A New Capital Regulation For Large Financial Institutions

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Abstract

We design a new, implementable capital requirement for large financial institutions (LFIs) that are "too big to fail". Our mechanism mimics the operation of margin accounts. To ensure that LFIs do not default on either their deposits or their derivative contracts, we require that they maintain a cushion of equity and junior long-term debt sufficiently great that the credit default swap price on the long-term debt stays below a threshold level. If the CDS price moves above the threshold, the LFI can issue new equity to bring it back down. If this effort fails and the CDS price stays above the threshold for a predetermined period of time, the regulator intervenes. We show that this mechanism ensures that LFIs are always solvent, while preserving some of the benefits of debt.

1. Introduction

If there is one lesson to be learned from the 2008 financial crisis, it is that large financial institutions (LFIs) are too big to fail.[1] This may be for (sound) economic reasons or (less sound) political economy ones. The economic reasons are that LFIs are highly interconnected through a web of contracts, that the failure of one will lead to the failure of others, and that while the economy can survive the loss of a single LFI it cannot survive the loss of the entire financial sector. The political economy reasons are that politicians cannot resist the pressure by the public or by the LFIs themselves to intervene in a crisis.

Of course, a regime in which LFIs won't be allowed to go bankrupt in the normal way can impose large costs on society. First, there is the possibility of large future taxpayer losses to cover bail-outs. Second, knowing that they will be saved, LFIs may engage in risky behavior that will help to bring about the very crisis that society is trying to avoid. We already see signs that the market has understood that large LFIs may, paradoxically, be safer after the crisis than before. Large banks, which before the crisis could borrow at 29 basis points below small banks' borrowing rates, can today borrow at 78 basis points below. For the 18 bank holding companies with more than $100 billion in assets the 49bps advantage corresponds to a $34.1 billion subsidy a year.[2]

Given that society will bear the ex post costs of LFI failures there is a strong argument for regulating LFIs ex ante to mitigate these costs. The question, of course, is what form should the regulation take. Many suggestions have been made. These include limiting the size of LFIs; restricting the kinds of activities an LFI can undertake (as in the former Glass-Steagall act and the "Volcker plan" that is part of the 2010 Dodd and Frank Act); encouraging LFIs to plan for their own demise by writing living wills; issuing debt that converts into equity if the company is in trouble ("COCO bonds"); constraining executive pay; or requiring LFIs to take out contingent capital insurance.[3] In this paper we argue for a different approach. We suggest that, rather than micro-managing the

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[1] The too-big-to-fail doctrine is not new (Stern and Feldman, 2004), but its practical relevance has often been questioned (Meltzer, 2004).

[2] Baker and McArthur (2009).

[3] For proposals to restrict bank size, see, for example, Fisher (2010); to restrict activities, see Kotlikoff (2010); for living wills, see Goodhart and Schoenmaker (2010); for convertible bonds, see Squam Lake Report (2010);for constraining executive compensations, see Bebchuck and Spamann (2009); for contingent capital insurance, see Acharya et al. (2010) and Kashyap et al. (2008).

activities of an LFI, it might be better to implement an early warning system that will alert the regulator to the fact that an LFI is in trouble. The regulator can then intervene before the damage spreads to other institutions and social costs are incurred. We propose a mechanism that achieves this goal. It is market-based and minimizes policy-maker discretion. It also avoids bail-outs.

In broad terms, our mechanism mimics the way margin calls function. In a margin account an investor buys some stock, putting down only part of the cost. When the stock price drops, the broker who extended the loan asks the investor to post additional collateral. The investor can choose between posting new collateral (and in so doing re-establishing the safety of the position) or having his position liquidated (which allows creditors to be paid in full). With a dynamic system of margin calls, the broker minimizes the amount of collateral posted by the investor, while at the same time ensuring that the debt is paid with probability one.

Our capital requirement system works in a similar way. First, we distinguish between an LFI's "systemically relevant" obligations, e.g., bank deposits, short-term interbank borrowing, derivative contracts; and its "non-systemically relevant" ones, e.g., long-term debt. We regard the systemic obligations as sacrosanct—they should be protected in all circumstances. In contrast the non-systemic obligations can at least in principle be impaired (although it is a feature of our mechanism that this will not happen in equilibrium) because they are not generally held by other financial institutions. This debt is typically held in the portfolios of mutual funds and pension funds, which can absorb losses on the debt in the same way that they absorb losses on equity investments. In our mechanism the systemic obligations would be explicitly senior, while the non-systemic ones would be explicitly junior.[4] (In the current system, this priority is implicit rather than explicit.)

Not only do we allow an LFI to have non-systemic obligations, we *require* it. That is, an LFI would be forced to have a minimum ratio of junior long-term debt to assets as in the Basel III proposal. Moreover, LFIs would have to post enough collateral

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[4] An LFI could also issue secured debt, which would lie between systemic and non-systemic debt in seniority.

(equity) to ensure that the junior long-term debt, as well as the systemically relevant debt, is paid in full.

 In our capital requirement system, when a fall in the value of the underlying assets puts the junior debt at risk, LFI equity-holders are faced with a margin call and they must either inject new capital or lose their equity. There are three main differences between our system and standard margin calls: the trigger mechanism, the action taken if the trigger is activated, and the presence of the additional cushion of junior long-term debt. In a margin account the broker looks at the value of the investments (which is easily determined since all assets are traded) and compares the value of the collateral posted with the possible losses the position might have in the near future. If the collateral is insufficient to cover an adverse movement in the value of the position, the broker calls for more collateral. In the LFI case, the value of investments (i.e., the value of the LFI's assets) is not easily calculable, because the underlying assets—commercial loans and home equity lines, for example—are not standardized and not frequently traded. Thus it is not easy to determine when the margin is too thin to protect the existing debt.

To solve this problem we rely on the price of a credit default swap (CDS) on an LFI's junior long-term debt as the trigger. A credit default swap is an insurance claim that pays off if the LFI fails and creditors are not paid in full. Since the CDS is a "bet" on the institution's strength, its price reflects the probability that the junior long-term debt will not be repaid in full. In essence, the CDS indicates the risk that the LFI will fail. As we will explain, the CDS is a better indicator than equity, because equity prices capture also the upside and thus might disguise the probability of default when the assets are very volatile. As an alternative to the CDS we could use the yield on the junior long-term debt, although this debt tends to be less liquid than the CDS.

In our mechanism, when the CDS price rises above a critical threshold, the LFI can issue equity to bring it down. If this effort fails and the CDS price stays above the threshold for a predetermined period of time, the regulator intervenes. (The criterion for intervention might be that the average CDS price over the previous month exceeds 100 basis points.)

The role of the regulator is the second difference from a standard margin call system. Debt-holders of an LFI are often dispersed and so cannot coordinate their actions:

one of the regulator's roles is to act as a coordinator. If the regulator intervenes she first determines whether the LFI debt is at risk – in effect, she carries out a "stress test". If she finds that the long-term debt is not at risk (i.e., the CDS prices were inaccurate), then she declares the company adequately capitalized and to prove it injects some government money. If, on the other hand, she finds that the debt is at risk, the regulator eliminates all the debt except for the systemic obligations and replaces the CEO with a receiver (or trustee). The receiver's task is to raise as much cash as possible from the new "debt-lite" firm. To this end he may sell it (possibly after running it for a while); alternatively, he may recapitalize the firm and raise cash by carrying out an IPO. Any cash raised is used to pay off creditors—however, they receive a haircut (at least 20%, say). Shareholders are wiped out. Any remaining funds go to the taxpayer. This regulatory takeover is similar to a milder form of bankruptcy, and it achieves the goals of bankruptcy (discipline on the investors and management) without imposing systemic costs.

The third difference from a standard margin call system is the layer of junior long-term debt. This debt has a dual function: to provide extra protection for the systemic obligations and to provide the underlying asset on which the CDS is traded.

As will become clear below, the stress test and haircut are important features of our approach. The stress test prevents "bear raids" that can lead to the liquidation of a healthy LFI. The haircut ensures that the CDS price provides an accurate assessment of an LFI's probability of default.

One of the advantages of our approach is that it is easily applicable to all financial institutions regardless of their organizational structure. One of the weaknesses of the current capital requirement system is that it applies only to certain types of institutions (commercial banks, but not investment banks or hedge funds), creating ample opportunity for regulatory arbitrage. In contrast, our rule can be applied to all financial institutions holding assets in excess of a predetermined threshold ($200 billion, say).

