A Tax on Systemic Risk

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Abstract

We advocate that systemic risk of the financial sector needs to be regulated, using a measure of an individual financial firm's contribution to systemic risk that is based on Acharya, Pedersen, Philippon, and Richardson (2009a). We propose that each financial firm should be charged a "tax" based on its expected loss conditional on the occurrence of a systemic crisis. In our preferred approach, individual firms would be required to purchase *contingent capital insurance*, that is, insurance against the losses they incur during systemic crises. The cost of this insurance determines the firm's systemic risk tax. We discuss why a joint private-public provision of such insurance has the right incentive properties to get the financial sector to internalize systemic risk. We provide an example of how such a systemic risk tax could be calculated and also discuss its relationship to other contingent capital proposals such as forced debt-for-equity conversions.

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I. Introduction

Systemic risk can be broadly thought of as the failure of a significant part of the financial sector – one large institution or many smaller ones – leading to a reduction in credit availability that has the potential to adversely affect the real economy. Given the interconnectedness of the modern financial sector, and for the purposes of systemic regulation, one should think of a "financial firm" as not just the commercial bank taking deposits and making loans, but also include investment banks, money-market funds, insurance firms, and potentially even hedge funds and private equity funds. There are several types of systemic risk that can be generated from the failure of a financial institution, and especially so during a financial crisis, such as counterparty risk, spillover risk due to forced asset sales, increased cost of inter-bank borrowing, and the risk of "runs" on the shadow banking system.

Current financial regulations such as the Basel capital requirements seek to limit each institution's risk. However, unless the external costs of systemic risk are internalized by each financial institution, the institution will have the incentive to take risks that are borne by others in the economy. That is, each individual firm may take actions to prevent its own collapse but not necessarily the collapse of the system. It is in this sense that the financial institution's risk is a negative externality on the system.[2] An illustration from the current crisis is that financial institutions took bets on securities and portfolios of loans (such as AAA-rated sub-prime mortgage backed tranches) which faced almost no idiosyncratic risk, but large amounts of systematic risk. Thus, financial regulation should be focused on limiting systemic risk, that is, the risk of a crisis in the financial sector and its spillover to the economy at large.

Acharya, Pedersen, Philippon and Richardson (2009a), referred to as APPR hereafter, propose theoretically and justify empirically that in order to address the systemic risk externality, each institution must face a "tax" that is based on the extent to which it is likely to contribute to systemic risk (defined by APPR as the realization of states of the world in which the financial sector as a whole becomes undercapitalized). This paper proposes two novel schemes to estimate such a tax: (i) pricing of *contingent capital insurance for systemic risk*, that is, an

[2] An analogy can be made to an industrial company that produces emissions which lower its own costs but pollute the environment.

insurance for each firm against itself becoming undercapitalized when the financial sector as a whole becomes undercapitalized; and, (ii) *market-based discovery of the price of such risk insurance* that financial institutions must purchase partly from the private sector and mostly from the government or the central bank.

For the first scheme, we provide an explicit calculation formula for contingent capital insurance and illustrate how the systemic risk tax varies with the size of the institution, its leverage, risk (volatility), and importantly, correlation with rest of the economy or the systemically important part of the financial sector. In applying the method to the period prior to the start of the financial crisis in July 2007, the measure of systemic risk sorts well on the firms that ended up running aground in the crisis, e.g., only 18 firms show up in the top 15 systemic firms in all four 4 years of 2004-2007. These firms are a who's who of the current crisis, including A.I.G, Bank of America, Bear Stearns, Citigroup, Countrywide, Fannie Mae, Freddie Mac, Goldman Sachs, Hartford Financial, JP Morgan, Lehman Brothers, Lincoln National, Merrill Lynch, Metlife, Morgan Stanley, Prudential Financial, Wachovia and Washington Mutual. Moreover, the measure is not just size-based as many of these firms also show up, once adjusted for their market capitalization.

The second scheme (introduced in Acharya, Pedersen, Philippon and Richardson (2009b) and similar to the deposit insurance proposal of Dewatripont and Tirole (1993)) has several attractive features. Specifically, in this scheme we propose that each financial firm would be required to buy insurance against its own losses in a systemic risk scenario in which the whole financial sector is doing poorly. In the event of a pay off on the insurance, the payment should not go to the firm itself, but to the regulator in charge of managing systemic risk and stabilizing the financial sector. This would provide incentives for the firm to limit its contributions to systemic risk (to lower its insurance premium, e.g., by lowering size, leverage, risk and correlation with the rest of the financial sector and economy), provide a market-based estimate of the risk (the price of insurance), and avoid moral hazard (because the firm does not get the insurance pay off). Since the role of the private sector in providing such insurance is primarily for price discovery and the amount of private capital available to provide such systemic insurance likely to be limited, most of the insurance (say 95%) would be purchased from the regulator and the rest (remaining 5%) from the private sector.

The paper is organized as follows. Section II makes a case for regulating systemic risk and why a tax on systemic risk may be the optimal economic policy. Section III presents an example of such a tax on financial firms based on price of their contingent capital insurance for their systemic risk contributions. We provide an exact formula for the price of each firm's contingent capital insurance and calibrate it using data prior to the start of the financial crisis starting in the summer of 2007. Section IV describes our preferred option of a joint private-public scheme to tax systemic risk of financial firms (including details of the exact implementation). In Section V, we compare our proposed measure and regulation of systemic risk to existing contingent capital proposals in the literature, especially the forced debt-for-equity conversions proposed in Flannery (2005) and Kashyap, Rajan and Stein (2008). Section VI concludes.

II. Regulating Systemic Financial Risk

Systemic risk can be broadly considered to be the joint failure of financial institutions or markets which lead to the impairing of the financial intermediation process. As described below, we stake the view that systemic risk emerges when the financial sector as a whole becomes undercapitalized. In practice, the threat of insolvency for any firm arises either through (i) capital risk, that is, the market value of assets fall below obligations, or through (ii) funding liquidity risk, that is, the risk that a financial institution will be unable to pay its obligations with immediacy at some point in the future. This firm-level insolvency risk can spread, i.e., become systemic risk, through (i) counterparty risk, (ii) fire sales, (iii) increase in the cost of liquidity transfers, for example, in inter-bank markets, or (iv) the igniting of contagious runs. We briefly describe each of these below and a particular example of how systemic risk emerged in the current crisis.

With respect to counterparty risk, if a financial institution is highly interconnected to many other financial institutions, then its failure can have a ripple effect throughout the system. For example, consider the over-the-counter derivatives market. The main reason for systemic risk in OTC markets is that individual institutions do not observe the totality of trades being done by their counterparties. The prime example in the current crisis is A.I.G. which built up $540 billion of one-sided credit default swap exposure on the so-called AAA-tranches of securitized products. These positions were built up with no or little capital and collateral support. Because all the trades were in the same direction, once the trades lost value, it meant that A.I.G.'s failure would be passed on throughout the financial system.

With respect to fire sales, consider the spillover risk that arises as one institution's trouble triggers liquidity spirals, leading to depressed asset prices and a hostile funding environment, pulling others down and thus leading to further price drops and funding illiquidity,and so on.[3] Indeed, the probability of asset fire sales was one of the reasons the government intervened and put into conservatorship both Freddie Mae and Fannie Mac. Between them, the institutions held over $1.4 trillion of mortgage-backed securities, $250 billion of which were in the less liquid non-prime mortgage area.

The third is that weak financial institutions raise the cost of transferring liquidity to safe institutions, endangering even otherwise solvent institutions' health through an *interest-rate contagion*. This effect, motivated theoretically by the work of Acharya (2001, 2009) and Diamond and Rajan (2005), appears to have contributed to the substantial rise in both secured and unsecured inter-bank borrowing costs during the crisis. For example, Acharya and Merrouche (2009) find that weak banks in the UK increased their liquid reserves (kept with the Bank of England) substantially more than safe banks, and identify that this precautionary hoarding of liquidity raised the cost of borrowing of safe banks, both against treasury collateral as well as on unsecured basis. If such interest-rate contagion persists, then over time even safer institutions can become progressively unprofitable and eventually insolvent.

The fourth is that many financial institutions have fragile capital structures in that they hold assets with long-term duration or low liquidity but their liabilities are highly short-term in nature. While commercial banks are not as subject to large-scale runs due to deposit insurance and central banks' lender of last resort support, the other institutions are, and indeed, many of them, most notably Bear Stearns and Lehman Brothers, as well as a number of managed funds in the money market and hedge fund arena experienced "wholesale" runs during the crisis. For example, the collapse of Lehman Brothers and the value of its short-term debt caused the largest money market fund, the Prime Reserve Fund, to "break the buck", leading to a run on the entire system. And, importantly, commercial banks too are subject to localized runs in the wholesale funding and inter-bank markets if they are perceived to have exposure to institutions experiencing large-scale runs. Many cite this issue as the proximate cause for the near collapse of the financial system when Lehman Brothers failed in September 2008.

[3] See, for example, Brunnermeier and Pedersen (2008), Garleanu and Pedersen (2007), and Mitchell, Pedersen, and Pulvino (2007).

It is clear from these examples that a firm's systemic risk can have broad effects on the financial sector as a whole. Nevertheless, based on a risk/return tradeoff, an individual firm may still find it worthwhile to hold large amounts of illiquid securities, or concentrate its risk into particular ones (e.g., subprime-based assets), or put high amounts of leverage on its books (as a way to drive up excess returns). The reason is that the firm's optimization does not take into account the systemic risk it imposes on other financial institutions. By its very nature, therefore, systemic risk is a negative externality imposed by each financial firm on the system.

Arguably, a major failure of the current crisis was that existing financial sector regulations seek to limit each institution's risk seen in isolation and are not sufficiently focused on systemic risk. As a result, while individual firm's risks are properly dealt with in normal times, the system itself remains, or is in fact encouraged to be, fragile and vulnerable to large macroeconomic shocks.

