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 an equity cushion sufficiently great that their own credit default swap price stays below a threshold level, and a cushion of long term bonds sufficiently large that, even if the equity is wiped out, the systemically relevant obligations are safe. If the CDS price goes above the threshold, the LFI regulator forces the LFI to issue equity until the CDS price moves back down. If this does not happen within a predetermined period of time, the regulator intervenes. We show that this mechanism ensures that LFIs are always solvent, while preserving some of the disciplinary effects of debt.

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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. The too-big-to-fail doctrine has been around for a long time (Stern and Feldman, 2004), but its practical value has often been questioned (Meltzer, 2004). The backlash following the demise of Lehman Brothers, and the effort exerted to save major financial institutions at all cost, has established that the United States does not have the will to let large financial institutions fail. Whether the too-big-to-fail doctrine is based on economic thinking (the cost of a large failure is too high) or political reality (the pressure to save LFIs is too strong), the conclusion is the same: we need to rethink how we regulate these institutions.

Traditionally, bank capital regulation has been thought of as a corollary to the introduction of deposit insurance. The existence of this insurance makes debt a cheap source of financing for banks. Depositors and other creditors will lend at low interest rates because they know that their debts are secure: they will be repaid by the bank if things go well, and by the government if things go badly. Capital requirements, then, are a necessary evil to prevent banks from abusing the ability to borrow cheaply, dumping large losses onto taxpayers. The Basle Accords, for instance, require banks to hold some minimal capital level to protect deposits against the risk of fluctuations in the value of bank assets. That the Basle Accords were aimed at protecting deposits and not at avoiding bank bankruptcies is suggested by the fact that Tier 2 capital ratios include long-term debt. Obviously, long-term debt provides a safety cushion for deposits but not insurance against bankruptcy.

In the United States, the traditional capital requirement was not applied to investment banks, in spite of their size, because they had no insured deposits. The events of Fall 2008 have shown the futility of this approach. In spite of not having deposits, investment banks experienced a loss of confidence from their short-term creditors, and, because of the alleged systemic implications of this event, they were rescued by the Federal Government.

Shielding an LFI from bankruptcy has a cost. Bankruptcy performs some important goals for a financially distressed company. It allows an efficient choice to be made between reorganization and liquidation; and it penalizes incumbent managers and shareholders for defaulting on their debts. So why cannot LFIs be allowed to fail?

Two main economic arguments are usually given against permitting an LFI to go bankrupt. First, unlike other firms financial companies are highly interconnected through a web of contracts. When a LFI goes bankrupt its contracts (including all the hedges established with other parties) are put in jeopardy, and other LFIs can suffer because they suddenly find their positions unhedged. Reconstituting hedges overnight can be prohibitively expensive, pushing other LFIs into bankruptcy, and leading to systemic failure. The second reason, which is more specific to deposit-taking banks, is that LFIs perform the transformation of liquidity, exposing themselves to the risk of runs (Diamond and Dybvig, 1983). The failure of a large bank, then, can cause psychological contagion, leading depositors to start runs on other banks.

Given the above, we see the goal of regulation as being to preserve the incentive effects of bankruptcy while avoiding the possibility that an LFI is insolvent with respect to its systemic obligations: interbank lending, derivatives and deposits. Conditional on this first goal being achieved, regulation should minimize the probability that an LFI is dragged into any form of bankruptcy, given that the risk of even some minor bureaucratic delay in repayment can undermine confidence.

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 the creditors to be paid in full). In other words, 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. LFIs will post enough collateral (equity) to ensure that the debt (all the debt, not just the deposits and derivative contracts) is paid in full with probability one. When the fluctuation in the value of the underlying assets puts debt at risk, LFI equityholders are faced with a margin call and they must either inject new capital or lose their equity. There are three main differences between margin calls and our new capital requirement system: the trigger mechanism, the action taken if the trigger is activated, and the presence of an 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 following days. 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 determinable, 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. In addition, debtholders are often dispersed and so unable to coordinate a margin call. If a margin call approach is to be followed, we need to find an easily observable trigger.

To solve this problem we rely on the credit default swap (CDS) market as a trigger mechanism. A credit default swap on an LFI 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 debt will not be repaid in full. In essence, the CDS indicates the risk that the LFI will fail. In our mechanism, when the CDS price rises above a critical threshold, the regulator forces the LFI to issue equity until the CDS price moves back below the threshold. If this does not happen within a predetermined period of time the regulator intervenes.

The second difference from a standard margin call system is precisely this role of the regulator. The regulator first determines whether the LFI debt is at risk – in effect, she carries out a stress test. If the debt is not at risk (i.e., the CDS prices were inaccurate), then the regulator declares the company adequately capitalized and to prove it injects some government money. If the debt is at risk, the regulator replaces the CEO with a receiver (or trustee), who recapitalizes and sells the company, ensuring in the process that shareholders are wiped out and creditors receive a haircut. 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 any of the costs (systemic effects).

Finally, the third difference from a standard margin call system is that to protect the systemic obligations, besides the equity cushion, we require also a layer of junior long- term debt. This debt has a dual function, to provide an additional cushion for the systemic obligations and to provide the underlying asset on which the CDS is traded.