Our mechanism belongs to the category of market-based corrective actions, analyzed by Bond et al. (2010). We eliminate the possibility of multiple equilibria, however, by having the regulator impose a cost on bondholders even when the debt can be paid back in full (this does not happen on the equilibrium path).

Our capital requirement mechanism resembles in some respects the interesting proposal by Flannery (2005), which has been refined by many others (Albul et al (2010), McDonald (2010), Flannery (2009), Pennacchi et al. (2010), Raviv (2009), Squam Lake Working Group on Financial Regulation (2009)). In this proposal debt is converted into equity when the value of equity becomes close to zero. This solution has some potential shortcomings. First, it is lenient toward management, eliminating one of the disciplinary effects of debt. Second, it can have perverse effects: the manager talking down the stock so as to obtain more slack. Third, it can generate a self fulfilling equilibrium, in which the equity price is low because the market anticipates that equity will be diluted in a debt conversion.[5] These shortcomings have been addressed in a recent proposal advanced by the Squam Lake Working Group on Financial Regulation (2009). This proposal conditions the conversion of the debt on two events: the declaration by the regulator that the financial system is suffering a systemic crisis and the violation by the bank of covenants in the "convertible" debt security. Apart from the exact mechanism, the main practical difference between this proposal and ours is the timing: our proposal tries to prevent systemic crises, while the Squam Lake Working Group proposal tries to minimize the costs when a crisis occurs.

Our proposal is also similar to Duffie (2010), who advocates the use of a mandatory offer to existing shareholders to purchase new equity at a low price when a financial institution fails to meet a stipulated liquidity or capital requirement. In fact, we provide a market-based trigger for such a requirement.

In addition our proposal is related to that of Kashyap et al. (2008), who devise a form of state contingent insurance to inject capital in the banking sector during a systemic crisis. The two proposals have in common that they both rely on a contingent capital rule. They differ, however, in that our proposal relies only on firm-level information, while their proposal depends on aggregate information. We discuss the differences further below. Finally, our market-based trigger is similar to various proposals to use subordinated debt as a signal of bank solvency (see, e.g., Calomiris (1999) and, for a comprehensive survey, Evanoff and Wall (2000)). While the idea of using the market to

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[5] Pennacchi et al. (2010) eliminate the possibility of multiple equilibria by giving shareholders the option to buy back the shares at the issuing price. This modification does not resolve (in fact, it exacerbates) the first concern: that convertible debt becomes too lenient toward management.

collect information is common to both sets of proposals, the mechanism and the trigger differ. More importantly, we explain how a debt instrument can provide valuable market signals even if the institution is not allowed to go into bankruptcy.

Our proposal follows the micro approach to prudential regulation in that it deals with the perverse incentives at the company level, but it does not address the possible underinvestment problem that will occur at the macro level if all financial institutions find themselves in trouble and try to deal with this by shrinking their lending rather than raising new equity. Kashyap and Stein (2004) propose to address this problem by having an adjustable capital requirement, which depends possibly on the business cycle. Our proposal can easily be merged with theirs, since the CDS trigger can be indexed to macroeconomic factors.

The rest of the paper proceeds as follows. Section 2 describes the framework. Section 3 presents the main results. Section 4 extends the model to the case where LFI activities are endogenous; in particular, the LFI can choose how much risk to undertake. Section 5 provides further discussion of our mechanism and describes how it would work in practice. Section 6 concludes.

2. Framework

As we have noted, the economic logic of "too big to fail" is based on the idea that financial institutions are highly interconnected through derivative and repo contracts and that the default of one might trigger losses for counterparties, producing further defaults. To function properly the financial system needs to operate under the assumption that certain assets, such as deposits, are "worry free", i.e., depositors do not have to monitor counterparty solvency. This belief saves a tremendous quantity of resources, permitting the system to operate more efficiently. But this belief can be supported only if the prompt and full repayment of "sensitive" or "systemically relevant" obligations is not in question. In this respect, even the risk of some minor bureaucratic delay in repayment can undermine confidence. For this reason, we assume that the role of regulation is not only to eliminate the risk of losses on systemic obligations, but also to protect such obligations

from the uncertainty triggered by a default on non-systemic obligations. In short, we suppose that the regulator wants to avoid bankruptcy altogether.[6]

In what follows, we categorize as systemic obligations short-term interbank borrowing, derivative contracts, and bank deposits; while we consider long-term debt as non-systemic. We refer to non-systemic obligations as "financial debt".

From the issuer point of view, there may be various advantages to issuing systemic obligations over non-systemic ones; for example, they may incur a lower interest rate.[7] In our formal model we will not include the advantages of systemic obligations (although we will relax this assumption at the end of Section 3). Indeed our formal model does not deal with the issue of why an LFI issues sensitive obligations, such as bank deposits, at all. To put it another way our model is as much one of a regular company such as General Motors as it is of Citigroup or AIG. In future work we hope to deal more thoroughly with what is special about a financial institution. Note, however, that the current approach has one advantage. The recent crisis suggests that some non-financial firms are also too big to fail, and our mechanism may be relevant for them as well.

To the extent that our model applies to a generic company we have to explain why such a company raises capital by issuing debt rather than equity. There are several possible reasons. First, debt may be cheap to the extent that it is implicitly backed by the government. Second, debt has certain tax advantages. Third, debt reduces agency costs.

In our model we focus on this last reason--the agency benefits of debt-- but the thrust of our analysis carries through regardless of the motive for issuing debt. To model the agency benefits of debt in a very simple manner we assume that the LFI manager can "steal" a fraction λ of the cash flow available after having paid down the debt. One possible interpretation of this assumption is that managers can pay themselves large bonuses as long as the firm does not become insolvent afterwards. If the company

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[6] In other words, we are implicitly assuming that the cost of a systemic failure outweighs everything else in the regulator's objective function.

[7] A difference between systemic and non- systemic obligations will also arise if the LFI can use systemic obligations strategically to ensure a government bailout. Since in our model there is no scope for a government bailout, this strategic motive will be absent in equilibrium.

becomes insolvent, then the managers risk losing their bonuses because creditors can try to reclaim them through a fraudulent conveyance suit.[8]

In the absence of a board that is loyal to shareholders, this managerial agency problem cannot be resolved through contracts, since shareholders have no legal right to bind managers through contracts, while they do have the ability to constrain them through debt and fraudulent conveyance suits.

For simplicity we consider a three date model with the structure displayed in Figure 1, where the $p_i > 0$ indicate the probabilities of the various branches and the V_i the cash flow realizations in the different states of the world.

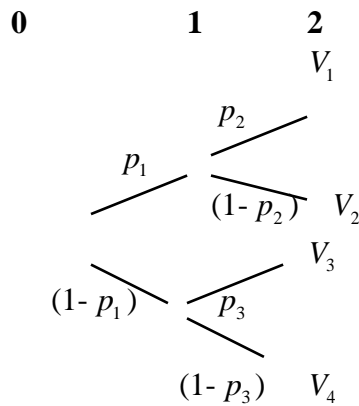| 0	1	2
		V_1
	p_2	
p_1		
	$(1-p_2)$	V_2
		V_3
$(1-p_1)$	p_3	
	$(1-p_3)$	V_4

Figure1

We suppose that $V_1 > V_2 > V_3 > V_4$.

In our model the firm's capital structure consists of a choice of debt D due at date 2 (we will discuss the possibility of short-term debt in Section 5.4). (To repeat, we do not distinguish between systemic and non-systemic debt until the end of Section 3.) We

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[8] The New York's "fraudulent conveyance" statute gives creditors the right to recover a payment to an insider if "the paying firm (1) did not receive fair consideration for the payment and (2) at the time had unreasonably small capital for its business operations" (Fried (2008)). Similarly, the 2005 "Bankruptcy Abuse Prevention and Consumer Protection Act" introduced the possibility of clawing back executive bonuses paid in the last two years under the fraudulent conveyance rule or in the last year under the preference-payment rule. In the early 1990s the Resolution Trust Corporation sued former employees of Drexel Burnham Lambert Inc., seeking the return of more than $250 million of bonuses paid. Many Drexel employees agreed to surrender a portion of their bonus. This situation is not unique to the United States. Thorburn (2004) finds that in 23% of the Swedish bankruptcy cases she studies there are fraudulent conveyance claims, with successful recovery in two thirds of the cases. In 86% of the cases where fraud is alleged the transfer has been made to insiders.

assume that the capital structure is set in a value maximizing way at date zero as a result of some takeover threat or coordinated effort by large shareholders. At date 1 the LFI manager can modify the capital structure by issuing equity only if he has shareholders' approval. At date 2 the company pays out the cash flow V_i, i=1,...,4, according to the state, and terminates. The market is supposed to be risk neutral, and the interest rate is zero.