APPR suggest a methodology to get around this market and regulatory failure and induce financial institutions to internalize the negative externality of systemic risk. Firms are often regulated to limit their pollution or taxed based on the externality they cause (see, for example, the classic regulation theory of Stigler, 1971, and Peltzman, 1976). Similarly, APPR propose a "Pigovian tax" on financial firms' contribution to systemic risk.[4]

Specifically, APPR show that the optimal policy would be for the regulator to "tax" (i.e., charge a premium to) each individual bank an amount equal to the sum of two components:

i. *The expected losses upon default of the liabilities that are guaranteed by the government*:

That is, the **government guarantees in the system need to be priced**, in other words, financial firms must pay for the guarantees they receive. Because the price of these guarantees will vary across firms due to the firm's risk characteristics, the firm will choose an optimal level of leverage and risk-taking activities at a more prudent level. Currently, the Federal Deposit Insurance Corporation (FDIC) in the United States chooses the level of FDIC premiums on a risk- adjusted basis. However, in

[4] See, for example, Baumol (1972).

reality, premiums are only charged when the fund is poorly capitalized so the current FDIC scheme will in general not achieve this optimal policy.

ii. *The expected systemic cost times the percentage contribution of each firm to aggregate financial sector losses above a certain threshold.*

Thus, the systemic risk also needs to be priced, that is, **financial institutions need to internalize the costs of the negative externality imposed on the system**. There are two terms to this component of the tax. The first term – expected systemic costs – measures the level of the tax. There is substantial evidence on what leads to financial crises and the costs to economies of such crises beyond the impact of a normal economic downturn.[5] The second term - the percentage contribution of each institution to the financial sector collapse – measures which institutions pay more tax.[6]

Putting aside the political economy of the viability of systemic tax charges, the biggest hurdle to successful implementation is setting the price. Sections III and IV of this paper provide examples of how to obtain this price and charge and implement the tax on the portion of each firm's contribution to the overall systemic risk of the sector.

III. Contingent Capital Insurance: Theory and Evidence

Most proposals for regulating systemic risk rely on the regulator measuring the systemic risk of various institutions and restricting their behavior in some way, through capital requirements or returning to some form of Glass-Steagall style restrictive on scope. As described in Section II, an

[5] There is growing evidence of large bailout costs and real economy welfare losses associated with banking crises. For example, Hoggarth, Reis and Saporta (2002) estimate output losses somewhere between 10-15% of GDP. Caprio and Klingebiel (1996) argue that the bailout of the thrift industry cost $180 billion (3.2% of GDP) in the US in the late 1980s, and document that the estimated cost of bailouts were 16.8% for Spain, 6.4% for Sweden and 8% for Finland. Honohan and Klingebiel (2000) find that countries spent 12.8% of their GDP to clean up their banking systems whereas Claessens, Djankov and Klingebiel (1999) set the cost at 15-50% of GDP. The above papers outline the costs of financial crises. Of equal importance is the probability of such crises occurring, In an extensive analysis across many countries and time periods, Reinhart and Rogoff (2008a, 2008b) look at the factors that lead to banking crises, thus providing some hope of probabilistic assessments of such crises Borio and Drehmann (2009) study leading indicators for banking systems affected by the current crisis.

[6] APPR argue that this can be measured by a financial firm's expected losses in a systemic crisis. APPR provide an empirical analysis of this measure for both the crisis of 2007-2009 and historical data going back to 1963. There are a number of other papers that also provide measures of systemic risk, including Lehar (2005), Gray, Merton, and Bodie (2008) , Gray and Jobst (2009), Huang, Zhou and Zhu (2009), Adrian and Brunnermeier (2008) ,Tarashev, Borio and Tsatsaronis (2009) and Segoviano and Goodhart (2009).

alternative possibility is to tax the activity leading to systemic risk. The tax has two benefits: (i) it discourages behavior that leads to systemic risk, and (ii) the generated levies would go towards a general "systemic crisis fund" to be used in the future by the regulators to help pay for systemic costs, either injecting capital into solvent financial institutions affected by the failed firms or even supporting parts of the real economy hurt by the lack of adequate financial intermediation. Of course, in equilibrium, some institutions will find it optimal to still engage in these behaviors and therefore pay the higher taxes, while others will lessen their use.

A. Pricing Model for Systemic Risk

Putting aside for the moment who receives the insurance payments, suppose we require (relying on results and insights from APPR) that each financial firm take out *contingent capital insurance,* that is, insurance against itself becoming undercapitalized when the financial sector as a whole becomes undercapitalized. The pricing of such an insurance contracts fits into the literature on pricing multivariate contingent claims (see, for example, Margrabe (1978), Stulz (1982), Stapleton and Subrahmanyam (1984), Kishimoto (1989), Rosenberg (2000) and Camara (2005)). This literature develops contingent-claim valuation methodologies for cases in which the valuation of claims depends on payoffs that are based on the realizations of multiple stochastic variables. Here, the insurance contract only pays off if the financial institutions' results are extremely poor when the aggregate sector is in distress.[7]

To make the argument more formal, let X_{it} and M_t be the value of the financial institution i's and the aggregate market's (e.g., financial sector or public equity market) particular measure of performance (e.g., as mentioned above, equity value, equity value/debt value, writedowns, etc.). It is well-known that the value of any contingent claim that depends on X_{iT} and M_T can be written as

$$V_t = E_t [F(X_{iT}, M_T) SD_T] \qquad (1)$$

where $F(\cdot)$ is the payoff function depending on realizations of X_{iT} and M_T at maturity of the claim, and SD_T is the stochastic discount factor or the pricing kernel.

[7] For related contingent claim analyses that focus on the balance sheets of financial institutions, see also Lehar (2005) and Gray and Jobst (2009, 2010).

Beyond assumptions about the stochastic process followed by the variables, the problem with equation (1) is that it requires estimates of preference parameters, such as the level of risk-aversion and the rate of time discount. Alternatively, assuming continuous trading, one can try and set up a self-financing strategy that is instantaneously riskless. Then, as in Black and Scholes (1973), one can solve the resulting partial differential equation with the preference parameters being embedded in the current value of the assets. Valuation techniques such as Cox and Ross (1976) can then be applied.

Appealing to Brennan (1979) and Rubinstein (1976), Stapleton and Subrahmanyam (1984) show that risk-neutral valuation can be applied in a multivariate setting even when the payoffs are functions of cash flows and not traded assets as may be the case for our setting. In particular, under the assumption that aggregate wealth and the stochastic processes are multivariate lognormal and the representative agent has constant relative risk aversion preferences, one can apply risk neutral valuation methods to the pricing equation (1).

As described above, assume that the financial institution is required to take out insurance on systemic losses tied to the market value of equity of the firm and the overall sector. Formally, a systemic loss is defined by:

1. the market value of the equity of the aggregate financial sector, S_{MT}, falling below K_{S_M}, and
2. the required payment at maturity of the claim is the difference between some prespecified market value of the equity of the financial institution K_{S_i} and its actual market value S_{iT}.

The payoff at maturity *T* can be represented mathematically as

$$F(S_{MT}, S_{iT}) = \frac{\max(K_{S_M} - S_{MT}, 0)}{K_{S_M} - S_{MT}} \times \max(K_{S_i} - S_{iT}, 0) \qquad (2)$$

Applying the results in Stapleton and Subrahmanyam (1984), equation (1) can be rewritten as

$$V_t = \frac{1}{r^{T-t}} \int_0^{\infty} \int_0^{\infty} \frac{\max(K_{S_M} - S_{MT}, 0)}{K_{S_M} - S_{MT}} \times \max(K_{S_i} - S_{iT}, 0)\, \phi'(S_{MT}, S_{iT})\, dS_{MT}\, dS_{iT}$$

$$= \frac{1}{r^{T-t}} \int_0^{K_{S_M}} \int_0^{K_{S_i}} (K_{S_i} - S_{iT})\, \phi'(S_{MT}, S_{iT})\, dS_{MT}\, dS_{iT}, \qquad (3)$$

$$\phi'(S_{MT}, S_{iT}) = \frac{1}{2\pi(T-t)\sigma_{S_M}\sigma_{S_i}(1-\rho_{Mi})S_{MT}S_{iT}} e^{-\frac{1}{2(1-\rho_{Mi}^2)}\varpi_T}$$

where,

$$\varpi_T = \left[\left(\ln S_{MT} - (T-t)\ln r - \ln S_{Mt} + {}^{(T-t)\sigma_{S_M}^2}\!/_2 \right) \Big/ \sigma_{S_M}\sqrt{T-t} \right]^2 + \left[\left(\ln S_{iT} - (T-t)\ln r - \ln S_{it} + {}^{(T-t)\sigma_{S_i}^2}\!/_2 \right) \Big/ \sigma_{S_i}\sqrt{T-t} \right]^2$$

$$- 2\rho_{Mi} \left[\left(\ln S_{MT} - (T-t)\ln r - \ln S_{Mt} + {}^{(T-t)\sigma_{S_M}^2}\!/_2 \right) \Big/ \sigma_{S_M}\sqrt{T-t} \right] \times \left[\left(\ln S_{iT} - (T-t)\ln r - \ln S_{it} + {}^{(T-t)\sigma_{S_i}^2}\!/_2 \right) \Big/ \sigma_{S_i}\sqrt{T-t} \right],$$

and σ_{S_M}, σ_{S_i}, and ρ_{S_M} are the volatility of the financial sector return, the volatility of the return of the financial institution *i*, and the correlation between them, respectively.

For a given set of parameter values describing the multivariate process for the financial firm's stock price and the final sector's stock price, we can estimate the value of the insurance contract using Monte Carlo simulation. We provide some examples and comparative statics to describe some of the underlying economic intuition for the price of this insurance contract.

B. Comparative Statics

Figure 1 graphs the insurance costs as a % of the equity of the financial firm as a function of the correlation between the firm's equity return and the market return, and as a function of the strike rate of the insurance contract. Specifically, the payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to (total liabilities + market equity value) falls below some strike rate, ranging from 1% to 10%. For example, 1% would be a very weak capital requirement while 10% would be strict. We assume the following parameters based on recent history: market volatility of 16%, firm equity volatility of 27%, risk-free rate of 4% and a current firm's ratio of market value of equity to (total liabilities + market equity value) equal to 10%. The contract has a four-year maturity.

The figure shows that the insurance costs are nonlinearly increasing the stronger the capital requirement and the higher the correlation between the firm's equity return and the market's return. Most important, these factors interact nonlinearly, so the greatest impact by far is when the trigger takes place closer to 10% *and* the correlation is very high. To better understand the magnitude of the insurance cost, consider a firm with $100 billion market value of equity, $1 trillion of assets, highly correlated with the market, and facing a trigger close to 10%. Even for these extreme values, the four-year cost is only around $1 billion, which illustrates the fact that the likelihood of both the firm and the market collapsing is a rare event.

While clearly the insurance trigger and correlation are key factors, what else drives the magnitude of the insurance cost? Figures 2A-2C depict insurance charges as a % of equity value as a function of the volatility of the firm's equity return and the volatility of the market return for three given strike rates of the insurance contract, namely 10%, 7.5% and 5%. As before, the payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to (total liabilities + market equity value) falls below the strike rate of 10%. We also assume the following parameters based on recent history: correlation between the firm equity return and the market return of 55%, risk-free rate of 4% and a current firm's ratio of market value of equity to (total liabilities + market equity value) equal to 10%. The contract again has a four-year maturity.

