group value, $GV = D_0 + E_0$.

3.1 Comparing group values

Insert here Tables 1-3

In Table 1, Panel 1 we present the base case with relatively low values for all parameters. A first observation is that the subsidiary structures with unilateral as well as mutual rescue choose to shift most of the deposits to one subsidiary. This "debt diversity" exists even for small $k > 0$ as a result of the interest tax shield. Tax benefits of debt can be maximized by concentrating leverage to one of the subsidiaries.[11] The stand-alone banks are by definition not able to take advantage of debt diversity. The branch structure chooses some debt diversity 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 (GV), and that both the subsidiary structures have higher GVs than the branch (BR) and the stand-alone structures ($2SA$). The subsidiary structures are best able to take advantage of financial synergies by adjusting leverage. The default costs

[11] Luciano and Nicodano (2014) obtained this result for the one-way rescue case. In the mutual recue case the same result holds because by concentrating debt to one subsidiary the likelihood of rescue is shifted towards one subsidiary.

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 1 Panel 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 2 we raise the tax rate to 10 percent while other parameters remain the same as in Table 1, Panel 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 2 in comparison to Table 1, Panel 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 3. 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 3. 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 3. 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. 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 3 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.

The last numerical exercise presented in Table 4 asks how constrained leverage affects the ranking when the tax shield benefit is taken into account. We expect this case to increase the relative value of branches, since the branch structure can exploit the tax advantage through some debt diversity within its corporate structure while the constrained subsidiary structures cannot.

We derive numerical solutions for optimized private values of each organization using the same parameters as in Table 2. The tax rate, k, is 10 percent, the bailout probability, π, is 5 percent and the default costs, α, are 25 percent. The capital requirements we impose on the affiliates of the subsidiaries and the stand-alone banks are equal to the optimized unconstrained face values of debt for each of the branch bank affiliates. Thus, the branch bank optimizes its total face value of debt for the whole bank while the other banks are constrained for each legal entity. The face values of deposits for the branch bank's affiliates are 81 and 108 as in Table 2. In Table 4 these face values are imposed on the subsidiary banks and the stand-alone banks as well.

Table 4 shows that the subsidiary structure with mutual rescue still reaches the highest group value followed by the subsidiary structure with one-way rescue and the branch structure. The group value, GV, of the latter is closer to those of the subsidiary structures than in the unconstrained case in Table 2.

Insert Table 4 here

As a general conclusion we can state that leverage constraints offset the value advantage of the subsidiary structures relative to the branch structure in the presence of benefits from an interest tax shield.

3.2 Is there a trade off between bank value and expected loss?

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 – and ultimately on consumers – 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 all creditors, households and firms as well as other financial institutions.

The systemic effects of a bank's default in our framework can be expressed as $K(F\exp(-rT)-D)$ where the parenthesis expresses the expected loss to creditors and K represents bank-specific factors affecting the systemic impact of a loss of a particular size. The expected loss within the parenthesis is the difference between the value of the bank's debt in the absence of default possibilities ($F\exp(-rT)$) and its actual no-arbitrage value, D_0. Since we are comparing the systemic effects of the default of a particular bank with different organizational structures, we consider K a constant and focus the analysis on how the expected loss depends on the organizational structure.

Table 5 shows the expected losses in the different organizational structures under the same assumptions about parameters as in Tables 1-4. In the subsidiary cases there is one column for each affiliate, as well as a column for the whole group. This column shows the sum of the two affiliates' expected losses. The branch organization has only one column since the affiliates cannot default individually. The expected losses of the stand-alone banks are shown individually as well as jointly.

Table 5 here

The first four cases in Table 5 show expected losses for different parameters when leverage is unconstrained. 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 the first four cases representing unconstrained leverage. 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. The reason for this result is that the branch bank exploits debt diversity to a lesser extent than the subsidiary structures and that the branch bank affiliates rescue each other if one is insolvent.

It can be observed that the expected losses in the subsidiary cases 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 maximum expected loss for the stand-alone banks is approximately the same as for the branch bank. The maximum expected losses for the subsidiary structures are mostly substantially higher than the maximum for the branch and the stand-alone banks. The subsidiary structure with one-way rescue has a low expected loss when the default cost parameter is high in case 4 but the expected loss for the subsidiary with mutual rescue remains high in this case as well.