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 (forthcoming). 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 one proposed by Flannery (2005). In his case, however, the debt is converted into equity when the value of equity becomes close to zero. This solution has three potential shortcomings. First, it is too 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 generates multiple equilibria, some of which are inefficient. 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. Besides 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 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, because 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 related 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 collect information is common to both sets of proposals, the mechanism and the trigger differ. If we want to avoid bankruptcy for sure, subordinated debt as a signal of a bank solvency will not work, because it is always safe. In addition, as we explain in Section 5, CDSs have several advantages as a trigger mechanism.

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 endogenize the level of LFI activities. Section 5 provides further discussion of our mechanism and describes how it would work in practice. Section 6 concludes.

2. Framework

If there exists any economic logic to the “too big to fail” argument, this logic resides in the fact that financial institutions are highly interconnected through derivative and repo contracts and thus the default of one might trigger losses on the counterparties, producing further defaults. This cascade can occur not only for actual losses, but even for potential ones. 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 in systemically relevant obligations, but also to protect such obligations from the uncertainty triggered by a default on non-systemically relevant obligations. In short, we suppose that the regulator wants to avoid bankruptcy altogether.

In what follows, we categorize as systemically relevant obligations short-term interbank borrowing, derivative contracts, and bank deposits; while we consider long-term debt as non-systemically relevant. We refer to non-systemically relevant 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 attract a lower interest rate.[1] In our formal model we will not include the advantages of systemic obligations, but we will relax this assumption at the end of Section 3. Throughout, we will adopt the perspective that, from a social point of view, defaulting on a systemic obligation is significantly more costly than defaulting on a non-systemic one.

There are several reasons why banks and other large financial institutions issue debt. First, as noted above, 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

[1] A difference between systemic and non- systemic obligations will also arise from an LFI point of view 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.[2]

For simplicity we consider a two-period model with the structure displayed in Figure 1, where the p_i indicate the probabilities of the various branches and V_i the cashflow realization in the different stats of the world.

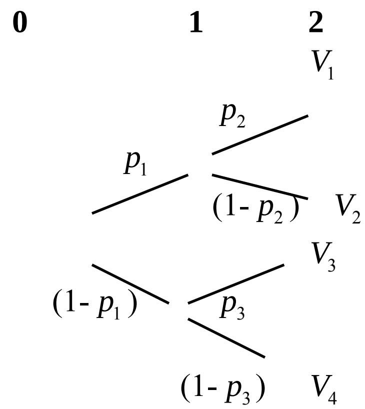

Figure1

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 time 2 (we will discuss the possibility of short-term debt in Section 5.3). (To repeat, we do not distinguish between systemic and non-systemic debt from the issuer point of view until the end of Section 3.) We assume that the capital structure is set in a value maximizing way at time zero as a result of some takeover threat or coordinated effort by large shareholders. At time 1 the LFI manager can modify the capital structure by issuing equity only if he has shareholders' approval. At time 2 the company pays out the cash

[2] 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.

flow V_i with 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 assumed that there is a benefit, but not a 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 with probability one.[3]

We could, of course, qualify this extreme result by introducing a 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 costs of the LFI's bankruptcy are so great that bankruptcy must be avoided with probability 1.[4]

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.

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

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

[3] The LFI will use the debt it issues to buy back equity at time 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.

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

but debt is paid with probability one. In the next section we will show that this is possible. We start by assuming that at time 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 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 capital requirements to be state contingent. However, we assume that the initial debt level D is not state contingent.

Consider a time-zero debt level D (due at date 2) such that $V_4 < D < V_3$. Then, if at time 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 equityholders, 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

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

The value of the LFI at time zero can be calculated as the expected value of the time-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 time 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. There is a real cost of preventing bankruptcy in equilibrium: the largest debt the bank can have is

$D = V_4 + p_3(1-\lambda)(V_3 - V_4)$ rather than $D = V_1$, and so there will be more stealing in equilibrium than in the first-best. If society is willing to put up with a positive probability of bankruptcy, then a higher debt level can be supported. In fact it is easy to show that as the constraint on the probability of bankruptcy is weakened sufficiently the first-best for the LFI (if not for society) is achieved under our mechanism.

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 debtholders 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. If markets are efficient these prices incorporate not only what informed traders know about the value of the LFI's assets but also what traders expect that the regulator would do in case of insolvency (an example of market-based corrective actions). As Bond et al (forthcoming) show, this endogeneity of market prices limits the effectiveness of market-based corrective actions. We take this problem into consideration and we 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.

As for the margin requirement, it is necessary to determine not only when the margin will be called, but also what happens if the margin call is not answered in a timely fashion. In our case, we assume that if new equity is not raised (or is not raised in a sufficient amount), so that the trigger remains activated for a relatively extended period of time (let's say a month), then the regulator will intervene. When the regulator intervenes, we assume the following procedure:

(1) The regulator first determines whether the LFI debt is at risk – in effect, she carries out a stress test. If 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 replaces the CEO with a receiver (or trustee). The receiver wipes out the existing equity and debt (keeping in place systemically relevant obligations, such as derivative contracts or bank deposits), and recapitalizes and sells the LFI for cash within a reasonable period of time (possibly through a public offering). The receiver distributes the proceeds from the sale according to absolute priority, except that she ensures that creditors are not fully repaid, and that shareholders receive nothing (anything left over goes to the government). [5]

We assume a timing as in Figure 2. After the realization of the first shock at date 1, the manager has the option to raise equity. After this decision has been made market prices are observed. At this point the regulator has the option to intervene before the second shock is realized. At date 2 the second shock is realized.