The figures show the importance of the interaction between firm volatility, market volatility and the triggers. A few observations are in order. First, across the different strike rates, the three dimensional shape is quite similar. The pattern shows a highly nonlinear relationship that requires both the firm and market volatilities to be high. This should not be surprising given that the payoff occurs only in states where both the firm and market are undercapitalized. Second, in comparison to Figure 1, the key factor in determining the insurance cost is the level of volatility. For example, for firm and market volatilities of 50% and 25% respectively, the insurance costs runs as high as 6%, 4% and 2% of equity value for the strike rates of 10%, 7.5% and 5%. This is important for understanding the properties of contingent capital insurance. Since volatility tends to be pro-cyclical (high in bad times and low in booms), the cost of contingent capital insurance in general will be pro-cyclical as well. In order therefore to reduce pro-cyclicality of insurance charges, the regulator would have to make the strike rates countercyclical (higher strikes in good times), setting the overall insurance cost such as to avoid an over-

leveraged financial sector and an over-heated economy. This design issue is similar to the trade-off the FOMC must make in connection with setting interest rates.

In the next subsection, we apply the insurance model of Section III.A to available data preceding the financial crisis of 2007-09. In particular, we comment on both the insurance charges and systemic risk contributions that would have emerged if the plan had been put in place during the 2004-2007 period.

C. The Financial Crisis of 2007-2009

This section empirically analyzes systemic risk taxes based on contingent capital insurance for U.S. financial institutions around the recent financial crisis. (APPR provide a much more extensive empirical analysis of financial firms' contribution to systemic risk.) Here, the institutions have been selected according to (i) their role in the U.S. financial sector, and (ii) their market cap as of end of June 2007 being in excess of 5bln USD. The companies can be categorized into the following four groups: *Depository Institutions* (e.g., JPMorgan, Citigroup, Washington Mutual, etc.), *Security and Commodity Brokers* (e.g., Goldman Sachs, Morgan Stanley, etc.), *Insurance* Carriers (e.g., AIG, Berkshire Hathaway, etc.) and Insurance Agents, Brokers and Service (e.g., Metlife, Hartford Financial, etc.) and a group called *Others* consisting of non-depository Institutions, real estate firms, etc. The total number of firms that meet all these criteria is 102.

Table 1 contains descriptive year-by-year statistics of the implied $ insurance charge for these 102 firms across the four groups, that is, Depository Institutions, Security and Commodity Brokers, Insurance, and Others over the period 2004-2007. As with the simulations provided in Section III.B above, the insurance payoff is triggered when the aggregate stock market falls 40%, and the payoff is based on the fall in the firm's equity value when the ratio of equity value over total assets drops below 10%. The amounts are in $millions and represent the cost over a four-year period. The main parameter inputs - volatilities and correlations - are estimated over the prior year, and the current ratio of equity value over total assets is computed accordingly from CRSP and COMPUSTAT.

Several observations are in order. First, there is a clear ordering of the insurance cost across the type of institution. In particular, broker/dealers face the highest costs every year;

insurance companies the lowest. Second, for most years, and most of the institution types, there is significant skewness in the cross-section of insurance charges, in other words, the mean is multiple times the median. While this finding is mostly due to skewness in the distribution of asset size across firms, the results of Section II.B showed that high costs are due to simultaneous extreme parameters and the moneyness of the option, properties likely to affect just a few firms. Third, there is considerable variation through time in the insurance fees, with a general decline in the level of these fees from 2004-2007. The reason for this variation is the general decline of volatilities over this same period.

This latter finding points to the need to state a few caveats. Table 1 provides results on insurance fees based on short-term volatility estimates of the financial firms and the market. Acharya, Cooley, Richardson and Walter (2010) present evidence that, during the latter years of the relevant period, the term structure of volatility was sharply upward sloping. While higher expected volatility in the future may not affect the cross-sectional rankings or proportional share estimates of who pays the systemic tax, it clearly impacts the contingent capital insurance costs. The latter year calculations provided in Table 1 therefore are underestimated. Similarly, the contingent capital insurance pricing model of Section II.B makes a number of assumptions about equity return distributions, most notably multivariate normality. To the extent conditional normality produces unconditional fat tails, this assumption may not be as unpalatable as it first seems. Nevertheless, there is evidence that return distributions have some conditional fat tailness which would also increase the level of the insurance fees.

To better understand what determines the fees during this period, Table 2 provides results of cross-sectional regressions of the insurance charges for each firm, both in $ amounts (Table 2A) and as a percentage of equity value (Table 2B), against parameters of interest, including leverage (i.e., the moneyness of the trigger), correlation with the market, the firm's volatility and the institutional form. Generally, across each year, the R-squared's roughly double from the mid 20s to around 50% when the institutional form is included in the regression. The broker/dealer dummy is especially significant. This is interesting to the extent that much of the systemic risk emerging in the crisis derived from this sector. Table 2 shows that, as early as 2004, the contingent capital insurance costs of the broker/dealer sector would have been a red flag.

Table 2 brings several other interesting empirical facts to light. First, in every year, leverage is a key factor explaining the insurance costs across firms. This result should not be

surprising given that the contingent capital trigger is based on leverage. But if one believes the trigger *does* capture systemic risk, it suggests that higher capital requirements will have a first-order effect in containing systemic risk. Second, the correlation between the firm's return and the market return is a key variable, possibly more important than firm volatility itself. The reason is that without sufficient correlation the probability that both the firm and market will run aground is remote, pushing down the cost of insurance. Finally, Table 1 showed that there was significant variation in the mean insurance costs over the 2004-2007. Table 2 runs a cross-sectional stacked regression over the 2004-2007 period but also includes market volatility as an additional factor. While the R-squared does drop from the mid 20s in the year-by-year regressions to 16% (in Table 2A) and 19% (in Table 2B) for the stacked regressions, the drop is fairly small. This is because the market volatility factor explains almost all the time-series variation.

This result highlights an important point about contingent capital insurance. Just prior to the crisis starting in June 2007, market volatility was close to an all-time low. Putting aside the previously mentioned issues of short- versus long-term volatility and conditional fat tails, this low volatility necessarily implies low insurance charges. Consistent with Table 1's summary, Table 3 presents the $ and % insurance charges firm by firm. For almost all the financial firms, the capital contingent insurance costs seem quite low especially in light of what happened just a few months later.

Interestingly, Table 3 shows an important difference between contingent capital insurance and the systemic risk tax. Recall that the systemic risk tax separates into the product of two components - the expected systemic costs and the proportional share of systemic risk. Table 3 provides an estimate of this share across the 102 firms, and therefore is a measure of the latter component of the systemic risk tax. Using the capital insurance charge as its basis, just 5 firms provide over 50% of all the risk, and 15 firms 92% of the risk. This is a key finding and perhaps not surprising given the outcome of the crisis that followed, namely that most of the systemic risk is concentrated in just a few places. Note that in order of importance, Table 3 lists Morgan Stanley, Citigroup, Merrill Lynch, JP Morgan, Goldman Sachs, Freddie Mac, Fannie Mae, Lehman Brothers, Bear Stearns, Metlife, Bank of America, Prudential Financial, Hartford Financial, Countrywide and Wachovia as the leading systemic firms. At least 9 of these firms either failed or required extraordinary capital infusions or guarantees. In fact, probably only JP Morgan and to a lesser extent Goldman Sachs was considered somewhat safe at the height of the crisis in the late Fall of '08 and the Winter of '09.

Table 4A and 4B show that this finding is not a fluke by also reporting the rankings of the insurance costs in the earlier periods of 2004, 2005 and 2006. For example, Table 4B reports the $ charges in all four periods and shows that the exact same firms (albeit in different order) show up consistently in the top 15. In fact, the only additions to the list are Washington Mutual, A.I.G. and Lincoln National, two of which failed in the crisis. On a preliminary basis, these results suggest that a measure like the one calculated here, i.e., the cost of contingent capital insurance, does a good job of deciphering which firms are systemic and should pay the share of the tax. Of some importance, Table 4A shows that these rankings are not solely size-based as most of these firms also show up on a percentage of equity basis as well, and APPR provide more extensive evidence of this type for predicting the realized performance of financial firms during the stress-test (SCAP) exercise, the crisis period of 2007-09, and other crises of the past..

That said, measurement errors are likely, especially if some financial firms have fatter tail distributions, or face different individual term structure volatilities than other firms. A natural way to rectify this problem would be to allow market participants to estimate and trade on these insurance costs. In a competitive market, it is likely that the measurement errors would be reduced. In the next section, we discuss such a private option for pricing and implementing a tax on systemic risk.

IV. A Public-Private Plan

The core idea of a private plan to tax systemic risk is that each financial firm would be required to buy private insurance against its own losses in a systemic risk scenario in which the whole financial sector is doing poorly. In the event of a pay off on the insurance, the payment should not go to the firm itself, but to the regulator in charge of managing systemic risk and stabilizing the financial sector. This contingent capital insurance cost, however, is not necessarily equal to the tax. It would be used to determine the proportionate share of each financial firm's contribution to the total systemic risk tax. The level of the systemic risk tax would be determined by the expected systemic costs of a financial crisis (see footnote 5) times the proportionate share of each firm.[8] The important point is that each firm's share would be determined by the private market for insurance.

[8] The expected systemic costs may be higher or lower than the contingent capital insurance costs. The insurance costs assume a dollar systemic cost for every dollar of loss of the firm in a systemic risk scenario.

This scheme would not only provide incentives for the firm to limit its contributions to systemic risk (to lower its insurance premium, e.g., by lowering size, leverage, risk and correlation with the rest of the financial sector and economy), but also provide a market-based estimate of the risk (the cost of insurance), and avoid moral hazard (because the firm does not get the insurance pay off). Since the role of the private sector in providing such insurance is primarily for price discovery and the amount of private capital available to provide such systemic insurance likely to be limited, we argue that most of the insurance would be purchased from the regulator and the rest from the private sector.

Specifically, our solution would be to quasi-privatize the guarantees and systemic costs in the economy through private reinsurance (or a public-private scheme).[9] The idea behind these proposals is that private insurers would help price the insurance while the government would provide most of the capital underlying the insurance. While some reinsurance schemes have been looked at by the FDIC, most recently in 1993, with the conclusion that the market is not viable, there is reason to be more optimistic today. Financial markets in general have become much more sophisticated in how they develop niche markets. As case in point is that co-insurance programs are not without precedent; indeed, motivated by the events of September 11, 2001, the Terrorism Risk Insurance Act (TRIA) was first passed in November 2002, and offers federal reinsurance for qualifying losses from a terrorist attack.