In the absence of any debt the market value of the LFI (which we label V^U, i.e., value of the unlevered firm) would be

$$V^U = (1-\lambda)[p_1 p_2 V_1 + p_1(1-p_2)V_2 + (1-p_1)p_3 V_3 + (1-p_1)(1-p_3)V_4].$$

If we introduce debt D, due at date 2, such that $V_4 < D < V_3$, then the market value of the debt V^D at issue will be

$$V^D = [p_1 p_2 + p_1(1-p_2) + (1-p_1)p_3]D + (1-p_1)(1-p_3)V_4,$$

and the total value (net of the systemic debt) of the levered LFI (V^L) will be

$$V^L = V^U + \lambda[p_1 p_2 + p_1(1-p_2) + (1-p_1)p_3]D + \lambda(1-p_1)(1-p_3)V_4.$$

Not surprisingly, since we have assumed that there is a benefit, but not a (private) cost, of debt, the value of a LFI is monotonically increasing in the level of debt outstanding. Strictly speaking, the above formula applies only for $V_4 < D < V_3$, but the same reasoning extends to all intervals. As a result, a value-maximizing LFI left to its own devices will pick a debt level equal to V_1, which would lead to bankruptcy essentially all the time.[9]

We could, of course, qualify this extreme result by introducing a private cost of debt for the LFI. Instead, however, we will focus on the social cost of debt. In particular, as discussed above, we will assume that the social cost of the LFI's bankruptcy is so great that bankruptcy must be avoided with probability 1.[10]

To ensure no risk of bankruptcy a regulator could impose a debt level less than or equal to V_4. However, this would impose a high cost for the LFI, which will lose

$\lambda[p_1 p_2 + p_1(1-p_2) + (1-p_1)p_3](D-V_4)$ in value.

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[9] The LFI will use the debt it issues to buy back equity at date zero. Shareholders are able to extract the full value of the company through this buy-back even though the ex post value of equity is zero.

[10] We do not consider mechanisms that use taxpayers' money to bail out the LFI in equilibrium.

The question then is whether there exists a contingent capital requirement such that the value of the LFI is above

(1) $$V^L = V^U + \lambda V_4,$$

but debt is paid with probability one. In the next section we will show that this is possible. We start by assuming that at date 1 the states of the world are observable and verifiable (i.e., everyone knows whether we went along the upper branch of the tree or the lower one). We then relax this assumption and show how such a rule is implementable even if the states of the world are observable but not verifiable, as long as there is an active market for credit default swaps.

3. Main Results

3.1 The States of the World are Verifiable

In this section we allow the regulator to force the company to raise additional equity capital as a function of what happens between dates 0 and 1 (whether we follow the upper branch or the lower one). We continue to assume that the initial debt level D is not state-contingent. [11]

Consider a date zero debt level D (due at date 2) such that $V_4 < D < V_3$. Then, if at date 1 the realization is positive (upper branch of the tree), the debt is not at risk and nothing needs to be done. If the realization is negative (lower branch of the tree), then the debt starts to become risky and the LFI receives a margin call, i.e., it is forced to raise more equity. In order for the debt to return to being riskless, the LFI must raise $y \equiv D - V_4$. However, by diluting the entire value of existing equity-holders, the LFI can raise at most

$$p_3(1-\lambda)(V_3 + y - D).$$

Hence feasibility requires

$$p_3(1-\lambda)(V_3 + y - D) \geq y,$$

which implies that for a debt level D to be made riskless through a margin call it must satisfy

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[11] One possibility we rule out is that the initial capital structure mandates that leverage be increased if the company is in the upper branch. Allowing this would not affect the benefits of our market-based capital requirement.

(2) $$D \leq V_4 + p_3(1-\lambda)(V_3 - V_4).$$

The value of the LFI at date zero can be calculated as the expected value of the date-2 payoffs minus the expected value of the additional equity issue, or

$$V^L = (1-\lambda)[p_1 p_2 (V_1 - D) + p_1(1-p_2)(V_2 - D) + (1-p_1)p_3(V_3 + y - D)] + D - (1-p_1)y.$$

Substituting the value of y we obtain

(3) $$V^L = V^U + p_1 \lambda D + (1-p_1)\lambda V_4.$$

Since (3) is increasing in the debt level D, it will be optimal for the LFI to set D at the maximum level compatible with the financing constraint (2). Substituting this level in (3) and rearranging we obtain the maximized value of the LFI $\hat{V}^L$:

(4) $$\hat{V}^L = V^U + \lambda V_4 + \lambda p_1 p_3 (1-\lambda)(V_3 - V_4).$$

Equation (4) has an easy interpretation. In a levered firm debt prevents managerial stealing. Since in all states of the world there is at least V_4 in debt, the second term (λV_4) represents the stealing prevented in all states of the world. With probability p_1 the higher debt level remains in place and this will prevent some further stealing. Since in these cases the debt level exceeds V_4 by $p_3(1-\lambda)(V_3 - V_4)$, and stealing occurs at rate λ, this explains the third term. With probability $(1-p_1)$ at date 1 we find ourselves in the lower branch of the tree. Since in these cases the debt level must be brought down to V_4 to avoid default, there is no additional stealing prevented in these states of the world. Thus, there is no additional term.

Since (4) is clearly larger than (1), when we require a LFI never to fail, a contingent capital allocation yields a higher market value for the LFI than a non-contingent capital allocation.

Equation (4) also provides us with a nice intuition for the conditions that will make a LFI with a contingent capital structure more valuable than a LFI with a non-contingent capital structure. If we interpret $(V_3 - V_4)$ as a measure of the volatility of the underlying assets, we have that the higher the volatility, the higher is the difference between (4) and (1). Similarly, for a low level of agency costs λ ($\lambda < 1/2$), the larger the size of the agency problem λ, the larger is the difference between (4) and (1). For a high level of agency costs this relationship is inverted because the amount of extra borrowing

the LFI can undertake with a contingent capital structure is limited by the difficulty of raising additional equity, which is not worth a lot when agency costs are high. Finally, a contingent capital structure is more preferable the more likely is the good case scenario (i.e., the higher p_1 and p_3 are).

We should emphasize that our mechanism does not achieve the first-best. In the first-best there would be no bankruptcy *and* no stealing. One way to achieve this would be to have state-contingent debt: in state i the company owes $D = V_i$. The problem, of course, is that we are really interested in the case where the states of the world are not verifiable, in which case state-contingent debt would be hard to implement. Thus for the rest of the paper we will restrict ourselves to mechanisms of the following type: the company issues non-contingent debt at date 0, and the only possible adjustment consists of the issuance of new equity at date 1.

Given this, and the constraint that the probability of bankruptcy must be zero, it is easy to see that we have solved for the second-best; that is, one cannot do better than to set $D = V_4 + p_3(1-\lambda)(V_3 - V_4)$ and have the company issue new equity if it follows the lower branch between dates 0 and 1. The reason is simple: lower levels of debt lead to more stealing while higher levels of debt lead to the possibility at date 1 that the company cannot issue enough equity to avoid bankruptcy at date 2.

3.2 The States of the World are Not Verifiable

So far we have assumed that the states of the world are verifiable and that the regulator can write a state contingent rule. This is clearly unrealistic. In fact, the very problem of a contingent capital requirement is how to make this rule implementable in a world where neither the regulator nor (many of) the debt-holders know what the true value of the LFI's assets is.

While the value of LFI assets is not verifiable, there are several claims on these assets that are generally traded and whose prices can be easily verified: a common stock, bonds, a short-term interest rate, and a credit default swap (CDS). If there is a significant fraction of traders who observe the state of the world, the prices of these securities will incorporate the informed traders' information. This information reflects not only what

traders know about the value of the LFI's assets but also what traders expect that the regulator will do in case of insolvency (an example of market-based corrective actions).