Figure 2: Timing

First shock is realized realized at at date 1	LFI decides whether to issue equity	Market price of CDS observed	Regulator decides whether to intervene	Second shock is realized at date 2

|________________|___________________|____________________|______________|

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). 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 price satisfies

[5] It is not essential that the regulator sell the LFI for cash, e.g., she could carry out a reorganization via a debt-equity swap. Our early warning system, based on a threshold for the CDS price, generalizes to these other approaches.

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

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 far as the CDS market is concerned, a "default" occurs when the regulator determines that the debt is at risk and imposes a haircut. If this haircut is predetermined (let's say 20%), the CDS prices will be a function of the (risk neutral) probability of default.

Proposition 1:

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 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 he will reorganize the LFI, imposing a cost on the debt-holders. Since the creditors receive a haircut, the initial debt will not be fully repaid and 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 he will find that the debt is not at risk and he 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.

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. The equity-holders will agree to let him issue equity since they will be wiped out if he does not (and, as long as the threshold level for the CDS price is strictly positive, the manager can issue slightly less equity than $D - V_4$, so that there is something left for initial equityholders). 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.[6]

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 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.

[6] 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.

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 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 time 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 because it determines the thickness of the market for the security underlying the CDS. The actual amount should be determined on the basis of accurate studies of what is necessary to sustain a vibrant CDS market[7], as well as on estimates of the formula (5).

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 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

[7] 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. At 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.

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. So 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

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

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

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

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

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

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 time1 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 equityholders 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 equityholders and debtholders), or the debt is risky and the equityholders 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 An implementable rule

Taken at face value, the model suggests an intervention every time the CDS price is above zero. This is clearly very impractical. First, if the price of the instrument is always equal to zero the instrument would hardly be traded. Second, in the real world no institution is perfect. For example, it is reasonable to assume that the regulator might make some mistakes and occasionally classify an adequately capitalized institution as not adequately capitalized and vice versa. As long as these mistakes are non-systematic, it is sufficient to have a rule with some flexibility. Consider for instance a rule that says that intervention is triggered whenever the CDS price is above 100 bps for at least 20 of the last 30 trading days. Assuming a loss upon default of 20%, this trigger would correspond to accepting a maximum risk neutral probability of default equal to 5%.

This rule will make the mechanism robust to speculation. Suppose that a bear raid is launched to drive the CDS price above the threshold, so as to trigger the mechanism and profit from it. If the regulator is perfect, the speculation will not pay off, because the regulator will find that the LFI is adequately capitalized and nothing will happen. If the regulator makes occasional mistakes, however, and, let's say, 5% of the time classifies as not adequately capitalized an institution that is, is there a risk of a self-fulfilling bear raid?

Suppose the haircut imposed on creditors is 20%. Then, if the LFI is adequately capitalized, a speculator will be unwilling to drive the CDS price over 100 bps because on average he will lose out. If the mechanism is triggered, with .95 probability the LFI is declared adequately capitalized and the CDS price will drop to zero, and with .05 probability the company is declared not adequately capitalized and a 20% haircut is imposed on the bondholders. In this latter case the CDS will pay 2000 basis points. Hence, the expected value of the CDS equals 100. It does not pay the speculator to drive the price above 100 if the expected payoff is only 100. As this example shows, the trigger rule can be designed to reflect the probability of regulatory mistakes and the haircut imposed when these mistakes occur.

One might wonder whether a CDS contract that insures against such a rare event will be actively traded. But the CDS on the U.S. Treasury bonds is very actively traded, while the probability of a default of the U.S. government, which can print its own currency, is quite remote.

Note that the requirement that the regulator, if he finds that the institution is adequately capitalized, must inject some funds serves two purposes. First, it insures the system against regulatory mistakes. If the regulator incorrectly concludes that the company is adequately capitalized, when it is not, the injection of some cash which is pari passu with respect to the existing debt ensures that default is less likely. Second, the injection increases the political cost of forbearance. Politically, it is very costly for a regulator to declare a company not adequately capitalized, since the shareholders and the bondholders will actively lobby against it. If she has an easy way out (to declare the company adequately capitalized at no cost), the regulator will likely abuse her discretion. This is the reason we want to make it politically costly to forbear. Having to commit taxpayers' money has this effect.

5.2 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?

One reason for using CDS prices is that it has been shown that the CDS market leads 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)).

We could certainly restate our mechanism in terms of bond prices. Bond issues, however, tends to 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 of solvency status than CDS prices. In fact, the success of CDSs is mainly due to their standardized nature, which ensures greater liquidity.

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.

We could use other debt-related market instruments as an alternative, or in addition, to CDSs. 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.

Finally, a rule that says that intervention is triggered whenever the CDS price is above 100 bps for at least 20 of the last 30 trading days will be less subject to manipulation than a rule that says that the CDS price can never go above 100.