In the rest of this section, we present a more detailed summary of the public-private plan to tax systemic risk. We first address the important issue of why a purely private approach may not be feasible. We then discuss specific details of the plan, including some practical intricacies relating to our overall proposal, for example, how frequently should the insurance (tax) be acquired (collected) and for what maturity, and what ex post discretion should the regulator have in providing insurance to failed firms and how it should deploy the insurance premia and payments collected.

A. Why the Need for a Public-Private plan?

Above, we described the need for the insurance to be provided side by side with the government in a joint private-public insurance scheme. The reason is that private insurance

[9] Similar schemes have been discussed before in the banking literature, especially with respect to deposit insurance, e.g., Dewatripont and Tirole (1993).

sector is not set up to insure against systemic risks. By their very nature, systemic risks cannot be diversified away. The underlying capital required to cover these losses therefore is quite large even though the possibility of such an event is very small.

Examples of this problem can be found in the current financial crisis with the major monoline insurers, such as Ambac Financial Group and MBIA, and, of course, the division of A.I.G. named A.I.G. Financial Products. These monolines guarantee repayment when an issuer defaults. Their historical focus of municipalities was less of a concern as there is a large idiosyncratic component to a municipality going bankrupt. But as their businesses focused more and more on structured products, such as asset-backed securities, collateralized debt obligations (CDOs) and collateralized loan obligations (CLOs), the insurance contracts took on systemic risk. Moreover, the majority of insurance was placed on the so-called AAA super senior portions. Almost by construction, the AAA-tranches' only risk is systemic in nature.[10] Undercapitalized relative to the systemic event, almost all the monolines and A.I.G. Financial Products were effectively insolvent.

Though the possible insolvency of insurers is not a problem per se, it still could lead to distortions in the pricing of the insurance contracts. The bigger issue is that these insurers may be systemic due to their counterparty risk. A.I.G.'s systemic nature is now understood, but even the smaller monolines caused havoc in the market for distressed securities. For example, on January 18, 2008, when Ambac Financial Group was downgraded from AAA to AA, it led to a simultaneous downgrade of bonds from over 10,000 municipalities and institutions. Thus, the issue is that monolines have their own too-big-to-fail designation, causing them to take large, directional, systemic bets. The anticipated government bailout reduces overall market discipline allowing them the "free" license to underprice (and thus overextend) systemic risk insurance and default ex post when it has to be honored.

Even for extremely well-capitalized institutions, the insurance sector has struggled for a number of years of with providing open-ended (albeit diversifiable) catastrophe insurance. An extensive literature has studied this topic. While the models differ, the primary reason boils down to the inability of insurers to be capitalized well enough to cover large losses. See, for example, the evidence and discussion in Jaffee and Russell (1997), Froot (2001, 2007) and Ibragimov,

[10] Coval, Jurek and Stafford (2009) call these securities economic catastrophe bonds and show that the securities' underlying economics is akin to out-of-the-money put options on the aggregate market.

Jaffee, and Walden (2008). The solution in the catastrophe insurance markets has generally been greater and greater backing by the Federal and state governments (e.g., Federal primary coverage against floods in 1968, insurance against hurricanes after 1992 by Florida, and earthquake coverage by California after 1994).

Therefore, the type of joint private-public insurance program we propose is not without precedent. As mentioned above, one successful model is provided by TRIA. The program offers federal reinsurance for qualifying losses from a terrorist attack. TRIA is a good place to start and includes industry loss triggers and government excess of loss coverage. These features help minimize the insurance industry's losses yet also provide them with an incentive to monitor and reduce risks.[11]

Our proposed scheme would work similarly. But there are some key differences. First, with TRIA, the government's insurance only kicks in when the industry's aggregate losses reach a certain level. Here, the government shares the losses from the start. Second, with TRIA, the insurer pays all losses up to a deductible and pays coinsurance (15%) for losses above the deductible up to an aggregate event limit ($100 billion). Above the event limit, the government covers all losses at no charge. In contrast, we envision private side-by-side insurance with the government, e.g., 5% versus 95%. That is, the insurance industry would charge for and cover only 5% of all the losses. This percentage can be adjusted to make sure there is enough private capital to cover the part of losses covered by private insurance. Since terrorist attacks are less subject to moral hazard, there is less need for the government to charge for losses incurred in the TRIA program. For financial firms, this does not work because it is important to incentivize financial firms to become less systemic. For systemic financial events, the expected systemic costs must be internalized by the firms who produce these costs. We discuss the implementation of such a plan below.

B. How the Plan Would Work

The public-private insurance plan would be implemented as follows:

1. Each regulated firm would be required to buy insurance against future losses, but only losses during a future general crisis. For example, each financial institution would

[11] Kunreuther and Michel-Kerjan (2008) and Jaffee (2008) describe the participation of insurers in the TRIA program, as well as its applicability to other catastrophic insurance markets.

have a "target capital" of, say, 8% of current assets in the event of a crisis.[12] For every dollar that the institution's capital falls below the target capital in the crisis, the insurance company would have to pay *N* cents to the regulator (e.g., a systemic risk fund).[13] This way, the insurance provider would have every incentive to correctly estimate the systemic risk of a firm in a competitive market and charge the firm accordingly.

2. The charge would allow the regulator to determine the proportionate share of expected losses contributed by each firm in a crisis, in other words, the relative systemic risk of each firm in the sector. This would be used to determine who pays their share of the overall systemic tax. The regulator would then take this proportionate share of each firm and multiply it by the expected systemic costs of a crisis to determine the level of the tax.
3. To avoid double taxation, the fees paid to the insurance company would be subtracted from the firm's total systemic tax bill paid to the regulator.
4. The financial firms would need to keep acquiring insurance, and thus pay taxes, on a continual basis to ensure continual monitoring and price discovery, and to prevent sudden high insurance premiums from causing funding problems because the purchases of premiums are spread out. For example, each month, each firm would need to buy a fractional amount of insurance to cover the next future 5 years. Hence, the coverage of the next month would be provided by the insurance purchased over the last 5 years.
5. Note that the tax proceeds are *not* meant to bail out failed institutions, but to support the affected real sector and solvent institutions. In other words, to the extent systemic risk still remains once the tax has been imposed, the proceeds of the tax are to cover systemic risk costs. Future expected bailouts, i.e., government guarantees, need to be priced separately. As described in Section II, this portion equals the expected loss on its guaranteed liabilities, akin to the FDIC premium but to be charged irrespective of the size of the resolution fund.

[12] A crisis would be ex ante defined by the regulator as a time when the aggregate losses in the financial industry (or the economy at large) exceed a specified amount.

[13] *N* cents represents the proportional share of the private market's participation in the insurance component of the public-private plan. If the proposal were simply contingent capital insurance in which the firm got recapitalized if the firm were doing poorly in a crisis, then the government's share of the payout to the firm would be 100-N cents on the dollar, and the government would receive (100-N/100)% of the insurance premiums.

6. Most important, this market-based system could be used in combination with a system of direct regulation. Indeed, the market price of insurance and corresponding measure of each firm's systemic risk share may be one of several inputs into the regulator's estimate of a firm's systemic risk. Some characteristics such as interconnectedness visible to regulators and supervisors may not be adequately captured by the insurance market.

The main goal of the tax scheme gives incentive to limit systemic risk or to be well capitalized against systemic risk in order to reduce the cost of insurance. Thus, institutions will internalize their externality and the market price helps measure it.

V. Relationship to other proposals

An important obstacle to the two schemes we proposed in Sections III and IV is the moral hazard. The issue with moral hazard is that because the actions of the bank are not fully observable, once the premiums for the guarantees and systemic risk are set, the bank can then change its behavior. While a private market like the one described above in Section IV may be better able to monitor the bank's actions, the optimal contract usually calls for some type of state contingent payoff. What would the contract look like here?

The optimal contract often imposes a severe penalty function in bad states to get the agent, i.e., the bank, to avoid excessive risk-taking activities. The same intuition carries through for why the insurance industry imposes large deductibles. Here, the "punishment" could take a variety of forms, all with the intention of aligning incentives and thus bringing back market discipline. One particular way would be to require financial institutions to hold in their capital structure a new kind of "hybrid" claim that has a *forced* debt-for-equity conversion whenever a pre-specified threshold of distress (individual and systemic) is met. These hybrid securities have been called contingent capital bonds. The important insight is that if issuing equity capital on the balance sheet of financial institutions is expensive, then contingent capital bonds are one way of imposing penalties only in bad states of nature. This has both the benefit of recapitalizing the firm in a crisis, and brings back market discipline via creditor losses.[14] Examples in the literature

[14] A less discussed option is to bring back so-called "double liability" for stockholders and managers of the financial institution .Under double liability, shareholders of the bank lose not only the value of the stock but are also charged an additional penalty, in theory, up to the par value of their holdings. While double liability may be impractical and raises many issues, it was standard practice from 1863 to 1933.

of such approaches are: Wall (1989) proposed subordinated debentures with an embedded put option, and Doherty and Harrington (1997) and Flannery (2005) proposed reverse convertible debentures.

As one of the recent proponents of this idea, the paper by Kashyap, Rajan and Stein (2008, hereafter KRS) argues that the idea of automatic recapitalization can be applied to systemic risk. KRS propose a capital insurance scheme based on systemic risk. Each bank would issue capital insurance policies that would pay off when the overall banking sector is in bad shape, *regardless of the health of a given bank at that point*. The insurer would be a pension fund or a sovereign wealth fund that would essentially provide fully funded "banking catastrophe" insurance.

KRS do not provide a link between a firm's *own contribution* to the aggregate losses and the insurance fees it must pay. Thus, the financial institution would still have the incentive to lever up, take concentrated bets, and build illiquid positions which may improve the risk/return profile of the firm but nevertheless increase the systemic risk in the system. In other words, the negative externality would remain and not be priced. In fact, capital insurance policies could encourage institutions to load on aggregate risk.[15]

In contrast, our systemic risk tax requires the payment to go to the regulator, who then has discretion over which institutions, financial or real economy, deserve the capital support. The recent crisis has shown that moral hazard linked to aggregate risk taking is just a pervasive as moral hazard linked to specific risk. It is therefore crucial to reward firms which do not take too much aggregate risk, and to not punish those that do. Our proposal is meant to deal with precisely this issue.