The last case in Table 5 shows the expected losses in the constrained case corresponding to Table 4 above. The expected losses of the subsidiary structures decline substantially but remain higher than the expected loss of the branch structure. The expected loss of the stand-alone bank with relatively high leverage is now much higher than the expected losses of the subsidiaries with the same leverage. This result illustrates that the expected loss of a stand-alone bank is more sensitive to a leverage constraint than the subsidiary and the branch structures, wherein there is a degree of co-insurance.

Figures 1 and 2 show the Bank values (GV) vertically and the Expected losses (DEL) horizontally for the cases in Table 5. The base case with relatively low parameter values for the tax effect, default costs and probability of bailout is shown in Figure 1. The branch bank (BR) almost dominates the stand-alone banks since GV 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 (OWR) and the mutual rescue structure (MR).

Figure 1 here

Figures 2 a-c shows the other cases with unconstrained leverage while Figure 2d shows the case with leverage constraint from Table 5. In Figure 2a 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 2b. 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.

Figure 2 (a-d) here

Both the default cost parameter and the probability of bailout have been raised in Figure 2c 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 OWR bank has higher value than the BR and SA structures. Thus, if the regulator would want to constrain expected losses, it would prevent mutual rescue but allow one way rescue. In more practical terms this would imply ring-fencing of one subsidiary that would not be permitted to rescue the other one but would receive rescue from the latter.

Let us look at trade-offs in the sense of the increase in expected loss relative to the increase in bank value from moving from one structure to another. Value differences are small relative to the changes in expected loss in Figures 1, 2a and 2b but when we raise the default costs and the bailout probability in Figure 2c 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 MR structure relative to the benefit to the economy as a whole of reducing the expected loss is relatively high when default costs and probability of bailout are relatively high.

Finally, we turn to the case of constrained leverage in Figure 2d. The picture is very different with the financially independent stand-alone banks as the structure with the highest expected loss as well as the lowest value. The other structures are very similar in terms of both (higher) value and (lower) expected loss. This means that banks should be encouraged to implement rescue policies as opposed to strong ring-fencing, if the regulator is able to enforce strict capital requirements.

4 Effects of complexity

In this section we analyze effects on a bank's choice of organizational structure of factors that contribute to complex, or rather, complicated structures while retaining the assumption that the bank is transparent from the point of view of financial market participants. We extend the numerical analysis of the previous section to consider differences in size and volatility of the two affiliates, which measure the complexity of a bank.[12] These differences may apply to the affiliates of a cross-border bank or a conglomerate financial institution providing both traditional banking services and, for example, investment banking services.

Starting from the base case in the previous section we first reduce the size of the second affiliate to half the size of the home affiliate while all parameters remain unchanged. In other words, the loans of the two affiliates are 100 and 50. The top panel of Table 6 repeats the group values and the expected losses of different structures in the base case in Table 1 while the second panel shows the case with a smaller affiliate. Both the subsidiary structures (MR and OWR) increase the leverage of the home bank as well as the subsidiary's. They take advantage of debt diversity by increasing the face value of debt of the smaller subsidiary. The face value and, therefore, the leverage of the smaller subsidiary (in terms of loans) actually increases substantially in both the MR and the OWR cases. The high leverage of the small subsidiary leads to a dramatic increase in the expected loss of this subsidiary from 2.38 to

[12]Differences in expected returns are not studied because we assume that investors are risk-neutral (or, equivalently here, that evaluations are done under the risk-neutral measure). All the bank loans return the riskless rate in expectation.

176.67 for the MR bank and from 1.18 to 176.70 for the OWR bank. The group value of the smaller bank (153.48 for the MR) with 3/4ths of the loan value of the larger bank is substantially greater than 3/4ths of the group value of the larger bank (143.86). In other words, with two different-size subsidiaries the bank is able to increase its value relative to loans at the expense of a substantial increase in systemic risk.

Table 6 here

The branch bank (BR) with different size affiliates does not take advantage of debt diversity to the same extent as the subsidiary banks. The expected loss of the branch bank increases from .07 in the base case to 2.38 in the smaller bank. The group value in the smaller branch bank (141.95) actually falls relative to 3/4ths of the value of the larger bank (143.73). The expected loss and the group value of two stand alone banks are simply 3/4 of the base case values. Thus, in comparison with two stand alones the subsidiary banks can take advantage of the size difference while the branch bank actually loses relative to the two stand-alones.