As Bond et al. (2010) show, this endogeneity of market prices limits the effectiveness of market-based corrective actions. We take this problem into account and show that, if we use credit default swaps, we can design an intervention mechanism that supports fully revealing prices. As we discuss in Section 5.2, there are several reasons why prices of CDSs (if the CDS are properly collateralized and transparently traded on an exchange) are preferable to other debt-based prices. Yet, our result applies to any debt-like instrument.

The CDS is a contract that promises to exchange a bond with an amount of cash equal to the bond's notional value in the event of default (which, if our scheme is in place, would include receivership, since this leads to an automatic haircut). The price of this contract in basis points (p_{CDS}) is the insurance premium paid every year on a notional amount of $100 of debt. By arbitrage the CDS rate satisfies

$$\frac{p_{CDS}}{10000} = \pi(1 - \text{recovery rate})$$

where π is the (risk neutral) probability of default and the recovery rate is the proportion of the value of the debt recovered in the event of a default. As long as the haircut is predetermined, the CDS prices will reflect the (risk neutral) probability of default.

To understand how our mechanism works, consider Figure 2, where we have split up the interval between date 1 and date 2 into subintervals. Suppose that, after the realization of the first shock at date 1, the manager has the chance to raise equity. After he decides how much equity to raise the CDS market price is observed. At this point, if the CDS price is "too high", the regulator intervenes before the second shock is realized. At date 2 the second shock is realized.

Figure 2: Timing

First shock is realized at date 1	LFI decides whether to issue equity	Market price of CDS observed	Regulator decides whether	Second shock is realized

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                                              to intervene        at date 2

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The regulator's intervention, if it occurs, takes the following form:

(1) The regulator first determines whether the LFI debt is at risk – in effect, she carries out a stress test. If she finds that the debt is not at risk (i.e., the CDS prices were inaccurate), then the regulator declares the company adequately capitalized, and leaves management in place. To support her finding the regulator injects a predetermined amount of cash (as a percentage of assets) in the form of debt that is pari passu with respect to existing financial debt.

(2) If the regulator determines that the debt is at risk, the regulator eliminates all the debt except for the systemic obligations (derivative contracts, bank deposits, etc.), and replaces the CEO with a receiver (or trustee). The receiver's job is to sell the LFI for as much cash as possible within a reasonable period of time (alternatively, he may recapitalize the firm and raise cash by carrying out an IPO). The receiver distributes the proceeds from the sale according to absolute priority, except that he ensures that creditors are not fully repaid --the rule might be that they receive the smaller of what's available and 80% of what they are owed; that is, they receive a haircut of at least 20%-- and that shareholders receive nothing (anything left over goes to the government). [12]

In the remainder of this section we assume that the regulator intervenes if and only if the CDS price is greater than zero, i.e., any strictly positive CDS price is "too high". (This is obviously unrealistic. We discuss more realistic rules in Section 5.) We also suppose that the regulator has the same information as the CEO when she intervenes—she learns which branch of the tree the firm has gone down. Finally, we assume that, if the firm fails the stress test, the regulator-appointed receiver cancels *all*

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[12] It is not essential that the receiver raises cash, e.g., he could carry out a Chapter 11-type reorganization via a debt-equity swap. Our early warning system, based on a threshold for the CDS price, generalizes to such an approach.

the debt (recall that we are not distinguishing between systemic and non-systemic debt in the model).

Proposition 1:

Suppose that the state of the world is observable but not verifiable, and the sequence of events is as described above. Assume $D \leq V_4 + p_3(1-\lambda)(V_3 - V_4)$. Then the equilibrium price of a CDS p_{CDS} will be greater than zero at date 1 if and only if the lower branch of the tree is followed and the LFI raises equity with value less than $D - V_4$ at date1.

Proof:

Suppose that the lower branch is followed and the LFI raises equity less than $D - V_4$. Then it cannot be a rational expectations equilibrium for the regulator not to intervene. The reason is that there is then a positive probability that the debt will not be paid at date 2, and the CDS price will reflect this. Suppose instead that the market expects the regulator to intervene. The regulator will find that the LFI is under-capitalized, and so she will send in a receiver who will reorganize the LFI, imposing a haircut on the creditors. Since the creditors receive a haircut, the CDS price will be positive. Thus the unique rational expectations equilibrium is for the CDS price to be positive and for the regulator to intervene.

Consider next the case where the lower branch is followed and the LFI raises equity greater than or equal to $D - V_4$.Then if the regulator intervenes she will find that the debt is not at risk and she will invest some funds in the form of debt, which is pari passu with respect to the existing financial debt. The injection of cash will make the debt even safer. The debt is also not at risk if the regulator does not intervene. Thus the unique rational expectations equilibrium in this case is for the CDS price to be zero and for the regulator not to intervene.

Consider finally the case where the upper branch of the tree is followed. Then the debt is not at risk, and so the unique rational expectations equilibrium is one where the CDS price is zero and the regulator does not intervene. Q.E.D.

It is worth high-lighting how both the stress test and the haircut play important roles in the proof of Proposition 1. First, the stress test rules out a bad equilibrium of the following form: the CDS price is positive in spite of the fact that the LFI is not financially distressed; this triggers regulatory intervention; because, say, receivership is on average value-destroying, creditors are not fully repaid; this sustains the positive CDS price. Given the stress test, if the LFI is not financially distressed and the regulator intervenes, she will discover the truth and will not send in a receiver. Thus there is no bad equilibrium.

Second, the haircut rules out a situation where even though the LFI is financially distressed and intervention should occur the CDS price is zero and so intervention does not occur. This could happen because the market thinks that the receiver is better than current management and hence creditors will be fully repaid under receivership. With a haircut even the anticipation of a super-efficient receiver will lead to a positive CDS price.

Proposition 1 ensures that the CDS price is a perfect indicator of when the regulator needs to intervene. Anticipating the behavior of the CDS price and hence of the regulator, the CEO of a LFI will always prefer to issue equity of value $D - V_4$ when the first period realization is negative. If he does not, the CDS price will be positive, the regulator will intervene, and the CEO will lose his job (and his ability to steal). The equity-holders will agree to let him issue equity since they will be wiped out if he does not; and, as long as D is slightly less than $V_4 + p_3(1 - \lambda)(V_3 - V_4)$, their shares will still have positive value if the new equity is issued. Thus it is an equilibrium for a CEO to issue equity of value $D - V_4$ as long as $D \leq V_4 + p_3(1 - \lambda)(V_3 - V_4)$. (Below we discuss whether there can be multiple equilibria.)

Note that if the CEO tries to issue equity when the first period realization is positive--which he would like to do since this increases slack and stealing possibilities-- the equity-holders, knowing that the CDS price will be zero even without the new equity, will turn him down.

It follows from Proposition 1 that the optimal debt level for shareholders to put in place at date 0 is $D = V_4 + p_3(1-\lambda)(V_3 - V_4)$, as in Section 3.1. Note that if they set $D > V_4 + p_3(1-\lambda)(V_3 - V_4)$, then the market will realize at date 0 that there is a risk of bankruptcy, the date 0 CDS price will be positive, and the regulator will intervene right away.[13]

Proposition 2 summarizes the above discussion.

Proposition 2:

Under the CDS trigger mechanism described above, the shareholders will choose a debt level $D = V_4 + p_3(1-\lambda)(V_3 - V_4)$ at date 0 and will permit the CEO to issue equity of value $D - V_4$ at date 1 if and only if the first period realization is negative. The trigger is not activated, and on the equilibrium path bankruptcy is avoided with probability 1. The second-best is achieved.

Let's return to the issue of multiple equilibria. Suppose that even though $D \leq V_4 + p_3(1-\lambda)(V_3 - V_4)$ some investors fear that not enough equity will be raised; the CDS price will be positive; and the regulator will therefore intervene and wipe out all the equity-holders. This fear will generate a bad equilibrium in which investors do not underwrite the equity offering and regulatory intervention occurs even though it should not.[14] One way to eliminate this equilibrium is to guarantee that if the regulator takes over an LFI shortly after an equity offering, the money invested in the offering (plus a small amount of interest) will be considered senior to all the non-systemic obligations and returned to the investors. This additional provision makes investing a dominant strategy, ruling out the bad equilibrium.

3.3 Systemic and non- systemic debt

Let us return to the issue of systemic versus non-systemic debt. As we have noted, in our formal model we do not distinguish between the two. One way to introduce a

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[13] In our model, the government wants to limit the debt that the LFI issues. However, one can also imagine scenarios where the LFI doesn't want to issue financial debt and the government forces it to issue some in order that the CDS price can be used to assess the risk of default of the systemically relevant debt. See later in this section.