That said, the KRS automatic recapitalization in a systemic crisis could be reframed to provide capital to only those firms that are "failing" in a crisis. Each firm would be required to take out insurance against such states, thus, requiring higher insurance payments for the more systemic firms. This is clearly related to the contingent capital insurance for systemic risk described, priced and empirically analyzed in Section III.

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[15] The authors acknowledge this issue (page 38).

VI. Concluding Remarks

Motivated by Acharya, Pedersen, Philippon, and Richardson (2009a), we analyze proposals for "taxing" the systemic risk of financial firms. The centerpiece of these schemes is to measure the firm's share of expected losses conditional on the occurrence of a systemic crisis. As an example of one particular way to measure the firm's share of systemic risk, we analyze the pricing of contingent capital insurance from both a theoretical and empirical point of view. Using the current crisis as an illustration, the measure appears to successfully choose the systemic firms.

Nevertheless, our preferred approach for implementation is that individual firms would be required to purchase private insurance against the losses they incur during systemic crises. Overall, the main advantages of this approach for regulation of systemic risk are: (i) it forces regulators and financial firms to deal explicitly with systemic risk; (ii) it is based on tools tested and well understood by the private sector in that each financial firm routinely assigns a capital charge to its individual groups based on their contributions to enterprise-wide risk; and (iii) it reduces moral hazard in that it provides incentives for regulated firms not to contribute excessively to systemic risk.

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Table 1: Descriptive statistics of the dollar insurance charge across groups

This table contains descriptive statistics of the $ insurance charge across the groups by year: Depository Institutions, Security and Commodity Brokers, Insurance, and Others. The insurance payoff is triggered when the aggregate stock market falls 40% with the payoff based on the fall in the firm's equity value below a 10% equity value over total assets. The amounts are in $millions and represent the cost over a four-year period.

	2004	2005	2006	2007
All				
Mean	42.80	8.22	3.41	3.22
Median	1.77	0.33	0.07	0.02
Std. Dev.	102.00	19.20	9.11	8.35
Max	540.00	90.30	48.90	39.10
Min	0.00	0.00	0.00	0.00
Depository				
Mean	36.06	6.00	2.53	3.19
Median	4.99	0.86	0.43	0.34
Std. Dev.	88.20	13.80	6.32	8.57
Max	425.78	65.70	32.34	38.06
Min	0.06	0.00	0.00	0.00
Non-Depository				
Mean	29.68	8.56	1.76	2.06
Median	0.00	0.00	0.00	0.00
Std. Dev.	124.00	25.70	8.02	6.65
Max	540.00	90.30	41.00	25.50
Min	0.00	0.00	0.00	0.00
Insurance				
Mean	24.51	4.20	1.71	1.13
Median	0.77	0.05	0.02	0.00
Std. Dev.	51.40	8.90	4.14	2.69
Max	226.24	33.32	17.39	11.43
Min	0.00	0.00	0.00	0.00
Broker-Dealer				
Mean	162.00	30.00	17.70	14.00
Median	184.00	30.50	16.30	8.81
Std. Dev.	165.77	32.11	18.74	15.76
Max	461.00	87.80	48.90	39.10
Min	0.00	0.00	0.00	0.00

Table 2: Cross-Sectional Regression Analysis of Insurance Charges on Firm Characteristics (t-statistics in parenthesis)

Panel A: Dependent variable is $ insurance charge of each firm

	2004		2005		2006		2007		2004-2007	
Intercept	-31.5		-11.4		-8.1		-12.4		- 259.2	
	(-0.60)		(-1.08)		(-1.85)		(-2.86)		(-3.64)	
Equity/Assets	-148.4	-178.9	-33.5	-40.3	-14.0	-15.8	-10.1	-11.9	-46.2	-54.3
	(-3.92)	(-2.98)	(-3.92)	(-3.61)	(-3.75)	(-3.02)	(-4.65)	(-1.55)	(-5.06)	(-3.80)
Correlation w/ mkt	169.6	87.1	32.2	19.3	22.3	9.9	25.2	13.9	68.4	35.6
	(2.39)	(1.11)	(2.21)	(1.88)	(2.74)	(1.73)	(3.59)	(2.03)	(2.95)	(1.37)
Firm equity vol	120.3	-88.2	60.7	14.0	22.0	9.0	28.8	6.1	80.7	16.1
	(0.98)	(-0.71)	(1.90)	(0.56)	(2.45)	(1.41)	(3.10)	(0.64)	(3.08)	(0.55)
Dummy: broker/dealer		169.7		24.6		13.0		7.3		-201.6
		(1.85)		(2.26)		(1.84)		(0.93)		(-3.18)
Dummy: depository		33.0		-1.0		-1.9		-3.6		-246.1
		(0.53)		(-0.14)		(-0.56)		(-0.82)		(-3.71)
Dummy: nondepository		91.3		15.5		3.3		0.1		-226.7
		(0.92)		(1.25)		(0.55)		(0.01)		(-3.55)
Dummy: insurance		56.6		4.9		0.6		-2.4		-238.4
		(0.88)		(0.63)		(0.16)		(-0.49)		(-3.61)
Market volatility									2147.4	2228.6
									(3.52)	(3.64)
Adj. R^2	19.0%	41.5%	19.9%	45.0%	25.1%	47.9%	29.6%	46.4%	16.2%	25.7%

Panel B: Dependent variable is insurance charge of each firm as a % of market value of equity

	2004		2005		2006		2007		2004-2007	
Intercept	0.00023		-0.00081		-0.00014		-0.00021		-0.01038	
	(0.09)		(-0.33)		(-1.62)		(-2.45)		(-4.49)	
Equity/Assets	-0.00684	-0.00783	-0.00102	-00118	-0.00039	-0.00044	-0.00026	-0.00031	-0.00197	-0.00220
	(-4.26)	(-4.54)	(-4.87)	(-5.16)	(-4.86)	(-4.34)	(-5.00)	(-4.43)	(-5.20)	(-5.08)
Correlation w/ mkt	0.00301	0.00138	0.00051	0.00018	0.00042	0.00019	0.00039	0.00017	0.00121	0.00498
	(1.00)	(0.50)	(1.66)	(0.46)	(2.76)	(1.67)	(3.44)	(1.83)	(1.28)	(0.53)
Firm equity vol	0.00860	0.00108	0.00175	0.00066	0.00067	0.00013	0.00078	0.00027	0.00363	0.00156
	(2.05)	(0.27)	(2.59)	(0.37)	(3.31)	(2.90)	(3.29)	(1.42)	(3.99)	(1.83)
Dummy: broker/dealer		0.00700		0.00048		0.00030		0.00021		-0.00855
		(1.90)		(2.16)		(2.24)		(1.63)		(-4.74)
Dummy: depository										-0.01029
		0.00117		0.00031		-0.00005		-0.00004		(-4.85)
		(0.49)		(0.56)		(-0.60)		(-0.54)		
Dummy: nondepository		0.00337		0.00036						
						0.00010		0.00007		-0.00961
		(1.20)		(1.73)		(0.87)		(0.60)		(-4.83)
Dummy: insurance		0.00337		0.00044		0.00005		0.00002		-0.0961
		(1.30)		(1.53)		(0.68)		(0.24)		(-4.82)
Market Volatility									0.09261	0.09480
									(4.32)	(4.47)
Adj. R^2	22.1%	52.1%	25.7%	59.6%	33.3%	61.5%	36.4%	59.7%	19.3%	30%

Table 3

Company ranking by insurance charge

This table contains the list of US financial firms with a market cap in excess of 5 bln. dollars as of June 2007. The firms are listed in descending order according to their insurance costs. The insurance payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below 10% at the end of a four year period. The payoff equals the difference between the equity value implied by the 10% ratio and the final equity value. The volatility of the firm's equity, the volatility of the market, and the correlation between the two, are estimated using daily data over the prior year. The insurance calculation assumes a multivariate normal distribution of equity returns. The latter three columns represent respectively the insurance charge as a % of equity, the total $ insurance charge in millions and the ranking based on the total $ amount.

Ranking (based on%)	Company equity	% of	$ charge	Ranking (based on $) and % Contribution to Costs
1	BEAR STEARNS COMPANIES INC	0.000978	16.292	9 4.96%
2	FEDERAL HOME LOAN MORTGAGE CORP	0.000636	25.521	6 7.77%
3	LEHMAN BROTHERS HOLDINGS INC	0.000524	20.719	8 6.31%
4	MERRILL LYNCH & CO INC	0.000478	34.649	3 10.55%
5	MORGAN STANLEY DEAN WITTER & CO	0.000443	39.129	1 11.92%
6	FEDERAL NATIONAL MORTGAGE ASSN	0.000387	24.616	7 7.50%
7	GOLDMAN SACHS GROUP INC	0.000311	27.558	5 8 .39%
8	COUNTRYWIDE FINANCIAL CORP	0.000263	5.6808	14 1.73%
9	METLIFE INC	0.000239	11.426	10 3.48%
10	HARTFORD FINANCIAL SVCS GROUP I	0.000235	7.3309	13 2.23%
11	PRINCIPAL FINANCIAL GROUP INC	0.000182	2.8404	18 0.87%
12	LINCOLN NATIONAL CORP IN	0.000178	3.421	17 1.04%
13	PRUDENTIAL FINANCIAL INC	0.000175	7.8739	12 2.40%
14	JPMORGAN CHASE & CO	0.000167	27.645	4 8.42%
15	CITIGROUP INC	0.00015	38.058	2 11.59%
16	AMERIPRISE FINANCIAL INC	0.000147	2.1912	19 0.67%
17	E TRADE FINANCIAL CORP	0.000141	1.326	21 0.40%
18	C I T GROUP INC NEW	0.000137	1.4368	20 0.44%
19	WASHINGTON MUTUAL INC	0.000116	4.351	16 1.33%
20	COMMERCE BANCORP INC NJ	8.7E-05	0.61563	28 0.19%
21	SOVEREIGN BANCORP INC	8.34E-05	0.84257	26 0.26%
22	GENWORTH FINANCIAL INC	6.59E-05	0.98527	24 0.30%
23	NATIONAL CITY CORP	6.07E-05	1.1636	22 0.35%
24	WACHOVIA CORP 2ND NEW	5.66E-05	5.549	15 1.69%
25	KEYCORP NEW	5.22E-05	0.70366	27 0.21%
26	S L M CORP	4.83E-05	1.1444	23 0.35%
27	UNUM GROUP	4.58E-05	0.41017	32 0.12%
28	UNIONBANCAL CORP	4.45E-05	0.36689	34 0.11%
29	STATE STREET CORP	4.28E-05	0.98425	25 0.30%
30	BANK OF AMERICA CORP	4.21E-05	9.1278	11 2.78%