The third and fourth panels in Table 6 show group values and expected losses for equal-size affiliates with different volatilities. In panel 3 the home affiliate has a high return volatility of 0.2 while the volatility for the other affiliate remains 0.05. The subsidiary banks concentrate the high leverage to the high volatility home subsidiary, which in the OWR bank is the rescuing affiliate. The expected losses of the high volatility subsidiary are very large in both cases. The group value of the MR bank is higher than the group value of the OWR bank, which is only slightly higher than the group value of the branch bank. The expected loss of the latter is quite small, however. Clearly, the MR bank dominates the

OWR since the latter has a lower group value and a higher expected loss. The branch bank does not create as much leverage and as a consequence its expected loss is small although its value is only slightly lower than the OWR subsidiary bank.

In panel 4 the home bank has a lower volatility than the other affiliate. The leverage for the two affiliates of the MR bank and the branch bank are simply reversed, and the group values and the expected losses are the same as in Panel 3. The OWR bank now becomes identical in leverage, group value and expected loss to the MR bank. Both subsidiary banks concentrate the leverage to the high volatility subsidiary, which in the OWR case is the one that can receive rescue. The group values of the subsidiary banks are higher than the group values of the branch bank but as in the previous case the higher values are obtained at the expense of very large expected losses.

Figure 3 here

These results are illustrated in Figure 3 where the expected loss (DEL) is shown along the horizontal axis and the group value (GV) along the vertical axis. Each organizational structure has one symbol for the different cases in this figure. It is clear that no structure dominates in all cases although from a regulatory point of view the expected losses associated with the subsidiary structures are more extreme in this figure than in figures 1 and 2 where all parameters were identical for the two affiliates.

From a regulatory point of view the implication of the analysis is that subsidiary banks that would be chosen based on group value are associated with very high systemic risk unless capital requirements are imposed when there are differences between the affiliates in terms of size and volatility. The branch bank and the stand-alone banks, in particular, cause relatively little systemic risk. The branch bank is actually dominated by the stand-alone banks in the case when there is a difference is size.

Complexity exacerbates the incentive to lever up in those structures, namely parent-subsidiaries, that already produce the greatest value and the greatest systemic risk in the absence of complexity. In this sense, we rationalize the fact that complexity is harmful to the economic system and potentially dangerous, and we quantify the effect of complexity in a calibrated model of banks. Shareholders, in the search for value maximization, have an incentive to choose parent-subsidiary organizations, and to lever them up so that systemic risk is much much higher than when complexity as defined here does not exist. The increse in value from greater leverage with complexity is not commensurate to the increase in expected losses: the reader can appreciate the differential effect by comparing the value and expected losses range in Figure 2 and 3: while the former is not so different, the latter is.

5 Complexity and policy reforms affecting organizational structure.

In reality the designation of organizational structures may be more blurred than the one we have used in the model. In particular, the functional organizations of banks with cross-border operations or banks supplying a variety of financial services do not necessarily coincide with the legal organizations. Therefore, the legal entities may not be easily separable from each other if a functional area or the bank as a whole faces distress. The ambiguity in the definition of subsidiaries and branches is an additional aspect of complexity. A bank like J.P. Morgan Chase with its more than 5000 subsidiaries is likely to be a combination of the organizational structures we have analyzed. Some functional areas are likely to operate across a number of subsidiaries that must default jointly as in a branch organization in our terminology. Other subsidiaries may be both functionally and legally well defined and separable in default without internal rescue arrangements as in our stand-alone banks. The units we call subsidiaries with mutual or one-way rescue arrangements are likely to consist of a number of separate subsidiaries that combine into a functional unit. This combined subsidiary unit under a bank holding company (BHC) is likely to be supported by other affiliates through internal financial arrangements through the holding company structure.

Banks differ in their internal financial arrangements. Carmassi and Herring (2015) note that, for example, HSBC and Banco Santander seem to operate in many countries with subsidiaries with substantial financial independence while banks like J.P. Morgan Chase and Citibank operate across borders in closely integrated subsidiaries that are more akin to branch organizations.

The lack of clear insolvency procedures for cross-border banks also has implications for the designation of affiliates in different countries as branches or subsidiaries with internal rescue arrangements. An affiliate in a particular county may legally be defined as a subsidiary but inability to implement insolvency procedures for the subsidiary on its own may force the bank to rescue operations as in a branch organization.