[14] We would like to thank Ken Ayotte for alerting us to the possibility of this bad equilibrium.

difference is to suppose that systemic debt can be issued at a lower interest rate than non-systemic debt, and so, ceteris paribus, an LFI would always like to issue 100% systemic debt equal to $D = V_4 + p_3(1-\lambda)(V_3 - V_4)$, unless prevented from doing so by a regulator. (To make the algebra simple, suppose that the difference in interest rates between the two types of debt is negligible, so that none of the formulae change.) How does our analysis change?

Note first that, if our CDS mechanism works perfectly, the regulator should not fear the issuance of 100% systemic debt since in equilibrium the mechanism is never triggered, and the debt is perfectly safe. However, this may be too rosy a perspective. Suppose that we are concerned about an "out of equilibrium" sequence of bad outcomes: the manager for some reason is unable to, or does not, issue equity at date 1 along the lower branch; the regulator is also unable to issue equity; and the regulator is unable to sell the company. One way to think about this is that the regulator may be forced to take over the company and run it until date 2 without changing its capital structure. If V_3 occurs, of course, there is no problem since the debt $D = V_4 + p_3(1-\lambda)(V_3 - V_4)$ can be fully repaid. However, if V_4 occurs, then the firm will default on its systemic debt, possibly leading to a public bail-out.

How can such a scenario be avoided? Our view is that a simple way to do this is to (a) limit the fraction of total debt that can be systemic; (b) make the systemic debt senior. In the above example, the most systemic debt that can always be paid back at date 2 is V_4, and so the fraction of systemic debt should be limited to

(5)
$$\frac{V_4}{V_4 + p_3(1-\lambda)(V_3 - V_4)}.$$

Requiring that an LFI issue non-systemic junior long- term debt has another benefit. For CDS prices to provide useful information, the underlying instrument should face the risk of default, at least out of equilibrium. Junior long-term financial debt plays this role. In theory, it is irrelevant how much junior long-term debt there is, as long as there is some. In practice, the amount is important for two reasons: it determines the

thickness of the market for the security underlying the CDS;[15] and it provides an extra cushion for the systemic obligations in case the regulator is slow to intervene. Suppose we want to make sure that each institution has a sufficient cushion to endure a delay of six months: It would be reasonable for us to set the rules such that after an institution has exhausted its equity layer, the probability of its running through the junior debt layer in six months is less than 5%. If asset volatility is around 8% per year, our calculations suggest that maintaining a layer of junior long-term debt worth roughly 11% of assets will offer the necessary protection. By today's standards, this figure is hardly high: For the eight largest banks, the long-term debt-to-asset ratio in September 2008 was 19%. A new regulatory system that required a CDS rate below 100 and a long-term debt layer of at least 11% would therefore not be a great burden for the major banks today.

3.4 Why Not Short-Term Debt?

As an alternative, regulatory intervention could be made contingent on the interest rate at which short-term debt is refinanced. While in many cases, this is equivalent, in what follows we will show that sometimes an intervention contingent on the short-term debt rate will not prevent a LFI from going bankrupt.

To analyze this possibility, let's allow the LFI to issue short-term debt, which the LFI has to roll over at time 1 (since there is no cash flow at time 1). As long as the debt is less than or equal to V_4 the debt is riskless and at time 1 it can be refinanced at the riskless rate (which we assumed to be zero). If the amount of short term debt is $V_4 < STD \leq p_3 V_3 + (1 - p_3) V_4$, then it can be issued at the riskless rate at time 0, but in the lower branch it can be refinanced only at a rate above zero. Finally, if $STD > p_3 V_3 + (1 - p_3) V_4$, the debt cannot be issued at the riskless rate even at time 0 and the regulator will always intervene. So the only contingent intervention occurs for $STD = p_3 V_3 + (1 - p_3) V_4$.

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[15] Since our rule is meant to apply only to very large financial institutions (let's say with more than $100 billion in assets), a 10% requirement, which implies at least $10 billion in bonds, seems reasonable. From a casual inspection, this amount appears sufficient to generate an active CDS market, since several companies with less than that amount of outstanding bonds have actively traded CDSs. Yet, before implementing this rule, an in depth study is needed.

Now consider what happens if $STD = p_3 V_3 + (1 - p_3) V_4$. If the first realization is good, the debt is risk free and no intervention will occur. But if the first realization is bad, the debt can be refinanced only by promising the entire firm to the debt-holders (i.e., $STD = V_3$). After observing a positive refinancing rate, the regulator will intervene, but it will be too late, since the LFI has already pledged all its assets, making it impossible to avoid default if V_4 occurs.

Therefore, either the LFI adopts a non-contingent capital structure with D=V_4, or bankruptcy cannot be avoided with probability one, making this system undesirable.

4. Endogenizing LFI activities

So far we have taken the LFI's activities as given. One concern is that our mechanism may encourage the LFI to take on inappropriate obligations or engage in excessively risky behavior, particularly if it is in danger of being taken over by the regulator ("gambling for resurrection"). To investigate this possibility we introduce an investment opportunity at time 1, which can have positive or negative net present value. The investment has a cost of i and return R with probability π and r otherwise. For simplicity, we consider only the case where the realization of this investment opportunity is perfectly correlated with the value of the underlying assets (so $\pi = p_2$ in the upper branch and $\pi = p_3$ in the lower branch). For simplicity and without loss of generality we suppose that r =0. We also assume that the ranking of the states is unchanged by whether the investment project is undertaken and succeeds or fails:

$$V_3 + R < V_2.$$

Note that a risky investment opportunity at time 1 has the potential to introduce an additional agency problem. While the manager captures a fraction of the upside of any investment (in the form of stealing), he suffers no downside cost. Hence, in the presence of date 0 debt a manager may choose to undertake some negative present value investments, as in traditional risk shifting models.

Given these various agency problems, in the absence of regulation it is optimal for the shareholders to set the initial long-term debt level at D=∞, but to allow the manager to raise short-term senior debt at time 1. (We go back to ignoring the distinction between

systemic and non-systemic debt, and so none of the initial debt is senior.) With a D=∞ debt level, the initial shareholders will eliminate any stealing, since there will be no equity payoff. An infinite level of debt also eliminates any incentive to risk shift, again because the manager cannot steal any of the returns from a successful project. Finally, D= ∞ will not prevent any positive NPV project from being undertaken since, by raising short-term debt senior to the long-term debt, the manager will always be able to finance such a project. If $V_4 \geq i$, the short-term debt is riskless, and so the face value of the senior debt will be i. If $V_4 < i$, the short-term debt is risky, and so the face value of the senior debt will exceed i.

The manager is completely indifferent about which projects to finance, given that there is nothing for him to steal at date 2, and we suppose that he is therefore willing to act on behalf of shareholders, undertaking positive NPV projects and not negative NPV ones (he can always be given a small equity stake to break his indifference).

Since with D=∞ the systemic obligations are always dragged into a bankruptcy procedure, triggering significant social costs, we assume that the regulator will want to intervene and limit the debt level D.

4.1 CDS mechanism

Consider now the case in which our CDS trigger mechanism is in place. Then the regulator will intervene whenever the CDS price is positive. We now solve the problem backward. We start from time 1 and we consider first the upper branch. Assume that $D < V_2$ (see below). The manager has to decide whether to invest or not. Since the investment opportunity requires a cash outlay, the manager can undertake it only if he can raise i. We assume that the manager has to get approval from shareholders to raise new funds, and that he has all the bargaining power in this negotiation, i.e., he makes a take- it- or- leave- it offer to shareholders. We denote by d the face value of short- term debt issued at time 1 and by y the amount of equity issued at time 1.