31	HUNTINGTON BANCSHARES INC	3.82E-05	0.20437	39	0.06%
32	COMERICA INC	3.63E-05	0.33666	35	0.10%
33	M B I A INC	2.42E-05	0.19672	40	0.06%
34	REGIONS FINANCIAL CORP NEW	1.81E-05	0.42231	31	0.13%
35	CAPITAL ONE FINANCIAL CORP	1.8E-05	0.58626	29	0.18%
36	BANK NEW YORK INC	1.64E-05	0.5158	30	0.16%
37	ZIONS BANCORP	1.52E-05	0.12619	43	0.04%
38	SUNTRUST BANKS INC	1.28E-05	0.39277	33	0.12%
39	B B & T CORP	1.15E-05	0.25406	38	0.08%
40	NORTHERN TRUST CORP	9.69E-06	0.13695	42	0.04%
41	M & T BANK CORP	9.16E-06	0.10596	44	0.03%
42	HUDSON CITY BANCORP INC	6.82E-06	0.044336	48	0.01%
43	FIFTH THIRD BANCORP	6.43E-06	0.13698	41	0.04%
44	MARSHALL & ILSLEY CORP	4.12E-06	0.050894	46	0.02%
45	NEW YORK COMMUNITY BANCORP INC	4.07E-06	0.021705	50	0.01%
46	P N C FINANCIAL SERVICES GRP IN	3.79E-06	0.093488	45	0.03%
47	T D AMERITRADE HOLDING CORP	2.46E-06	0.029364	49	0.01%
48	WELLS FARGO & CO NEW	2.42E-06	0.28287	36	0.09%
49	SCHWAB CHARLES CORP NEW	1.83E-06	0.047105	47	0.01%
50	AMERICAN INTERNATIONAL GROUP IN	1.55E-06	0.28175	37	0.09%
51	C N A FINANCIAL CORP	1.36E-06	0.017655	51	0.01%
52	C I G N A CORP	9.95E-07	0.014958	53	0.00%
53	AETNA INC NEW	6.95E-07	0.017586	52	0.01%
54	COMPASS BANCSHARES INC	6.12E-07	0.005615	54	0.00%
55	C B RICHARD ELLIS GROUP INC	3.09E-07	0.002583	56	0.00%
56	BERKLEY W R CORP	2.55E-07	0.001611	57	0.00%
57	ASSURANT INC	1.92E-07	0.001372	58	0.00%
58	ALLSTATE CORP	1.22E-07	0.004564	55	0.00%
59	SYNOVUS FINANCIAL CORP	3.74E-08	0.000375	61	0.00%
60	N Y S E EURONEXT	3.14E-08	0.00061	60	0.00%
61	TRAVELERS COMPANIES INC	2.56E-08	0.000909	59	0.00%
62	HUMANA INC	2.09E-08	0.000214	62	0.00%
63	INTERCONTINENTALEXCHANGE INC	1.30E-09	1.35E-05	68	0.00%
64	LOEWS CORP	1.25E-09	3.41E-05	63	0.00%
65	AON CORP	7.56E-10	9.46E-06	69	0.00%
66	A F L A C INC	5.89E-10	1.48E-05	67	0.00%
67	PEOPLES UNITED FINANCIAL INC	4.93E-10	2.63E-06	71	0.00%
68	BERKSHIRE HATHAWAY INC DEL	4.83E-10	2.38E-05	66	0.00%
69	U S BANCORP DEL	4.28E-10	2.45E-05	64	0.00%
70	AMERICAN EXPRESS CO	3.32E-10	2.41E-05	65	0.00%
71	MASTERCARD INC	2.67E-10	3.53E-06	70	0.00%
72	UNION PACIFIC CORP	4.90E-11	1.52E-06	72	0.00%
73	NYMEX HOLDINGS INC	2.69E-11	3.11E-07	73	0.00%
74	CHUBB CORP	1.27E-11	2.77E-07	74	0.00%
75	AMBAC FINANCIAL GROUP INC	5.94E-12	5.28E-08	75	0.00%

76	WESTERN UNION CO	2.57E-12	4.14E-08	76	0.00%
77	FIDELITY NATIONAL FINL INC NEW	1.94E-12	1.02E-08	78	0.00%
78	LEGG MASON INC	1.92E-12	2.49E-08	77	0.00%
79	JANUS CAP GROUP INC	1.72E-12	8.88E-09	79	0.00%
80	EDWARDS A G INC	1.26E-12	8.07E-09	80	0.00%
81	SAFECO CORP	6.11E-13	4.04E-09	82	0.00%
82	HEALTH NET INC	3.85E-13	2.28E-09	84	0.00%
83	BLACKROCK INC	3.42E-13	6.21E-09	81	0.00%
84	AMERICAN CAPITAL STRATEGIES LTD	1.46E-13	1.13E-09	86	0.00%
85	PROGRESSIVE CORP OH	1.25E-13	2.18E-09	85	0.00%
86	UNITEDHEALTH GROUP INC	3.71E-14	2.54E-09	83	0.00%
87	CINCINNATI FINANCIAL CORP	2.28E-14	1.70E-10	87	0.00%
88	MARSH & MCLENNAN COS INC	7.75E-15	1.33E-10	88	0.00%
89	TORCHMARK CORP	7.25E-16	4.64E-12	89	0.00%
90	CHICAGO MERCANTILE EXCH HLDG IN	5.69E-17	1.06E-12	90	0.00%
91	FIDELITY NATIONAL INFO SVCS INC	1.12E-17	1.17E-13	91	0.00%
92	COVENTRY HEALTH CARE INC	2.57E-20	2.32E-16	93	0.00%
93	WELLPOINT INC	1.42E-20	6.96E-16	92	0.00%
94	BERKSHIRE HATHAWAY INC DEL	2.79E-22	3.32E-17	94	0.00%
95	LOEWS CORP	4.34E-23	3.64E-19	95	0.00%
96	LEUCADIA NATIONAL CORP	1.18E-23	9.04E-20	96	0.00%
97	C B O T HOLDINGS INC	1.78E-25	1.94E-21	98	0.00%
98	ALLTEL CORP	1.36E-25	3.15E-21	97	0.00%
99	FRANKLIN RESOURCES INC	1.83E-34	6.05E-30	99	0.00%
100	T ROWE PRICE GROUP INC	2.36E-41	3.25E-37	100	0.00%
101	S E I INVESTMENTS COMPANY	3.69E-51	2.10E-47	101	0.00%
102	EATON VANCE CORP	5.56E-59	3.08E-55	102	0.00%

Table 4a

Ranking by insurance charge (by % of market value of equity)

This table contains the names of the top 20 companies ranked in descending order in according to their insurance charge for the specified periods as a % of their market value of equity. The insurance payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below 10% at the end of a four year period.

	July 2003 - June 2004	July 2004 - June 2005	July 2005 - June 2006	June 2006 - June 2007
1.	BEAR STEARNS COMPANIES INC	BEAR STEARNS COMPANIES INC	BEAR STEARNS COMPANIES INC	BEAR STEARNS COMPANIES INC
2.	GENWORTH FINANCIAL INC	FEDERAL HOME LOAN MORTGAGE CORP	FEDERAL NATIONAL MORTGAGE ASSN	FEDERAL HOME LOAN MORTGAGE CORP
3.	LEHMAN BROTHERS HOLDINGS INC	FEDERAL NATIONAL MORTGAGE ASSN	MORGAN STANLEY DEAN WITTER & CO	LEHMAN BROTHERS HOLDINGS INC
4.	PRUDENTIAL FINANCIAL INC	MORGAN STANLEY DEAN WITTER & CO	LEHMAN BROTHERS HOLDINGS INC	MERRILL LYNCH & CO INC
5.	MORGAN STANLEY DEAN WITTER & CO	LINCOLN NATIONAL CORP IN	GOLDMAN SACHS GROUP INC	MORGAN STANLEY DEAN WITTER & CO
6.	LINCOLN NATIONAL CORP IN	LEHMAN BROTHERS HOLDINGS INC	MERRILL LYNCH & CO INC	FEDERAL NATIONAL MORTGAGE ASSN
7.	FEDERAL NATIONAL MORTGAGE ASSN	GOLDMAN SACHS GROUP INC	METLIFE INC	GOLDMAN SACHS GROUP INC
8.	HARTFORD FINANCIAL SVCS GROUP I	MERRILL LYNCH & CO INC	HARTFORD FINANCIAL SVCS GROUP I	COUNTRYWIDE FINANCIAL CORP
9.	METLIFE INC	HARTFORD FINANCIAL SVCS GROUP I	PRUDENTIAL FINANCIAL INC	METLIFE INC
10.	MERRILL LYNCH & CO INC	PRUDENTIAL FINANCIAL INC	LINCOLN NATIONAL CORP IN	HARTFORD FINANCIAL SVCS GROUP I
11.	GOLDMAN SACHS GROUP INC	GENWORTH FINANCIAL INC	AMERIPRISE FINANCIAL INC	PRINCIPAL FINANCIAL GROUP INC
12.	JPMORGAN CHASE & CO	METLIFE INC	COUNTRYWIDE FINANCIAL CORP	LINCOLN NATIONAL CORP IN
13.	PRINCIPAL FINANCIAL GROUP INC	PRINCIPAL FINANCIAL GROUP INC	JPMORGAN CHASE & CO	PRUDENTIAL FINANCIAL INC
14.	E TRADE FINANCIAL CORP	JPMORGAN CHASE & CO	UNUM GROUP	JPMORGAN CHASE & CO
15.	UNUM GROUP	E TRADE FINANCIAL CORP	SOVEREIGN BANCORP INC	CITIGROUP INC
16.	TRAVELERS COMPANIES INC	UNUM GROUP	PRINCIPAL FINANCIAL GROUP INC	AMERIPRISE FINANCIAL INC
17.	C I G N A CORP	WASHINGTON MUTUAL INC	E TRADE FINANCIAL CORP	E TRADE FINANCIAL CORP
18.	SOVEREIGN BANCORP INC	C N A FINANCIAL CORP	WASHINGTON MUTUAL INC	C I T GROUP INC NEW
19.	WASHINGTON MUTUAL INC	COUNTRYWIDE FINANCIAL CORP	COMMERCE BANCORP INC NJ	WASHINGTON MUTUAL INC
20.	COMMERCE BANCORP INC NJ	COMMERCE BANCORP INC NJ	HUNTINGTON BANCSHARES INC	COMMERCE BANCORP INC NJ

Table 4b

Ranking by insurance charge (by total $ amount)

This table contains the names of the top 20 companies ranked in descending order in according to their insurance charge for the specified periods. The insurance payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below 10% at the end of a four year period.