Note that, in contrast to the prices of CDSs or other debt related instruments, equity prices are not a good measure of financial distress. While equity is very liquid and its market price hard to manipulate, it does not provide a good indicator of the state of the world for two reasons. First, since equity is insensitive on the downside (because of limited liability) and very sensitive on the upside, a small probability of a positive event can sustain significant equity prices even in the presence of a high probability of default. Hence, high equity prices do not necessarily guarantee that a LFI is not in serious trouble. Second, if we use equity prices as an indicator of the risk of default, bad self-fulfilling equilibria are hard to avoid. With CDS prices, a bad self-fulfilling equilibrium is eliminated by requiring the regulator to determine that the LFI is not adequately capitalized before taking control. In contrast, with equity, it is difficult to see what regulatory behavior would rule out an optimistic self-fulfilling equilibrium in which equity retains value because the market does not expect the regulator to intervene, and indeed the regulator does not intervene.

For the CDS to perform this function properly, however, they should be traded on an exchange, where the counterparty risk is minimized, if not eliminated, and where the positions of the various parties are transparently disclosed. Without such disclosure, the market would find it very difficult to assess the riskiness of individuals LFIs.

5.3 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. To analyze this possibility let's go back to the no-investment model of Section 3, but allow the LFI to issue short-term debt, which the LFI has to roll over at time 1 (since there is no cashflow 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 $V_4 < STD \leq p_3V_3 + (1 - p_3)V_4$, 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 $STD > p_3V_3 + (1 - p_3)V_4$, 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 $STD = p_3V_3 + (1 - p_3)V_4$.

Now consider what happens if $STD = p_3V_3 + (1 - p_3)V_4$. 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 debtholders (i.e., $STD = V_3$). After observing a positive refinancing rate, the regulator will intervene, but she will find no resources to avoid a default on the debt 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. In other words, an intervention contingent on the short-term debt rate cannot succeed in avoiding bankruptcy in all the states of the world.[8]

5.4 How would this rule have worked in the past crisis?

Our mechanism is similar in spirit to the "market-based" regulation underlying Basel 2, with different tiers of capital. The main difference, however, is that we rely on market prices and not on credit rating agencies. As events have shown, the reputational incentives underlying the rating mechanism, which worked very well for more than one hundred years, do not seem to have performed as expected during the last crisis. Would our mechanism have worked better? In answering this question, it is important to

[8] We do not want to claim that this is always the case, but simply that it can be the case.

appreciate that the CDS prices are endogenous with respect to the default rule we choose. On the one hand, this endogeneity implies that there is no guarantee that CDS prices will perform in the same way as in the past under our proposed rule. 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 prices as an indicator of the probability of financial insolvency. To minimize this latter effect we look at CDS prices before 10/14/2008 (i.e., the Paulson rescue of all the major US Banks).

Figure 3a plots the CDS prices for Citigroup and JP Morgan from 1/1/07 to 10/14/08. The prices are in basis points per year and refer to the cost of insuring 5-year debt against the possibility of default. Before July 2007 both banks had CDS prices close to zero: around 8 bps for Citigroup and 16 for JP Morgan. Assuming a loss upon default of 40%, these values correspond to a risk neutral probability of default of between 0.2% and 0.4%: very trivial numbers.

In July 2007 both CDS prices shot up, reaching a maximum of 63 for JPM and 50 for Citi. By the beginning of October they are both in the 30s range. From there on the history diverges. In October Citigroup CDS prices increase and start to be systematically higher than JPMorgan's ones. They pass the 100 mark on February 8th, 2008 and remained above that level for more than 20 sessions (Figure 3b). By contrast, the JP Morgan CDS, while fluctuating with the Citigroup one, stays mostly below the 100 bps level except for the most severe peaks of the crisis; they would have activated the trigger only in July 2008.

Figure 4a shows a similar plot for the two other major banks: Bank of America and Wells Fargo. Both have trivial CDS prices up to July 2007 and both experience a sharp increase at the beginning of the crisis. Similar to JP Morgan, however, the CDS prices have remained below the 100 bps mark except in the most acute phases of the crisis (Figure 4b). Before the summer of 2008, among these four banks only Citigroup had a CDS price above 100 for more than 20 out of the last 30 consecutive days. Hence, a trigger rule of the type described before would have worked well in singling out Citigroup early on.

To confirm that CDS prices are a good early warning system, in Figures 5 and 6 we look at the CDS prices of institutions that became insolvent. Figure 5 looks at Bear

Stearns CDS prices. For Bear the cost of insurance shot above the 100 mark at the beginning of August 2007 and stayed there for more than 30 consecutive days. While it temporarily dropped below that threshold toward the end of September/ beginning of October 2007, after the end of October it was consistently above that threshold, reaching 727 bps just before the JP Morgan rescue. Our trigger rule would have forced Bear to raise equity back in August 2007.