Given that the CDS mechanism is in place, the new senior debt must be riskless, otherwise the mechanism would be activated, forcing the LFI to raise more equity. For the investment to take place three conditions must be met: i) the manager is able to raise

enough funds to undertake the investment; ii) the shareholders are willing to approve the fund raising; iii) the manager's payoff from raising the funds and investing should be higher than his payoff from doing nothing;

The first condition is simply that

$$d + y \geq i \,.$$

The second condition is tantamount to saying that shareholders should not be made worse off from the fund- raising and investing. In the absence of the investment opportunity, the equity value is given by

$$(1 - \lambda)[p_2 V_1 + (1 - p_2) V_2 - D]\,.$$

The solvency constraint also implies $V_2 + (d + y - i) \geq d + D$ or

$$V_2 + y \geq i + D\,.$$

If the project is undertaken and financed with the pair (d, y) the value of the old equity will be

$$(1 - \lambda)[p_2 (V_1 + R + y - i) + (1 - p_2)(V_2 + y - i) - D] - y\,.$$

The shareholders will approve the project iff

(6)
$$y \leq \frac{1 - \lambda}{\lambda}(p_2 R - i)\,.$$

Finally, the manager's payoff if no money is raised is

$$\lambda[p_2 (V_1 - D) + (1 - p_2)(V_2 - D)]\,.$$

If he raises the necessary funds and invests his payoff is

$$\lambda[p_2 (V_1 + y + d - i + R - D - d) + (1 - p_2)(V_2 + y + d - i - D - d)]\,.$$

Hence, the manager is better off if

(7)
$$y + (p_2 R - i) > 0\,.$$

Condition (7) is very intuitive. The manager is better off under one of two conditions. Either the investment is positive net present value $(p_2 R - i > 0)$, so that he can steal a fraction of it; or new equity is issued ($y > 0$), so he can steal a fraction of this. If neither of these two conditions is satisfied, he has no interest in going ahead. If we combine (6) and (7), we obtain

Proposition 3:

Under the CDS trigger mechanism described above, no negative NPV investments will be undertaken.

If (6) and (7) are satisfied, then the manager will choose $y = \dfrac{1-\lambda}{\lambda}(p_2 R - i)$ and

$$d = i - y = i - \frac{1-\lambda}{\lambda}(p_2 R - i).$$

Let's now consider the lower branch. Given that the CDS mechanism is in place the short-term debt of face value d must again be riskless and so the manager will be able to undertake the investment if and only if

$$d + y \geq i.$$

Shareholders will automatically give their permission since otherwise the mechanism will be triggered and they will be wiped out. The solvency constraint requires that $V_4 + y \geq i + D$ and the ability to raise capital is limited by the value of equity that can be diluted, i.e,

$$y \leq (1-\lambda)[p_3(V_3 + R + y - i - D) + (1 - p_3)(V_4 + y - i - D)].$$

Rewriting this as

$$(8) \qquad y \leq \frac{(1-\lambda)}{\lambda}[p_3(V_3 + R) + (1 - p_3)(V_4) - i - D],$$

we can use $V_4 + y \geq i + D$ to obtain

$$(9) \qquad D \leq V_4 + (1-\lambda)[p_3(V_3 - V_4 + R) - i].$$

The manager's payoff is

$$(10) \quad \lambda[p_3(V_3 + y - i + R - D) + (1 - p_3)(V_4 + y - i - D)].$$

This is increasing in y and so the manager will ensure that (8) holds with equality. Substituting for y in (10), we can easily show that the manager is better off undertaking the project as long as $p_3 R > i$. .

We see from (9) that, if the project has positive net present value, i.e., $p_3 R > i.$, then the initial debt level can be set higher than in Section 3. This allows the investment to occur and increases the ex ante market value of the firm. Note that, given our

assumption that $V_3 + R < V_2$, D will lie below V_2, as we supposed in our analysis of the upper branch. On the other hand, if the project has negative net present value, then the debt level will be as in Section 3 and the investment will not occur.

In sum, in spite of the additional agency problem introduced by the time-1 choice of debt, endogenizing the activity level of the LFI does not change our results in any significant way. Not only is our CDS mechanism able to avoid bankruptcy in equilibrium, but it also eliminates any risk-shifting incentive.

4.2 The CDS rule and the agency cost of debt

One interesting byproduct of our rule is that it eliminates all the agency costs of debt. First, it eliminates the incentives to undertake negative NPV investments for traditional risk-shifting reasons. Indeed we saw above that no negative NPV projects will be undertaken.

Second, by forcing equity-holders to issue equity every time the debt becomes risky, our rule eliminates the Myers (1977) debt overhang problem. Either the debt is safe (and thus there is no transfer of value between equity-holders and debt-holders), or the debt is risky and the equity-holders have to issue equity not to be expropriated by the regulator. Either way there is no chance that a positive investment opportunity will be forgone to avoid the transfer in value associated with an equity issue.

Finally, while there is no asymmetry of information in our model, it is easy to see how, if such an asymmetry were present, our rule would eliminate any adverse selection in equity offerings a la Myers and Majluf (1984). In fact, by forcing an LFI to raise equity when the CDS prices reaches a threshold, our rule eliminates any discretion in the decision, removing any signal associated with it.

In sum, the endogeneization of the activity level does not change the nature of our results. In fact, it highlights the power of our mechanism, which not only eliminates the moral hazard problem introduced by the too-big-to-fail policy, but also removes the distortions created by two other agency problems: risk shifting and debt overhang.

5. Discussion

5.1 Why CDS?

In the previous section we have shown how to implement a state contingent capital structure in a world where the states are not verifiable by using CDS prices. Most LFIs, however, have several claims traded, for example, bonds or stocks, so why not use one of these other instruments?

Equity prices are not a good instrument. While equity is very liquid and its market price hard to manipulate, it does not provide a good indicator of the probability of default. Equity is insensitive on the downside (because of limited liability) and very sensitive on the upside, thus a small probability of a positive event can sustain significant equity prices even in the presence of a high probability of default.[16]

By contrast, any debt-related price is more suitable to the task, since debt is insensitive to the upside, but very sensitive to the downside. Instead of the CDS price, we could use debt prices or debt yields. For example, Taylor and Williams (2009) use the difference between the Libor rate and the overnight index swap (OIS) as an indicator of the aggregate credit risk of the interbank market. The idea is that the Libor at a certain maturity is a function of both the average of expected future overnight rates over the same maturity and the risk of credit, while the overnight index swap is a function only of the former. A similar indicator can be established for each individual institution. This indicator can replace or supplement the CDS price.

As we have shown in section 3.4, however, short-term debt yields run the risk of signaling the problem too late. By contrast, bond prices suffer from the problem of market segmentation and illiquidity. Bond issues differ along several dimensions: promised yield, maturity, covenants, callability, etc. As a result of this lack of standardization, the market for each bond issue tends to be rather illiquid, with most bond issues trading only occasionally. This illiquidity makes bond prices a less reliable indicator than CDS prices. In fact, the success of CDSs is mainly due to their standardized nature, which ensures greater liquidity.

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[16] This difference is not apparent in our simplified model, since the equity price will perfectly distinguish the upper branch of the event tree from the lower branch. This coincidence, however, is not generic. Imagine, for instance, that $V_3 > V_1 > V_2 > V_4$. Then, the value of equity in the lower branch can be higher than the value of equity in the upper branch, invalidating the role of equity as an indicator. By contrast, the CDS price, capturing the downside risk, will correctly signal when to intervene.

The CDS market has also been shown to lead other markets in terms of information discovery. It leads the stock market (Acharya and Johnson (2007)), the bond market (Blanco et al. (2005)), and even the credit rating agencies (Hull et al. (2004)).

Given the size of the stakes at play, one might worry about the temptation for a bank to manipulate its own CDS price. For this reason, and more generally to provide greater transparency, we believe that it is important for CDSs to be traded on an organized exchange, with all the rules that usually apply on such exchanges. There could also be an additional prohibition against firms trading in their own CDSs. A further important benefit of having CDSs traded on an exchange is that counterparty risk will be minimized, if not eliminated, and the positions of the various parties will be disclosed. Without such disclosure, the market would find it very difficult to assess the riskiness of individuals LFIs.

5.2 Did CDS predict the 2008 crisis?

Many critics (e.g., Anderson, 2009) argue that CDS price changes are mostly affected by variations in risk aversion and do not contain much information about the actual probability of default. One way to check this claim is to analyze the behavior of CDS rates for the nation's largest financial institutions throughout the 2008 crisis. Table 1 shows the one-year CDS rates ((in basis points) at various key moment during the crisis (the default of Bear Sterns hedge funds, the end of 2007, the collapse of Bear Sterns, and the rejection by Congress of the first version of Tarp).