	July 2003 - June 2004	July 2004 - June 2005	July 2005 - June 2006	
1.	FEDERAL NATIONAL MORTGAGE ASSN	FEDERAL NATIONAL MORTGAGE ASSN	MORGAN STANLEY DEAN WITTER & CO	MORGAN STANLEY DEAN WITTER & CO
2.	MORGAN STANLEY DEAN WITTER & CO	MORGAN STANLEY DEAN WITTER & CO	FEDERAL NATIONAL MORTGAGE ASSN	CITIGROUP INC
3.	JPMORGAN CHASE & CO	FEDERAL HOME LOAN MORTGAGE CORP	GOLDMAN SACHS GROUP INC	MERRILL LYNCH & CO INC
4.	MERRILL LYNCH & CO INC	JPMORGAN CHASE & CO	MERRILL LYNCH & CO INC	JPMORGAN CHASE & CO
5.	GOLDMAN SACHS GROUP INC	MERRILL LYNCH & CO INC	JPMORGAN CHASE & CO	GOLDMAN SACHS GROUP INC
6.	LEHMAN BROTHERS HOLDINGS INC	GOLDMAN SACHS GROUP INC	LEHMAN BROTHERS HOLDINGS INC	FEDERAL HOME LOAN MORTGAGE CORP
7.	PRUDENTIAL FINANCIAL INC	LEHMAN BROTHERS HOLDINGS INC	METLIFE INC	FEDERAL NATIONAL MORTGAGE ASSN
8.	CITIGROUP INC	PRUDENTIAL FINANCIAL INC	BEAR STEARNS COMPANIES INC	LEHMAN BROTHERS HOLDINGS INC
9.	BEAR STEARNS COMPANIES INC	METLIFE INC	PRUDENTIAL FINANCIAL INC	BEAR STEARNS COMPANIES INC
10.	METLIFE INC	CITIGROUP INC	HARTFORD FINANCIAL SVCS GROUP I	METLIFE INC
11.	HARTFORD FINANCIAL SVCS GROUP I	BEAR STEARNS COMPANIES INC	CITIGROUP INC	BANK OF AMERICA CORP
12.	BANK OF AMERICA CORP	BANK OF AMERICA CORP	BANK OF AMERICA CORP	PRUDENTIAL FINANCIAL INC
13.	WACHOVIA CORP 2ND NEW	AMERICAN INTERNATIONAL GROUP IN	WASHINGTON MUTUAL INC	HARTFORD FINANCIAL SVCS GROUP I
14.	WASHINGTON MUTUAL INC	HARTFORD FINANCIAL SVCS GROUP I	COUNTRYWIDE FINANCIAL CORP	COUNTRYWIDE FINANCIAL CORP
15.	LINCOLN NATIONAL CORP IN	WACHOVIA CORP 2ND NEW	WACHOVIA CORP 2ND NEW	WACHOVIA CORP 2ND NEW
16.	GENWORTH FINANCIAL INC	WASHINGTON MUTUAL INC	LINCOLN NATIONAL CORP IN	WASHINGTON MUTUAL INC
17.	PRINCIPAL FINANCIAL GROUP INC	LINCOLN NATIONAL CORP IN	AMERIPRISE FINANCIAL INC	LINCOLN NATIONAL CORP IN
18.	TRAVELERS COMPANIES INC	PRINCIPAL FINANCIAL GROUP INC	AMERICAN INTERNATIONAL GROUP IN	PRINCIPAL FINANCIAL GROUP INC
19.	C I G N A CORP	GENWORTH FINANCIAL INC	PRINCIPAL FINANCIAL GROUP INC	AMERIPRISE FINANCIAL INC
20.	SUNTRUST BANKS INC	COUNTRYWIDE FINANCIAL CORP	SOVEREIGN BANCORP INC	C I T GROUP INC NEW

Figure 1:
The graph depicts simulated insurance charges as a % of equity in three dimensions as a function of the correlation between the firm's equity return and the market return, and as a function of the strike rate of the insurance contract. Specifically, the payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below the strike rate, ranging from 1% to 10% (i.e., Ki=10 to 100). We assume the following parameters based on recent history: market volatility of 16%, firm equity volatility of 27%, risk-free rate of 4% and a current firm's ratio of market value of equity to total liabilities + market equity value equal to 10%. The contract has a four-year maturity.

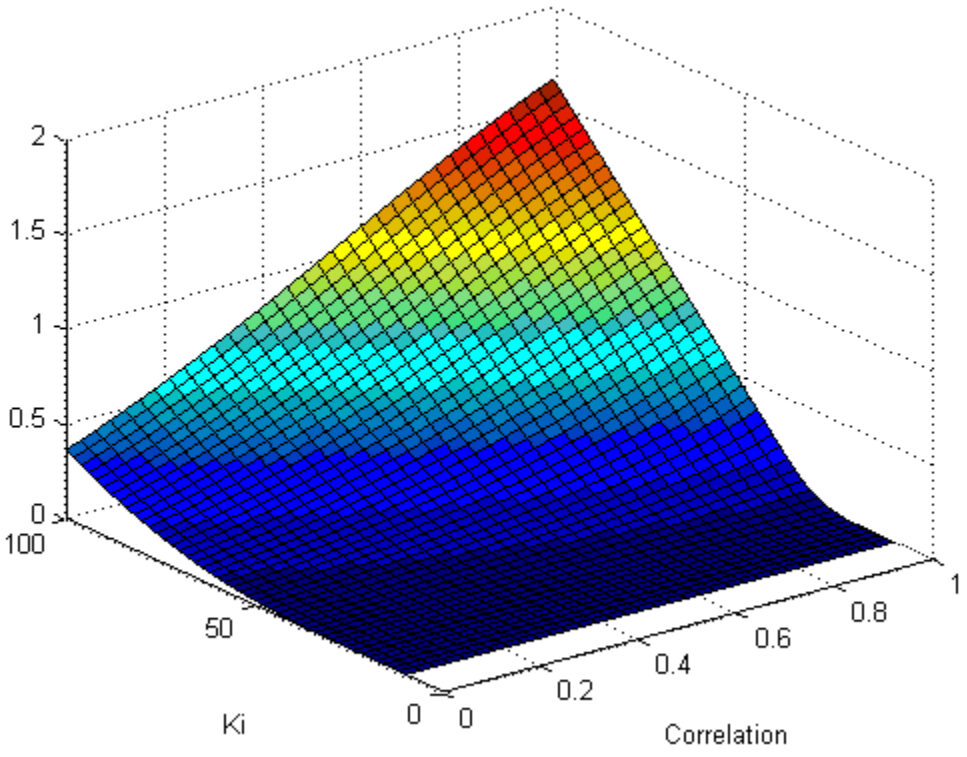


Figure 2a:

The graph depicts simulated insurance charges as a % of equity in three dimensions as a function of the volatility of the firm's equity return and the volatility of the market return for a given strike rate of the insurance contract. Specifically, the payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below the strike rate of 10%. We assume the following parameters based on recent history: correlation between the firm equity return and the market return of 55%, risk-free rate of 4% and a current firm's ratio of market value of equity to total liabilities + market equity value equal to 10%. The contract has a four-year maturity.

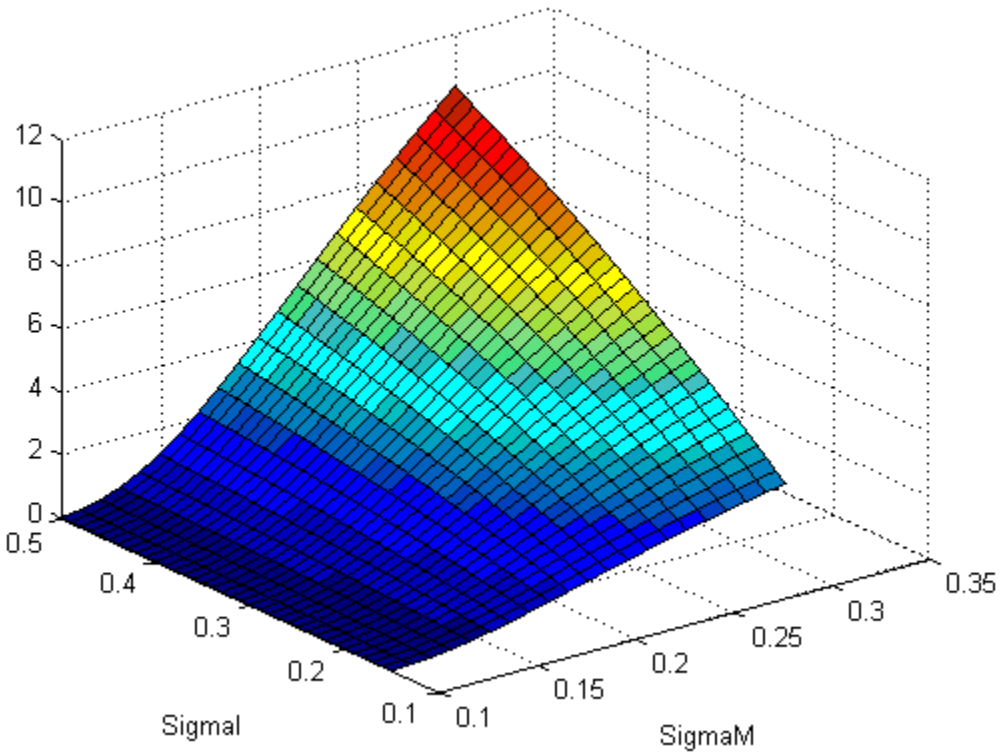


Figure 2b:

The graph depicts simulated insurance charges as a % of equity in three dimensions as a function of the volatility of the firm's equity return and the volatility of the market return for a given strike rate of the insurance contract. Specifically, the payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below the strike rate of 7.5%. We assume the following parameters based on recent history: correlation between the firm equity return and the market return of 55%, risk-free rate of 4% and a current firm's ratio of market value of equity to total liabilities + market equity value equal to 10%. The contract has a four-year maturity.