A similar picture emerges for Washington Mutual (Figure 6). The CDS prices shot above 100 at the end of July 2007. Washington Mutual reached the 20 out of 30 sessions above 100 bps in September 2007. Thus, our rule would have forced Washington Mutual to raise equity in September 2007; instead it waited until April 7th 2008, when it raised $7 billion of equity capital. This deleveraging reduced CDS prices from 481 to 321, showing that equity offerings do bring down CDS prices. But the equity offering was insufficient. Eventually, CDS prices went back up and reached 3,350 bps (not shown in the picture since it is out of scale) on 9/15 just before the Office of Thrift Supervision (OTS) seized WaMu savings bank from WaMu Inc. (the bank holding company) and placed it under the receivership of FDIC, forcing WaMu Inc. to file for Chapter 11 bankruptcy protection.

While this evidence is only suggestive it does show that CDS prices respond promptly to an increased probability of default and enables us to differentiate between more and less solid institutions. If our rule had been in place all the troubled institutions would have been forced to issue equity one year before they got into trouble.

5.5 Changes in Risk Aversion

A possible objection to our mechanism is that it implicitly assumes that risk aversion is constant. In fact, CDS prices can change not only because of a change in the probability of bankruptcy, but also because of a change in the price of risk (i.e., a change in risk aversion). If we had a good asset pricing model to separate changes in risk aversion from changes in the probability of bankruptcy, it would be very easy to sterilize changes in CDS prices from changes in risk aversion. Imagine, for instance, that changes in the CDS of U.S. Treasury bonds reflect only changes in risk aversion. Then we can adjust the trigger for changes in the price of U.S. Treasury CDS. In practice, however, an asset pricing model of this type does not yet exist (in fact there is not even direct evidence that risk aversion moves) and so such a correction is not possible.

Yet, we do not regard this as a major problem. If the price for risk 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.

5.6 The Regulator's time inconsistency

In our analysis we have ignored political economy considerations. But too-big-too-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 Prescot (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 at prices 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.

5.7 Risk of forbearance versus risk of panic

The risk of empowering a regulator with the right to life and death 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 manager and convert debt into equity 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.

Our mechanism eliminates this risk by leaving the regulator the option to limit her intervention to an audit. Clearly, this option reintroduces the risk of regulatory forbearance. Nevertheless, we think this risk is substantially reduced with respect to the current environment 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 with respect 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.

5.8 Regulators vs. markets

One potential criticism of our approach is that it relies excessively on public information. Regulators – many argue—are privy to non-public information and because of that they are in a much better position than the market to judge the solvency of various LFIs. This potential criticism collides with the reality that regulators have been very slow in taking over troubled LFIs. This might be for political economy reasons. Regardless of the cause, our mechanism incorporates the information present both in the marketplace and in the regulator's office, in the sense that the market provides a trigger, but the regulator can choose whether to intervene or not based on her own information.

5.9 Systemic effects

Our analysis focuses on the LFI insolvency problem from the point of view of an individual institution, ignoring the potential spillover effects that might lead to a systemic crisis. Since government intervention has been mainly justified as a way to minimize systemic effects, it is important to emphasize how our mechanism deals with the systemic dimension.

There are three reasons why the failure of an LFI might have effects on the entire system. First, losses on the credit extended to the insolvent LFI can make other LFIs insolvent. Second, the failure of an LFI can force the immediate liquidation of a large set of assets, depressing their prices and so reducing the assets' value of other LFIs, possibly triggering other failures. Third, the failure of an LFI has an immediate effect on the amount of financial and human resources dedicated to trading certain assets classes, temporarily reducing the liquidity and hence the value of those assets, with potentially negative effects on other financial institutions. For example, the demise of Drexel led to a collapse in the junk bond market, which exacerbated the Savings and Loan crisis.

Although our analysis is a partial equilibrium one, our mechanism does address the negative systemic effects. In fact, it is able to counteract all three negative feedback loops. First, by insuring that LFIs will be able to pay their debt with probability one, our mechanism eliminates the very root of any systemic problem, since no LFI will become insolvent. Second, our mechanism does not force any asset liquidation, thus avoiding a downward spiral in assets prices. Last but not least, by inducing equityholders to inject more equity in a poorly performing LFI, our mechanism increases the amount of capital invested in the sector, alleviating the shortage which is at the root of many crises.

In this latter respect, our mechanism is related to Kashyap et al (2008). They design a form of insurance contract that increases the availability of risk capital in the case of a systemic crisis. The main difference is in the mechanism to make certain states of the world verifiable. Kashyap et al (2008) rely on an aggregate industry profitability measure, while we rely on the individual LFI CDS prices. As a result, their approach is able to cope only with a systemic crisis, leaving the system exposed to crises like the demise of Drexel, which was severe, but not systemic.

Some people might see the latter feature of Kashyap et al (2008), that it limits the injection of capital to situations of systemic crisis, as a virtue. Our mechanism, however, can easily be modified to achieve the same objective. We can condition intervention not just on the CDS price of the institution in question, but also on the CDS prices of other major LFIs. In so doing, we can restrict capital injections to systemic crises, where most or all the LFIs have high CDS prices.

Last but not least, by making creditors suffer (at least out of equilibrium), our mechanism addresses one of the major causes of the crisis: the lack of incentives for lenders to be mindful of risk in their lending practices. Any mechanism that eliminates such an incentive runs the risk of excessive lending, with the systemic effects this implies.