While it is true that the CDS market did not anticipate any problem until the summer of 2007, after that the market provided a remarkably accurate indicator of the eventual fate of the major financial institutions. As the table makes clear, the market early on singled out Washington Mutual and Bear Stearns as the two most problematic institutions. In fact, if one had to predict in August 2007 the five institutions that would go under first on the basis of their CDS prices, one would be correct in four out of five cases. By the end of 2007, the data showed a decisive worsening of the situation for the investment banks and Washington Mutual. In late December, the market put the probability of Washington Mutual's defaulting within a year at 10%. By March 2008, that estimate had risen to 30%—and yet the regulator waited until September 25 to take over the bank.

The history of the 2008 crisis can also help us determine where the CDS-rate trigger should be set. Let's say our goal is to intervene between six and nine months in advance of a genuine failure: We can go back and see how high the CDS rates of failed institutions were six to nine months before the failures occurred. We can then determine the false positive rate by looking at how many stable institutions the trigger mechanism would have flagged as questionable.

In this analysis it is important to appreciate that the CDS rates are endogenous with respect to the default rule we choose. On the one hand, this endogeneity implies that there is no guarantee that CDS rates will perform in the same way as in the past under our proposed rule. In particular, the 20% haircut will impact the size of the potential loss and hence the price of the CDS. On the other hand, the continuous government interventions, which led to the rescue of Bear Stearns, AIG, Citigroup, and Bank of America, have certainly affected the reliability of CDS rates as an indicator of the probability of financial insolvency.

Table 2 presents a one-month average of one-year CDS rates six months and nine months before the "failure" of major institutions. We use failure here loosely, because Bear Stearns, Merrill Lynch, AIG, and Citigroup did not fail—they were of course rescued by the government, either through a shotgun wedding or direct taxpayer bailout. The classification "surviving" is also open to debate, since Goldman Sachs and Morgan Stanley could also be said to have been saved by the government. But these labels generally correspond to how the practical fate of these institutions has been understood.

As the table demonstrates, all the "failed" institutions had CDS rates above 100 basis points six months before their demise; only Lehman Brothers and Washington Mutual had CDS rates above 100 nine months before their collapse. With the exception of Bear Stearns, though, all of the institutions had CDS rates above 40 nine months before their demise.

In Table 3 we look at the false positives: examining when the institutions that did not fail would have first set off our market-based trigger. For the commercial banks—Bank of America, J.P. Morgan Chase, and Wells Fargo—the 100 basis points threshold would have been triggered only after the Lehman failure that sent the financial industry into a panic. For the two investment banks—Goldman Sachs and Morgan Stanley—it

would have been triggered in February '08 and in November '07, respectively. It is unclear, though, whether these are really false positives: One could easily argue in retrospect that these two institutions needed more capital back then. The 40 basis points threshold, by contrast, definitely seems to generate too many false positives—since it would have triggered an intervention in Wells Fargo back in November 2007. A trigger at 100 basis points therefore seems roughly appropriate.

Nevertheless, CDS rates do also reflect variations in risk aversion. Should we then have the trigger fixed in nominal terms or adjustable to sterilize the effect of these changes? The answer depends upon our view of what drives these changes. If the changes are due to some irrational exuberance or panic, then it would be reasonable to adjust the trigger to variation in the risk aversion. This can be done by eliminating the common component in the CDS prices. Yet, if we regard fluctuations in the risk premium as indications of changes in the marginal utility of wealth, then when the risk premium increases, it means that the welfare cost of a possible bankruptcy increases as well. Hence, the fact that our mechanism endogenously becomes tighter when the cost of a bankruptcy increases is a positive, not a negative, feature.

5.3 The Regulator's time inconsistency

In our analysis we have ignored political economy considerations. But too-big-to-fail is not just an economic problem, it is mainly a political economy problem. A benevolent government, who trades off the macroeconomic costs of restructuring or liquidating an LFI with the distortion in the ex ante incentives a bailout generates, will be systematically biased in favor of the bailout. The possibility of not being reelected reduces the government discount rate, biasing it in favor of the action that has the lower immediate costs, i.e. a rescue. In other words, the government faces a standard time-inconsistency problem a la Kydland and Prescott (1977). No matter how tough the ex ante rules are, when the problem arises, the government will cave in and modify these rules ex post. The anticipation of this behavior will destroy any desirable incentive effects.

In this context, our mechanism can be seen as a way to address this time-inconsistency problem by forcing the government to intervene earlier, at a time when the cost of intervention is substantially reduced, given that the systemic obligations are not at

risk and thus there is no danger of a catastrophe. The credibility of intervention could be further enhanced with additional provisions. For example, the regulator's budget could be derived from an endowment that the regulator uses to invest in institutions that are deemed safe, in spite of having a CDS price that triggered an intervention. If this is the case, the regulator would be very afraid of investing in risky debt, because any loss will impact her own budget.

The risk of empowering a regulator with the right to intervene is twofold. On the one hand, the regulator can arbitrarily close down perfectly functioning financial institutions for political reasons. On the other hand, the regulator, under intense lobbying by the regulated, can be too soft, a phenomenon known in the banking literature as "regulatory forbearance". Our mechanism, which bases intervention on a market-based signal, removes most of this discretion. The regulator cannot intervene if the market prices do not signal a situation of distress and cannot avoid intervention when they do.

While we made mandatory a regulatory intervention in case of high CDS prices, we deliberately did not require the regulator to fire the CEO and cancel debt as an automatic consequence of the triggered event, but only after the failure of a "stress test" performed by the regulator. While this discretion may run the risk of inducing some regulatory forbearance, it is designed to avoid another risk: of self-fulfilling panics. Every time we take away regulatory discretion and rely on market signals, we bear the risk of making the wrong decision if market signals are not perfect.

How worried should we be that our mechanism makes it too easy for the regulator to declare that an institution has passed the stress test? We think this risk is not too great because the regulator has to stick her neck out and assert that a firm that the market thinks is at risk of default is in fact perfectly safe. This risk is further reduced by the requirement that the regulator must invest some money in the LFI if she declares it to be adequately capitalized. This requirement has several benefits. First, it makes it politically costly for the regulator to forbear. Second, increasing the solvency of the LFI makes bear raids even less profitable, since the CDS price will drop further. Third, it makes the system robust to regulatory mistakes. If the regulator incorrectly concludes that the LFI is adequately capitalized, the LFI's solvency will be improved by infusing some liquidity.

The regulator faces two types of pressures: the industry pressure to bail out the LFI and the pressure from Congress to minimize the taxpayers' money at risk. Our choice of making new government debt pari passu tries to balance these opposing forces. On the one hand, we want to make it politically costly for the government to validate as adequately capitalized firms that are not. This cost would be maximized by making the government claim junior to everybody else's. On the other hand, we want to make it difficult to succumb to the industry pressure to bail out the LFI, which would be very strong if the regulator could inject funds in exchange for a junior claim on the LFI. Pari passu debt strikes a reasonable balance. If the firm is insolvent pari passu debt does help the existing creditors, but it is sufficiently junior to make the government suffer some pain.

One can argue that the government might always change the rules ex post, and waive its obligation to invest money. In this case, however, the underwriter of the CDS contracts would be able to sue the government for damages, since the government behavior would cause their price to rise.

An alternative approach would be to fix a price to insure LFI debt and require a private insurance company to audit the LFI and decide whether or not to insure the debt at that price. If the insurance company accepts the insurance, this supports the idea that the LFI is adequately capitalized; if it does not then we can be confident that the LFI is at risk and the regulator should feel no qualms about taking it over. Unfortunately, such a mechanism would be more likely to fail in a systemic crisis, where more LFIs would be audited and the capacity of any private insurer to absorb risk would be limited.

Some people may view our mechanism as a market-based nationalization. But it is no more a nationalization than is a bankruptcy. And the market-based trigger may provide a political cover for an early intervention, avoiding costly delays. In fact, during the recent crisis the political stigma associated with nationalization has delayed necessary interventions in the banking sector at considerable cost.

5.4 Macroeconomic effects

Our proposal follows the micro approach to prudential regulation in so much as it deals with the perverse incentives at the company level, but it does not address the

possible underinvestment problem that will occur at the macro level if all financial institutions find themselves in trouble and try to deal with this by shrinking their lending rather than raising new equity.

In the macro approach to prudential regulation (e.g., Kashyap and Stein, 2004), the reluctance to raise equity is generally justified by appealing to the Myers' (1977) debt overhang problem or to some adverse selection in equity offering (Myers and Majluf, 1984). If either of the forces behind these two models is the reason for the scarcity of capital in the banking industry, then our rule will automatically take care of this problem. As discussed in Section 4.3, our rule eliminates the negative effect of both debt overhang and adverse selection.