Several banking sector reform proposals have consequences for the organization of complex banks in terms of our distinction between different internal insurance arrangements among affiliates. Thereby, they also have consequences for the systemic risk of banks with international operations or involvement in other services than traditional commercial banking. The broad areas of reform are capital requirements, ring-fencing of affiliates and insolvency procedures for banks.

5.1 Capital requirements

As shown in Table 4, capital requirements on the level of a subsidiary would negate the value enhancement a subsidiary structure can obtain through debt diversity and internal rescue arrangements. Thereby, the systemic risk consequences associated with subsidiary structures could be eliminated or reduced. This requires that the capital requirements are truly binding through enforcement. There is evidence that Basel's risk-weighted capital requirements have not been effective in reducing banks' risk-taking.[13]

Another aspect of capital requirements of relevance in the context here is that they can be implemented either on each subsidiary or the parent bank. In our analysis of leverage constraints what mattered to mitigate systemic risk in subsidiries was a constraint imposed on the subsidiary. The Basel Committee as well as regulators in the EU and the US have over time shifted emphasis towards the consolidated leverage of multi-affiliate banks. Within our framework, constraining the consolidated leverage would still allow banks to exploit debt diversity and, thereby, concentrate the systemic risk in one or a few subsidiaries.

5.2 Ring-fencing

The second type of reform involves requiring banks to legally and functionally separate certain particularly risky activities or simply barring banks from those activities altogether. For example, the Vickers report proposes 'ring-fencing' of retail banking from investment banking in the UK. In the U.S., the Volcker Rule under Dodd-Frank prohibits an insured

[13] For example, Blundell-Wignall and Roulet (2013) show that a simple leverage ratio is strongly associated with default risk while the risk-weighted ratio is not.

depository institution or its affiliates from engaging in “proprietary trading.” In other words, proprietary trading in the US and investment banking in the UK must take place in a subsidiary that must not be rescued by the commercial bank. However, the proprietary trading subsidiary or the investment banking subsidiary may still be able to contribute to the rescue of the commercial bank subsidiary. In this case described we have one-way rescue. We have seen that there are incentives to create high leverage in the high risk and relatively small subsidiary with ability to come to the rescue of another affiliate. Thus, if the default of this subsidiary has systemic consequences, this type of ring-fencing may not reduce systemic risk.

5.3 Insolvency procedures

The third type of reform involves changes to the framework for dealing with the collapse of big or systemically important banks. There are two motivations behind such policies: first, to better ensure the stability of the system; second, to alert market participants that banks are more likely to be allowed to fail and that creditors will be forced to take losses. That awareness is perceived to remove advantages that big banks have previously enjoyed by being considered too big to fail. Within our framework, effective and credible insolvency procedures for banks would reduce the probability of bailouts. Although this reduces the value of the bailout put in our framework, strong incentives to concentrate leverage to one subsidiary (or few) remain and, thereby, high systemic risk.

6 Concluding comments

We have analyzed aspect of complexity in bank organizations in a model where banks can exploit financial synergies by their choice of internal arrangements for rescue of failing affiliates. Complexity originates in differences in size and asset- return distributions for the affiliates. The organizational structures were evaluated in terms of total value and expected loss to creditors in default, which was used as a proxy for contribution to systemic risk.

The numerical analysis incorporated default costs, a probability of state bailout and an interest tax shield as sources of financial synergies. Subsidiary structures were defined by the ability to rescue an affiliate subject to limited liability without threatening the whole bank. Rescue arrangements were either mutual or one-way. In branch structures rescue was not limited with the consequence that affiliates default jointly. In stand-alone banks there were no rescues but affiliates were financially independent.

The main result was that banks would generally prefer subsidiary structures with mutual rescue arrangements and, to a lesser extent, one-way rescue arrangements in the absence of leverage constraints. These subsidiary structures were also associated with the greatest systemic risk. Taking complexity into account the systemic risk of subsidiary structures increased dramatically relative to branch and subsidiary structures while value differences were small in comparison.

The regulator with the objective to minimize systemic risk would want to discourage subsidiary structures with internal rescue arrangements and prefer stand-alone structures ahead of branch structures. Stand-alone structures within a multi-affiliate bank would require operational as well as financial ring-fencing of functionally and legally separate affiliates. Potential costs of such structures would be an inability to exploit operational synergies between affiliates.

There are several aspects of ongoing work on financial sector regulation that could affect banks' choices of organizational structure as well as the systemic risk of the structures. These reforms include capital requirements, ring-fencing of affiliates and bank insolvency procedures. We provided examples of reforms, which are ineffective in reducing systemic risk.