5.10 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.

6. Conclusions

The 2008 financial crisis has exposed the magnitude of the too-big-to-fail problem and worsened the moral hazard it engenders. After September 2008, for instance, the differential interest rate on interbank loans between large and small banks dropped from -8 bps to -34 bps (Cho, 2009). This lower interest rate induces large financial institutions to borrow even more, increasing the risk to the system and the cost of the eventual bailout. It also severely distorts competition in favor of large banks, increasing the number and size of the banks that would need to be rescued in the future.

The too-big-to-fail problem arises from a combination of an economic problem – the cost of bankruptcy 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 debtholders if the company is too risky. We have shown that this mechanism ensures that LFIs do not face any risk of bankruptcy, while preserving 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 equityholders 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.

References

Acharya,Viral and Timothy Johnson,(2007), "Insider Trading in Credit Derivatives" *Journal of Financial Economics*,84(1):110-141.

Black, F., Scholes, M. (1973) Pricing of Options and Corporate Liabilities *Journal of Political Economy* 81 (3), 637-654

Blanco,R.,S.Brennan, and I.W.Marsh, (2005) "An Empirical Analysis of the Dynamic Relation between Investment-Grade Bonds and Credit-Default Swaps" *Journal of Finance*,60:2255-81.

Bond, Philip, Itay Goldstein, Edward Simpson Prescott, forthcoming, Market-Based Corrective Actions" Review of Financial Studies

Calomiris, C.W. (1999), "Building an Incentive-Compatible Safety Net" *Journal of Banking and Finance,* 23.

Cho, David, 2009, "Behemoths Born of the Bailout Reduce Consumer Choice, Tempt Corporate Moral Hazard", *Washington Post* Friday, August 28, 2009

Diamond, D. W., Dybvig, P. H., 1983, "Bank Runs, Deposit Insurance, and Liquidity" *Journal of Political Economy* 91 (3), 401-419

Evanoff, Douglas D. and Larry D. Wall, (2000), "Subordinated Debt and Bank Capital Reform" Federal Reserve of Chicago working paper.

Flannery, Mark J., (2005), "No Pain, No Gain? Effecting Market Discipline via Reverse Convertible Debentures", Chapter 5 of Hal S. Scott, ed., *Capital Adequacy Beyond Basel: Banking Securities and Insurance*, Oxford: Oxford University Press.

Fried, Jesse, (2008), "Uncle Sam should claw back Wall Street bonuses" http://blogs.law.harvard.edu/corpgov/.

Hull, J.,Mirela Predescu,and Alan White, 2004, " The Relationship between Credit Default Swap Spreads, Bond Yields, and Credit Rating Announcements," *Journal of Banking and Finance*, 28:2789-2811.

Kashyap, Anil K and Jeremy C. Stein, 2004, Cyclical implications of the Basel II capital standards, Federal Reserve Bank of Chicago Economic Perspectives 1Q/2004,

Kashyap, Anil K, Raghuram Rajan, and Jeremy C. Stein, (2008), "Rethinking Capital Regulation", University of Chicago working paper.

Kydland, F. E., Prescott, E. C. (1977) "Rules Rather Than Discretion - Inconsistency of Optimal Plans" Journal of Political Economy 85 (3), 473-491

Meltzer, Allan, 2004, A History of the Federal Reserve, Volume 1: 1913-1951, University of Chicago Press.

Myers, S. C. (1977), Determinants of Corporate Borrowing, Journal of Financial Economics 5 (2), 147-175.

Myers, S. C., Majluf, N. S. (1984) Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have, Journal of Financial Economics 13 (2), 187-221

Squam Lake Working Group on Financial Regulation, 2009, "An Expedited Resolution Mechanism for Distressed Financial Firms: Regulatory Hybrid Securities", April 2009

Stern, Gary H.; Feldman, Ron J., (2004), *Too Big to Fail: The Hazards of Bank Bailouts*, Washington, DC: Brookings Institution Press.

Taylor, John B. and John C. Williams, (2009), "A Black Swan in the Money Market" *American Economic Journal: Macroeconomics,* Vol. 1, No. 1, January 2009: 58-83.

Thorburn, Karin S, (2004), "Corporate Governance and Financial Distress" in New Pesrpectives on Economic Crime, Hans Sjogren and Goran Skogh, Edward Elgar Publishing.

Figure 3a: Citi and JP Morgan CDS prices leading to the crisis

The plot reports the prices (in basis points per year) of the 5-year credit default swaps on Citigroup and JP Morgan debt starting 1/1/07 to 10/14/08. Source: Bloomberg.