If the scarcity of capital is the result of other factors, however, our rule is subject to the same criticism as that of all micro-based prudential rules. To address the macro problem Kashyap and Stein (2004) propose an adjustable capital requirement, which depends on the business cycle or the price of certificates allowing banks to violate the standard capital requirement. Our proposal can easily be merged with theirs, since the CDS trigger can be indexed to macroeconomic factors.

5.5 Feasibility under the Dodd-Frank Bill

Our mechanism can be easily implemented under the provisions of the "Dodd-Frank Wall Street Reform and Consumer Protection Act" approved in July 2010. Title II of the Act provides the Financial Stability Oversight Council (FSOC) with the authority to "orderly liquidate" systemically relevant financial institutions. The Act does not require that this intervention follows a stress test triggered by a market indicator, but it does not prevent it. More importantly, the Act provides FSOC with the authority necessary to implement the steps requested by our model: fire the CEO, change the capital structure, impose a haircut on non-systemic debt.

Under Section 115 of the Act the FSOC can make recommendations on capital requirements and on the maximum amount of short-term debt for systemically relevant institutions supervised by the Fed. Capital requirements can be risk-based and thus can be contingent on the price of CDS. These requirements can also include a minimum amount of junior long-term debt.

Not only is our mechanism fully within the power of the FSOC and the Fed under the new legislation, it is also easy to implement. First, it would be simple, and not very different from the system of capital requirements currently in place. Second, it would be easily applicable to diverse financial institutions—such as hedge funds and insurance companies, as well as banks—if policymakers wanted to expand its reach. Many mechanisms designed explicitly for banks would be difficult to adapt to other financial institutions, but our system is based on three simple concepts that are easily portable: an equity cushion, a junior-debt cushion, and a CDS trigger. Last but not least, unlike non contingent capital requirements our mechanism will not have deflationary effects when applied. The key to our mechanism is not the toughness of the initial rules, but rather the promptness of the corrective action triggered by a market signal. This lack of a harsh crackdown means that the transition to our system would be relatively painless for the banks.

5.6 Comparison with the Main Alternatives

An alternative idea to deal with the too big to fail problem which has received a great deal of attention is to introduce some debt in the capital structure of banks that converts into equity when the bank is facing financial distress (Squam Lake Report). This debt (called contingent capital or CoCo) has some benefits. If, in extreme downturns, the conversion is triggered, debt-holders would be forced to absorb some losses without dragging other obligations (such as derivatives or repo contracts) into a lengthy bankruptcy process, an event that could trigger a systemic panic. This, in turn, will save taxpayers large amounts of money and will create the right incentives for creditors to monitor the issuers, instead of lending freely under the assumption that the government will bail them out.

This approach, however, has several shortcomings. A much discussed problem is the conversion trigger. If the trigger is based on accounting numbers, it might not be activated when it should be. The trigger set by Lloyds in the first Coco bonds (less than 5% Tier 1 capital) would not have been activated even at the peak of the crisis. If instead the trigger is activated when equity prices are low, the manager could deliberately talk down the value of the bank to activate the trigger and obtain equity on the cheap.

There is, however, a much larger problem, which has been largely ignored. If a bank is losing money because of its bad investments, a Coco bond will not prevent the bank from defaulting on derivative and repo contracts. It will only delay the timing of that default. In fact, one of the advantages of debt is that it puts a limit on the amount of resources an inefficient manager can waste: A default forces inefficient businesses to restructure and incompetent managers to be replaced. By eliminating the possibility of default, Coco bonds will increase the inefficiency in the banking industry, without preventing the possibility of a default on systemic obligations, and thus the risk of systemic crises.

By contrast, our mechanism is designed to force equity issues when a bank is undercapitalized, well before a major crisis occurs, boosting the protection offered to systemic claims (such as deposits and short term borrowing).

Our idea is similar to the approach, proposed by Duffie (2010), to mandate an offer to existing shareholders to purchase new equity at a low price when a financial institution fails to meet a stipulated liquidity or capital requirement. In fact, we provide a market-based trigger for such requirement. Furthermore, our provision to make the new equity funds invested senior, in the event that the LFI is taken over by the regulator shortly after the equity issue, eliminates the risk of multiple equilibria, to which Duffie's mechanism is subject.

6. Conclusions

The too-big-to-fail problem arises from a combination of an economic problem – the cost of defaulting on systemic obligations is too large to bear—and a political economy problem – a time inconsistency problem induces the government/regulator to sacrifice the long-term effect on incentives to avoid the short-term costs of a possible systemic collapse.

In this paper, we design a mechanism to address both these problems. This mechanism is similar to existing capital requirements in that it creates two layers of protections for systemic obligations, represented by equity capital and junior long-term debt. The first key difference is that the equity capital requirement relies on credit default swap prices, instead of the credit rating agencies, as the trigger mechanism. The second

key difference is in the way the government intervenes, which is designed to preserve the systemic obligations, but to penalize the long-term debt-holders if the company is too risky. We have shown that this mechanism ensures that LFIs do not face any risk of bankruptcy, while preserving some of the disciplinary effects of debt.

By triggering an early intervention (when the LFI is still solvent, the systemic obligations are not at risk, and only the junior debt starts to face a small chance of not being repaid in full), our mechanism is able to shift the government trade-off between restructuring and bailout in favor of the former. In so doing, it provides a way for the government to commit to tougher rules, overcoming its time inconsistency.

More generally, beyond the too-big to fail problem, our CDS-based capital requirement can be seen as mechanism to address possibly the fundamental agency problem generated by debt: i.e., the perverse incentives managers and shareholders have to "gamble for resurrection" when a company approaches default. Equity can be seen as an option on the value of the underlying assets, with a strike price equal to the value of the face value of debt (Black and Scholes, 1973). Much of the agency costs of debt arise from the fact that some actions (such as undertaking negative NPV risky investments) can increase the value of this option, while decreasing the value of the underlying assets. Our CDS-based capital requirement eliminates the divergence of interest between shareholders and creditors by forcing the equity-holders to exercise this option when it starts to become valuable (i.e., when a company is close to default). As a result, no negative NPV project will be undertaken, in spite of the risk-shifting possibility present.

Finally, our mechanism highlights the important role that credit default swaps can play in regulation. CDSs have been demonized as one of the main causes of the current crisis. It would be only fitting if they were part of the solution.

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Table 1: CDS rates of the main financial institutions at key dates during the crisis

These 1-year CDS rates are in dollar of premium to insure $10,000 of notional amount. When an institution filed for bankruptcy (as Lehman) the last CDS price before the filing is reported. Source: Datastream.

Financial Institution	8/15/2007	12/31/2007	3/14/2008	9/29/2008
BoA	11	29	93	124
WELLSFARGO	23	45	113	113
JPMORGAN	19	32	141	103
CITI	15	62	225	462
WACHOVIA	14	73	229	527
WAMU	44	422	1,181	3,305
GOLDMAN	28	78	262	715
MORGAN	31	129	403	1,748
MERRILL	29	159	410	666
LEHMAN	38	100	572	1,128
BEAR STEARNS	113	224	1,264	118
AIG	31	59	289	821

Table 2: Simulation of different trigger rules

These 1-year CDS rates are in dollar of premium to insure $10,000 of notional amount. The averages are over a calendar month 6 months or 9 months before the "default" date.   The trigger date is the first date when the previous month average of CDS rates exceeded the threshold. Source: Datastream.

"Failed" institution	Date of Default	Average CDS 6 months before	Average CDS 9 months before
BEAR STEARNS	3/14/2008	121	10
LEHMAN	9/15/2008	288	106
WAMU	9/25/2008	957	430
WACHOVIA	9/30/2008	176	45
MERRILL	9/15/2008	282	177
AIG	9/16/2008	234	70
CITI	9/30/2008	162	44

Table 3: Simulation of false positives with different trigger rules

These 1-year CDS rates are in dollar of premium to insure $10,000 of notional amount. The trigger date is the first date when the previous month average of CDS rates exceeded the threshold. Source: Datastream.

"Surviving" Institutions	False Positive Date with a Trigger at	
	100 bps	40 bps
BoA	9/22/2008	1/22/2008
WELLSFARGO	9/18/2008	11/23/2007
JPMORGAN	9/29/2008	2/15/2008
GOLDMAN	2/14/2008	8/20/2007
MORGAN	11/13/2007	8/22/2007