A next research step could be an equilibrium model in which policy makers choose the reforms anticipating banks' optimal behavior. We expect this to mitigate the leverage and systemic risk outcome of some organizational forms, and in particular the disruptive effect of complexity on systemic risk.

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Figure 1: DEL and GV in the base case

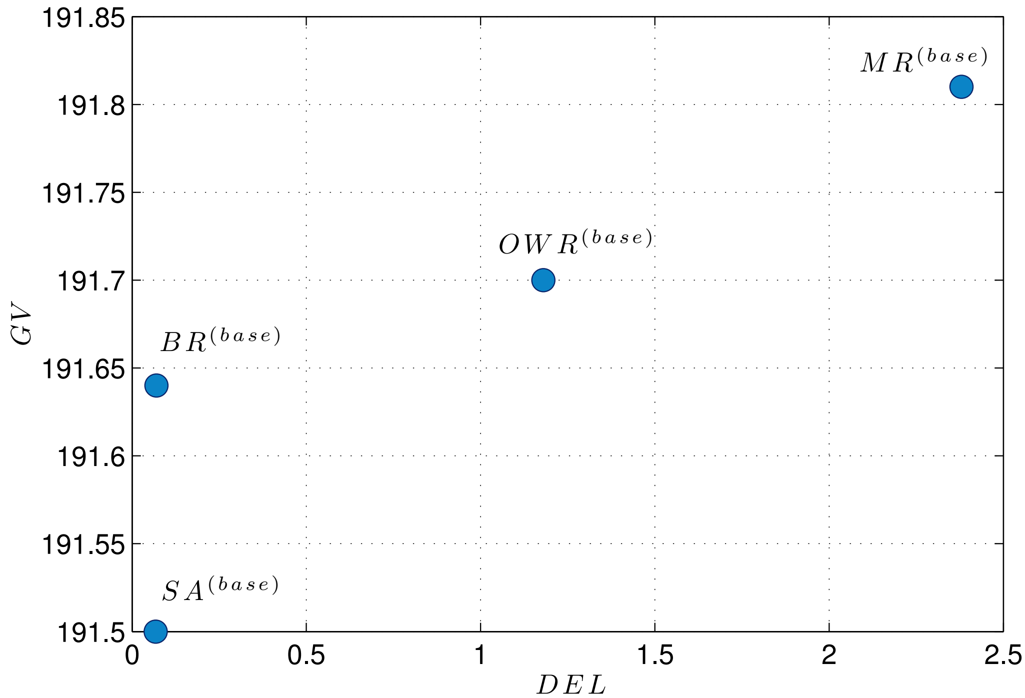

Figure 2: DEL and GV in the cases of Table 5, other than the base case.