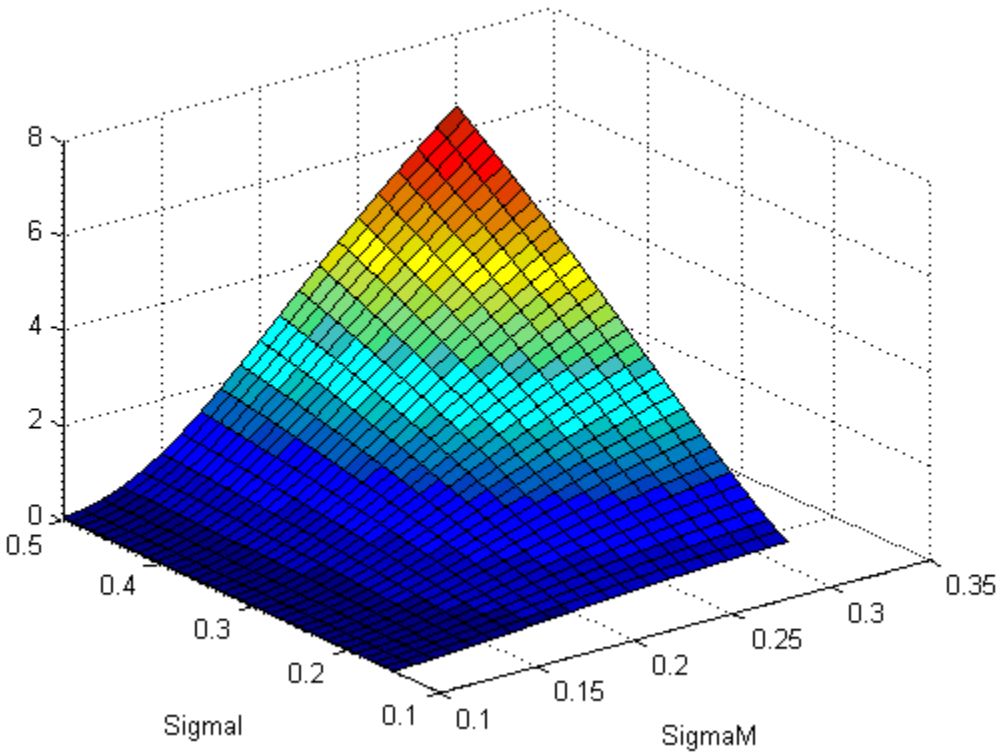
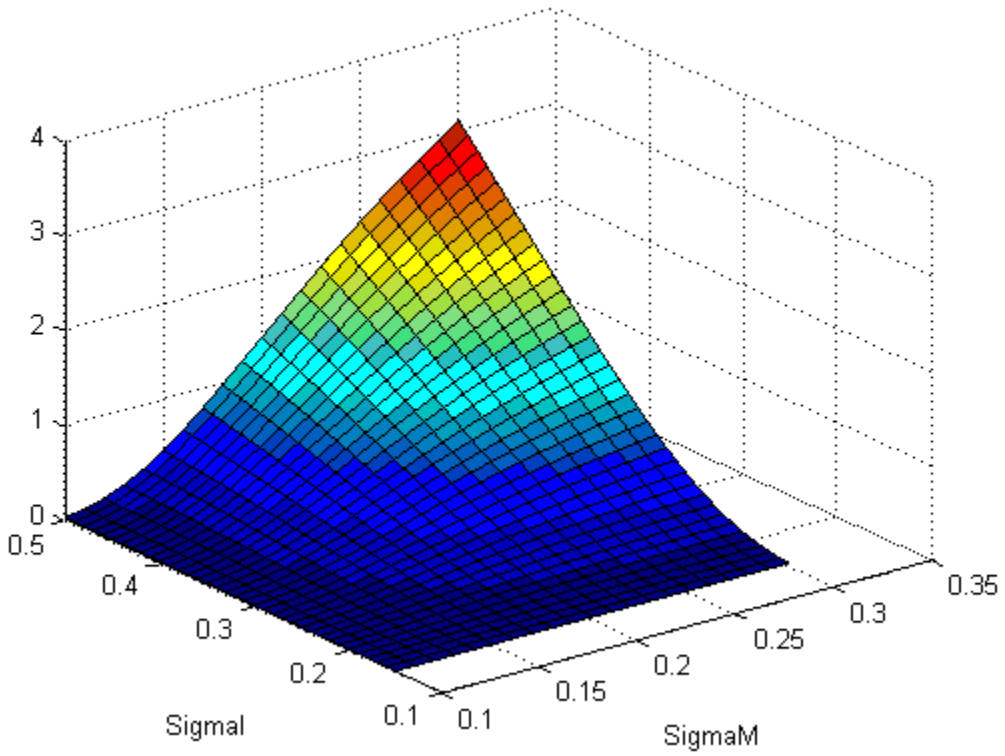


Figure 2c:

The graph depicts simulated insurance charges as a % of equity in three dimensions as a function of the volatility of the firm's equity return and the volatility of the market return for a given strike rate of the insurance contract. Specifically, the payoff is triggered when the market drops 40% and the firm's ratio of market value of equity to total liabilities + market equity value falls below the strike rate of 5%. We assume the following parameters based on recent history: correlation between the firm equity return and the market return of 55%, risk-free rate of 4% and a current firm's ratio of market value of equity to total liabilities + market equity value equal to 10%. The contract has a four-year maturity.



Appendix

This appendix contains the names of the U.S. financial institutions used in the analysis of the recent crisis. The institutions have been selected according to their inclusion in the U.S. financial sector and their market cap as of end of June 2007 where all firms had a market cap in excess of 5bln USD.

The companies can be categorized into the following four groups: **Depository Institutions(**JPMorgan, Citigroup, WAMU,…), **Security and Commodity Brokers**(Goldman Sachs, Morgan Stanley,…), **Insurance Carriers**(AIG, Berkshire Hathaway, Countrywide,…) and **Insurance Agents, Brokers, Service**(Metlife, Hartford Financial,…) and a group called **others** consisting of Non-depository Institutions, Real Estate etc..

The total number of firms in the sample is 102.

Note that although Goldman Sachs has a SIC code of 6282 thus initially making it part of the group called Others we have nonetheless chosen to put in the group of Security and Commodity Brokers.

Depository Institutions: 29 companies, 2-digit SIC code=60.	**Other: Non-depository Institutions etc.: 27 Companies, 2-digit SIC code=61, 62(except 6211), 65, 67.**	**Insurance: 36 Companies, 2-digit SIC code=63 and 64.**	**Security and Commodity Brokers: 10 Companies, 4-digit SIC code=6211.**
1.B B & T CORP	1.ALLTEL CORP	1.A F L A C INC	1.BEAR STEARNS COMPANIES INC
2.BANK NEW YORK INC	2.AMERICAN CAPITAL STRATEGIES LTD	2.AETNA INC NEW	2.E TRADE FINANCIAL CORP
3.BANK OF AMERICA CORP	3.AMERICAN EXPRESS CO	3.ALLSTATE CORP	3.EDWARDS A G INC
4.CITIGROUP INC	4.AMERIPRISE FINANCIAL INC	4.AMBAC FINANCIAL GROUP INC	4.GOLDMAN SACHS GROUP INC
5.COMERICA INC	5.BLACKROCK INC	AMERICAN	5.LEHMAN BROTHERS HOLDINGS INC
6.COMMERCE BANCORP INC NJ	6.C B O T HOLDINGS INC	5.INTERNATIONAL GROUP INC	6.MERRILL LYNCH & CO INC
7.HUDSON CITY BANCORP INC	7.C B RICHARD ELLIS GROUP INC	6.AON CORP	7.MORGAN STANLEY DEAN WITTER & CO
8.HUNTINGTON BANCSHARES INC	8.C I T GROUP INC NEW	ASSURANT INC	8.NYMEX HOLDINGS INC
9.JPMORGAN CHASE & CO	9.CAPITAL ONE FINANCIAL CORP	7.BERKLEY W R CORP	9.SCHWAB CHARLES CORP NEW
10.KEYCORP NEW	10.CHICAGO MERCANTILE EXCH HLDG INC	8.BERKSHIRE HATHAWAY INC DEL	10. T ROWE PRICE GROUP INC
11.M & T BANK CORP	11.COMPASS BANCSHARES INC	9.BERKSHIRE HATHAWAY INC DEL	
12.MARSHALL & ILSLEY CORP	12.EATON VANCE CORP	10.C I G N A CORP	
13.NATIONAL CITY CORP	13.FEDERAL HOME LOAN MORTGAGE CORP	11.C N A FINANCIAL CORP	
14.NEW YORK COMMUNITY BANCORP INC	14.FEDERAL NATIONAL MORTGAGE ASSN	12.CHUBB CORP	
15.NORTHERN TRUST CORP	15.FIDELITY NATIONAL INFO SVCS INC	13.CINCINNATI FINANCIAL CORP	
16.P N C FINANCIAL SERVICES GRP INC	16.FIFTH THIRD BANCORP	14.COUNTRYWIDE FINANCIAL CORP	
17.PEOPLES UNITED FINANCIAL INC	17.FRANKLIN RESOURCES INC	15.COVENTRY HEALTH CARE INC	
18.REGIONS FINANCIAL CORP NEW	18.INTERCONTINENTALEXCHANGE INC	16.FIDELITY NATIONAL FINL INC NEW	
19.SOVEREIGN BANCORP INC	19.JANUS CAP GROUP INC	17.GENWORTH FINANCIAL INC	
20.STATE STREET CORP	20.LEGG MASON INC	18.HARTFORD FINANCIAL 19.SVCS GROUP IN	
21.SUNTRUST BANKS INC	21.LEUCADIA NATIONAL CORP	20.HEALTH NET INC	
22.SYNOVUS FINANCIAL CORP	22.MASTERCARD INC	21.HUMANA INC	
23.U S BANCORP DEL	23.N Y S E EURONEXT	22.LINCOLN NATIONAL CORP IN	**Insurance, continued:**
24.UNIONBANCAL CORP	24.S E I INVESTMENTS COMPANY	23.LOEWS CORP	
25.WACHOVIA CORP 2ND NEW	25.S L M CORP	24.LOEWS CORP	FINANCIAL INC
26.WASHINGTON MUTUAL INC	26.T D AMERITRADE HOLDING CORP	25.M B I A INC	31.SAFECO CORP
27.WELLS FARGO & CO NEW	27.UNION PACIFIC CORP	26.MARSH & MCLENNAN COS INC	32.TORCHMARK CORP
28.WESTERN UNION CO		27.METLIFE INC	33.TRAVELERS COMPANIES INC
29.ZIONS BANCORP		28.PRINCIPAL FINANCIAL GROUP INC	34.UNITEDHEALTH GROUP INC
		29.PROGRESSIVE CORP	35.UNUM GROUP
		30. PRUDENTIAL	36.WELLPOINT INC