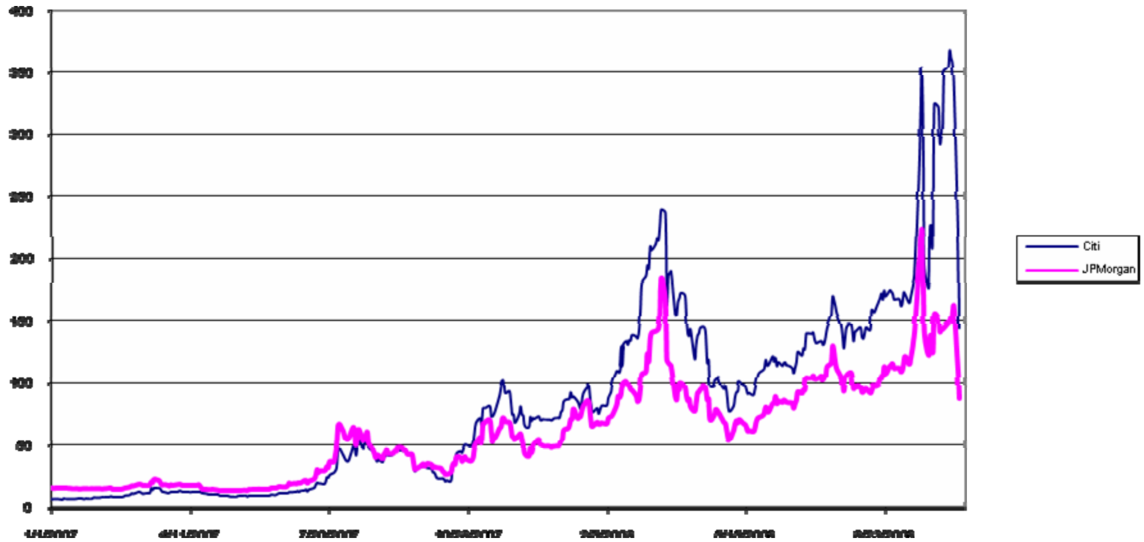

Figure 3b: Citi and JP Morgan CDS prices during the Bear Stearns Crisis (3/14/08) and the Lehman Crisis (9/15/08)

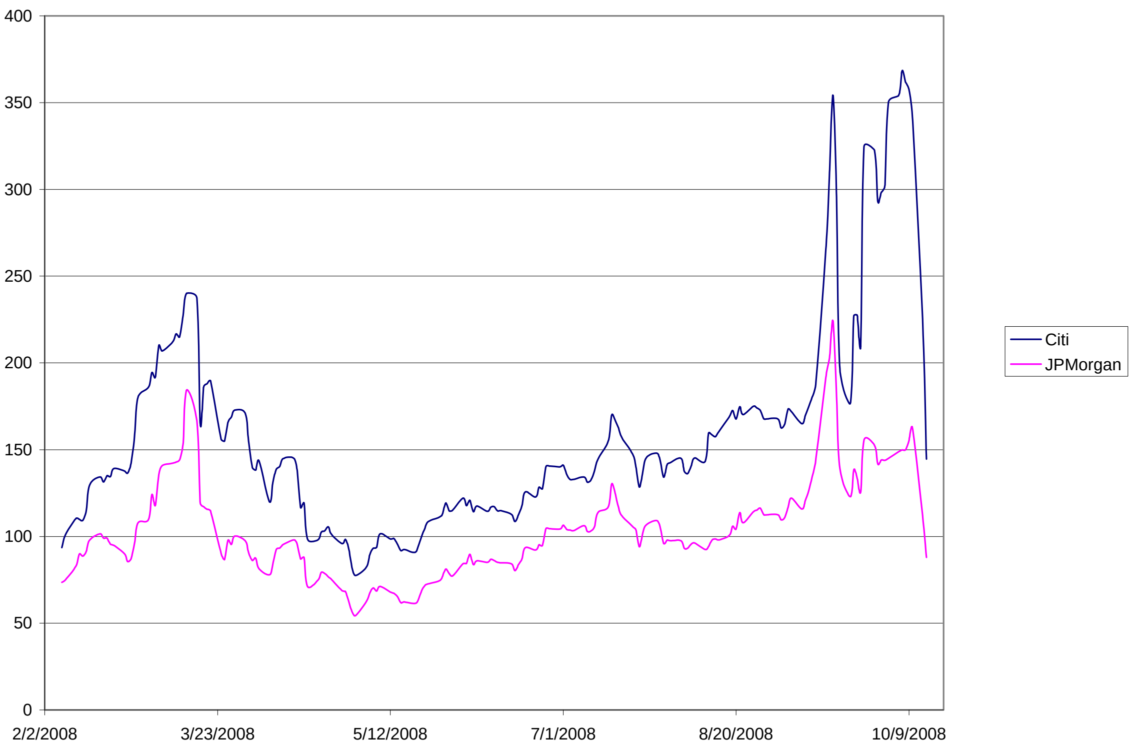

Figure 4a: BofA and Wells Fargo CDS prices leading to the crisis

The plot reports the prices (in basis points per year) of the 5-year credit default swaps on Bank of America and Wells Fargo debt starting 1/1/07 to 10/14/08. Source: Bloomberg.