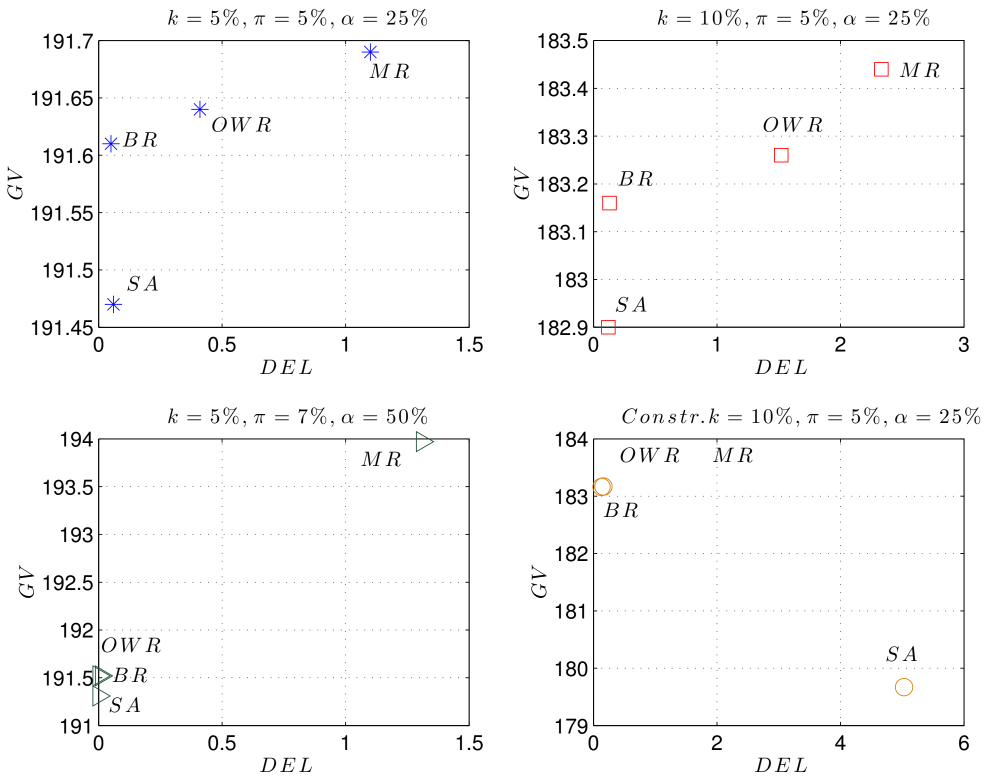

Figure 3: DEL and GV in the cases of Table 6.

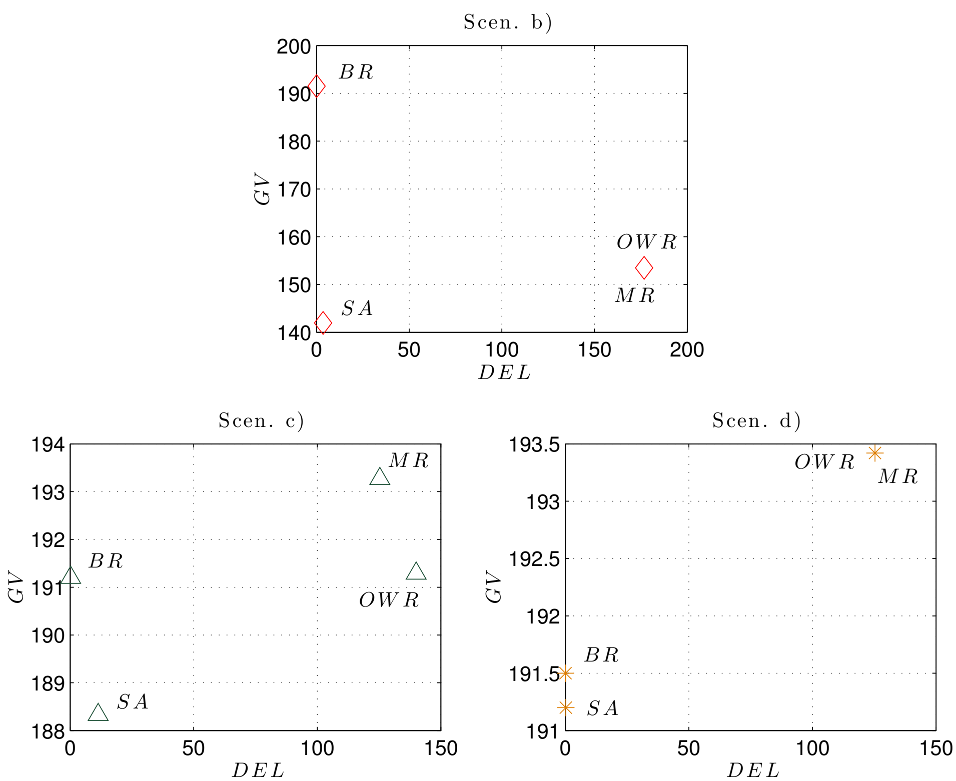

Table 1: Comparison of coinsurance arrangements with unconstrained leverage; Base case with $k = 5\%$, $\pi = 5\%$, $\alpha = 15\%$ in Panel 1, then increasing α to 25% in Panel 2. GV is group private value; SV is group social value.

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	
SV	**191.644**		191.58		191.636		191.50	
GV-k200	1.70		**1.81**		1.637		1.50	
SV-k200	**1.644**		1.58		1.636		1.50	

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	
SV	**191.62**		191.57		191.612		191.470	
GV-k200	1.64		**1.69**		1.613		1.471	
SV-k200	**1.62**		1.57		1.612		1.470	

Table 2: Comparison of coinsurance arrangements with un constrained leverage; $k = 10\%$ for $\pi = 5\%$, $\alpha = 25\%$. GV is group private value; SV is group social value.