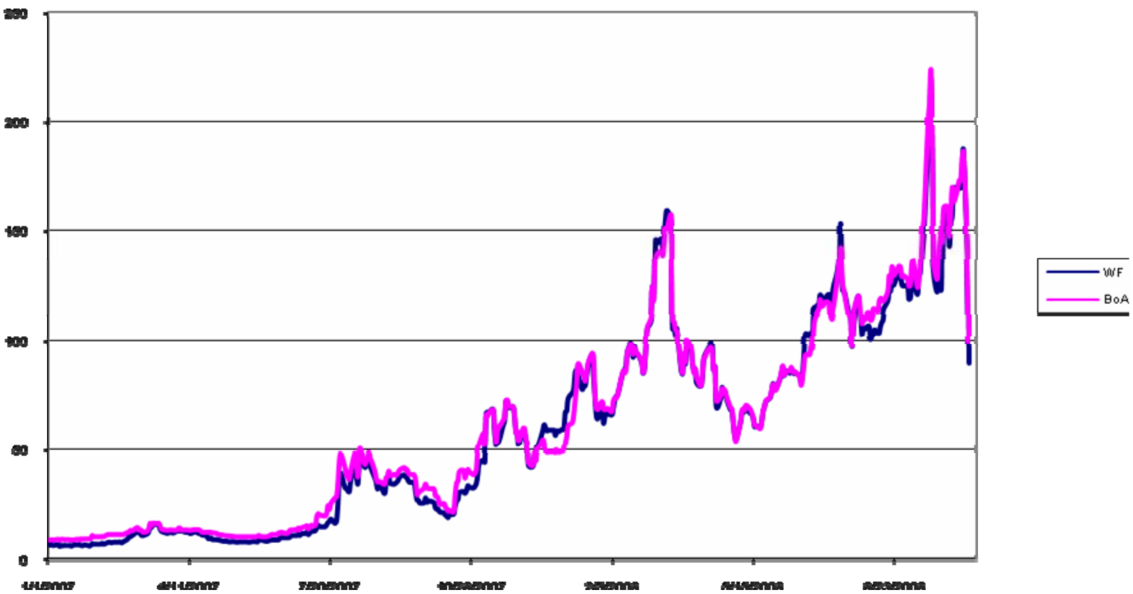

Figure 4b: BofA and Wells Fargo CDS prices during the Bear Stearns Crisis (3/14/08) and the Lehman Crisis (9/15/08)

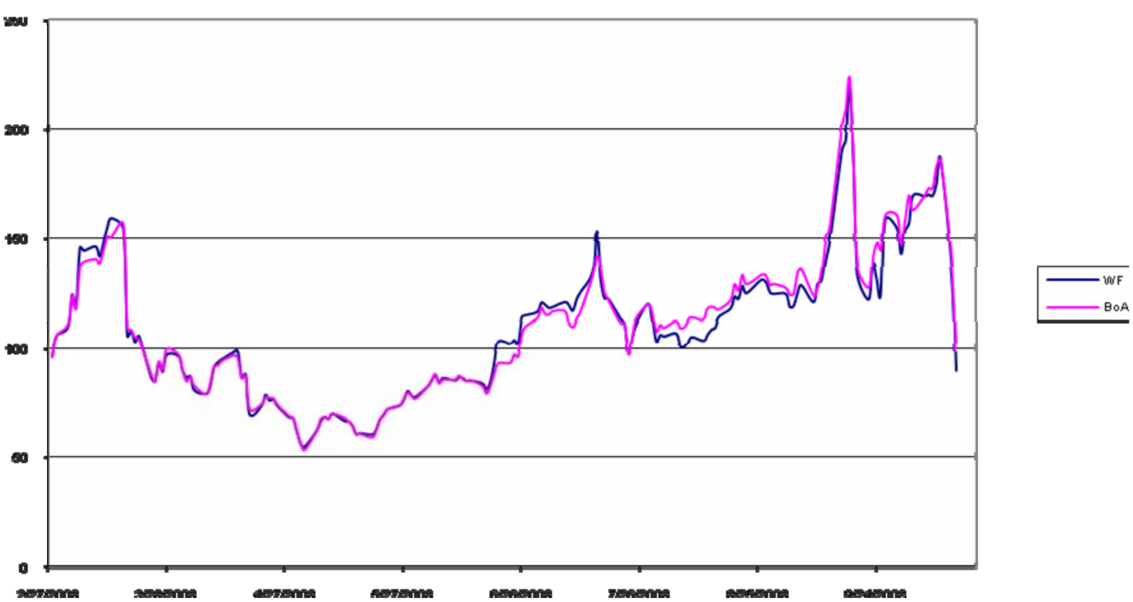

Figure 5: Bear Stearns CDS prices before the rescue

The plot reports the prices (in basis points per year) of the 5-year credit default swaps on Bear Stearns debt starting 1/1/07 to 10/14/08. Source: Bloomberg.

Figure 6: Washington Mutual CDS prices before receivership

The plot reports the prices (in basis points per year) of the 5-year credit default swaps on Washington Mutual debt starting 1/1/07 to 9/15/08. On that day all the major rating companies downgraded Washington Mutual and the CDS prices shot to 3,350 bps., where they stay until the Office on Thrift Supervision (OTS) seizes WaMu savings bank from WaMu Inc. and places it under the receivership of FDIC, which in turn sells it to JPMorgan Chase. On 9/26/08 WaMu files for Chapter 11 bankruptcy protection. On 10/17/07 WaMu reports 3Q07 results, with 72% loss in profits. On 4/7/08 WaMu raises $7bln of capital (two of which from TPG). Source: Bloomberg.