. 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	
SV	**183.19**		183.15		183.157		182.89	
GV-k200	3.26		**3.44**		3.158		2.90	
SV-k200	**3.19**		3.15		3.157		2.89	

Table 3: Comparison of coinsurance arrangements with unconstrained leverage; increasing π to 7%, for $k = 5\%$, $\alpha = 50\%$. GV is group private value; SV is group social value.

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	
SV	**191.523**		191.37		191.522		191.31	
GV-k200	1.523		**3.97**		1.522		1.31	
SV-k200	**1.523**		1.37		1.522		1.31	

Table 4: Comparison of coinsurance arrangements with constrained leverage; Face value for all organizational structures equal to the branch face value; $k = 10\%$ for $\pi = 5\%$, $\alpha = 25\%$. GV is group private value; SV is group social value.

k=10% π=5% α=25%	Sub_OWR		Sub_MR		BR		2SA	
F	81	108	81	108	81	108	81	108
D_0	63.08	83.95	63.08	83.95	63.08	83.98	63.08	79.08
D_0/E_0	2.32	9.43	2.32	9.43	2.32	9.43	2.23	8.60
Def. costs	0.0065	0.0947	0.0036	0.0947	0.0036	0.1059	0.0065	4.026
Bailout Put	0.0039		0.0039		0.0014		0.053	
GV	183.172		**183.174**		183.158		179.67	
SV	183.168		**183.170**		183.157		179.62	
GV-k200	3.172		**3.174**		3.158		-.33	
SV-k200	3.168		**3.170**		3.157		-.38	

Table 5: Expected loss for different parameters; $Fexp(-rT) - D_0$; $r = 0.05$,$T = 5$. 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 standalone banks the total expected loss refers to the sum of the expected losses of the two banks.

Parameters	Sub_OWR			SUB_MR			BR	2SA		
	Home	Sub	Total	Home	Sub	Total	Total	SA1	SA2	Total
k=5%, π=5%, α=15%	0	1.18	1.18	2.38	0	2.38	0.07	0.03	0.03	0.06
k=5%, π=5%, α=25%	0	0.41	0.41	1.10	0	1.10	0.05	0.03	0.03	0.06
k=10% pi=5% α=25%	0	1.52	1.52	2.33	0	2.33	0.13	0.06	0.06	0.12
k=5% pi=7% α=50%	0	0.01	0.01	1.31	0	1.31	0	0	0	0
Constr. k=10% pi=5% α=25%	0	0.16	0.16	0	0.16	0.16	0.13	0	5.03	5.03

Table 6: Expected loss for different parameters; Fexp(-rT)-D0; 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 standalone banks the total expected loss refers to the sum of the expected losses of the two banks. Numbers in italics are not obtained at an interior maximum but at a constrained max (301) or min (1).

	MR_h	MR_s	OW_h	OW_s	BR_h	BR_s	SA_h	SA_s
Base Case: $L_h=L_s=100$, Vol.=0.05, Corr.=0.2, k=0.05, $\pi=0.05$, $\alpha=0.15$ From Table 1, Panel 1								
F	1	207	1	201	84	112	90	90
Exp Loss	0	2.38	0	1.18	0.07		0.03	0.03
Total	2.38		1.18		0.07		0.06	
GV	191.81		191.70		191.64		191.50	
$Size_h>Size_s$: $L_h=100$, $L_s=50$, Vol.=0.05, Corr.=0.2, k=0.05, $\pi=0.05$, $\alpha=.15$								
F	91	*301*	91	*301*	71	101	90	45
Exp Loss	.048	*176.67*	.048	*176.70*	2.92		.03	.015
Total	*176.72*		*176.74*		2.92		0.045	
GV	*153.48*		*153.48*		141.95		143.625	
$Vol_h>Vol_s$: $L_h=L_s=100$, $Vol_h=0.20$, $Vol_s=0.05$, Corr.=0.2, k=0.05, $\pi=0.05$, $\alpha=.15$								
F	301	1	301	91	63	87		90
Exp Loss	125.34	0	139.52	.048	.21			.03
Total	125.34		139.99		.21			
GV	193.28		191.29		191.20			
$Vol_h<Vol_s$: $L_h=L_s=100$, $Vol_h=0.05$, $Vol_s=0.20$, Corr.=0.2, k=0.05, $\pi=0.05$, $\alpha=.15$								
F	1	301	1	301	87	63	90	
Exp Loss	MR=OW (mirror image of MR $Vol_h>Vol_s$)				Mirror image of $Vol_h>Vol_s$		.03	
GV	193,28		193.28		191.20			