The Mispricing of Credit Default Swaps: Institutional Causes and Effects

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This paper uses basic financial theory to evaluate important institutional factors and phenomena which have been reported to draw a connection between credit default swaps (CDSs) and the financial crisis. The investigation indicates that the recent financial crisis may have been largely caused by the mispricing the massive number of CDSs. Complex mathematical modeling of those derivatives based on unrealistic assumptions apparently led to an inefficient market for debt investments in general that exploded upon catalytic rises in residential mortgage defaults.
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1. Introduction

There remains no consensus on the causes of the recent financial crisis (Allen and Carletti (2010). Sabry and Okongwu (2009) blame lax underwriting standards in the mortgage market that resulted in massive defaults when the residential real estate boom in the U.S. burst in 2007, and contagion spread the problem to the rest of the financial system, at least partially because of the interlocking counterparty risk associated with credit default swaps (CDSs). Allen and Carletti (2010) suggest the world's central banks were culpable for providing excess liquidity that caused a bubble in asset prices that eventually collapsed, with the Federal Reserve being the main culprit due to its monetary easing designed to help the U.S. economy to recover from the recession at the turn of the century. Issing (2009) indicates that the high levels of liquidity flowing into risky debt markets shrinking yield spreads were a contributing cause, with market participants having only a "rudimentary understanding of their own transactions." Even institutions without exposure to the U.S. mortgage market failed when the price of risk rose significantly (Shin, 2009). An overview of the many events relating to the crisis is provided by Brunnermeier (2009).

This paper analyzes the contribution of CDSs to the financial crisis. There have been allegations that the enormous growth and size of this market was a huge potential risk to the financial system (McDonald, 2009), but the exact process by which it became such a danger and how hasn't been addressed in the financial literature. Because CDSs aren't subject to regulation, there isn't much transparency, and it is necessary to use industry reports and whatever other information can be obtained about the institutional characteristics of CDSs in order to be able to analyze them with the basic financial theory of asset pricing. While the lack of transparency in the market makes it difficult to reach a definitive conclusion, the investigation reveals a mispricing of CDSs to have been a major factor in the credit market bubble that eventually burst. In particular, narrow yield spreads were induced by the issue of underpriced CDSs, and when investors came to recognize the inadequacy of that spread, it widened considerably. A liquidity crisis ensued for some large firms, and contagion between companies with interlocking liabilities caused a system-wide financial crisis. The catalyst for that crisis was a rise in defaults on residential mortgages, but high defaults may have been inevitable given the deterioration in the quality of credit analysis motivated by the mispricing of CDSs. While CDS counterparty risk also contributed to the depth of the crisis (Heyde and Neyer, 2010), the primary cause of the boom and subsequent crash in the debt markets may have been the mispricing of CDS insurance provided on risky debts like subprime mortgages.

2. General Institutional Factors Affecting the Mispricing in the Massive Market for CDS

CDSs are actually rather simple instruments in concept, merely mandating that one party paying a periodic fee to another to insure the debts of some entity (such as a specified corporation) against default for a particular amount of time like 5 years (Zhang, Zhou, and Zhu, 2009). They are effectively debt insurance policies that are labeled otherwise to avoid the regulation that normally is imposed on insurance contracts. The principal amount of CDSs exceeded $60 trillion in 2007, although the present value of the actual payments due on them was estimated to be only $2 trillion (Sabry and Okongwu, 2009). This largely unregulated market grew astronomically from $900 billion at the turn of the millennium to over $50 trillion after Congress enacted a law exempting these products CDSs state gaming laws in 2000 (PIA Connection, 2008) and largely freed them from any regulation whatsoever through the Commodity Futures Modernization Act (McDonald, 2009). Many CDSs have therefore been contracted over the phone without any documentation whatsoever (Simon, 2008).

Any investment in a debt requires compensation not only for the time value of money but also a premium for the credit risk of the debt. Compensation for the time value of money is usually provided by the debt promising, at a minimum, a yield equal to that of the rate available on default-free government securities like U.S. Treasury bonds. The credit risk premium above that rate must compensate investors for not only the expected value of default losses but also for the systematic risk relating to the debt, as well as for any embedded options (Murphy, 1988).

In a CDS or bond insurance contract, there is no initial investment in the debt by the insuring party, and so only a credit risk premium is required. This premium must, however, include both the default risk premium and the systematic risk premium. Appropriate appraisal methods for estimating those premiums have long been known (Callaghan and Murphy, 1998).

However, many practitioners today apply pure mathematical theories to evaluate credit risk and estimate credit risk premiums to be required (Glantz and Mun, 2008). Unlike full structural models of credit analysis that evaluate default risk using a framework grounded in the actual liquidity causes of firm failure and that have been shown empirically to be superior to credit rating agency grades (Callaghan and Murphy, 1998), most mathematical theories of credit risk either divorce themselves from such realities by assuming perfect markets (Merton, 1974) or represent reduced form models that simply focus on superficial past correlations between variables (Altman, 1968). Rajan, Seru, and Vig (2008) have provided an analysis of the very large forecasting errors that result from the application of the latter such models that can fit "hard" historical data extremely well but ignore the "soft information" that can only be obtained via human judgment.

The models of such "'quants' who have wielded so much influence over modern banking" are, according to some analysts, "worse than useless" (NewScientist, 2008b), and the result has been catastrophic for many institutions religiously adhering to them. Just for instance, one major guarantor of debts via CDSs, the insurance company AIG, placed "blind faith in financial risk models" and their small elite staff of modelers who initially generated large income for the firm for a few years that later turned into decimating losses (Morgenson, 2008). Organizations naturally discourage pessimism and dissent, thereby tending to reinforce the beliefs of individual leaders that are accepted as dogma without critical thinking, and so forecasts of the coming crisis were ignored (Kolb, 2010).

Regulators' own predictions of serious problems and "horror stories" years in advance of today's crisis weren't acted upon because of successful lobbying by the very financial institutions that are today either bankrupt or rescued with government funding (Associated Press, 2008). For instance, the failures of the two federal agencies, Fannie Mae and Freddie Mac, were preceded in 2005 by a successful $2 million campaign by Freddie Mac to lobby Congress from restricting their own investments in higher-risk mortgages (Yost, 2008). These same agencies, banks, and other institutions provided assurances their lending practices (including those enabling loans without adequate documentation) were "safe" based on evaluations of past data (Associated Press, 2008). The extreme political influence of financial institution lobbyists is considered to be a root cause of

the financial crisis (Dell'Ariccia, Igan, and Laeven, 2010).

At least partially because of SEC and government regulator certification, many investors in debt securities look only at the credit ratings provided by a few rating agencies such as Moody's and Standard & Poors (S&P), which themselves evaluate credit largely using only mathematical models (Kolb, 2010). Those models, which typically employ statistics to uncover past relationships between debt defaults and a few variables, as in the seminal Altman (1968) study, and which the SEC itself determined in 2007 were antiquated and incorrect (Kolb, 2010), can ignore very important factors and possibilities (Woellert and Kopecki, 2008). While some have suggested that the models only need to be improved (NewScientist, 2008b), purely statistical models can't incorporate all possible factors that are relevant to a decision. In addition, statistical models are subject to the problems of spurious correlations between variables that are magnified as the number of variables is increased, so that attempts to incorporate more relevant variables may only increase other modeling errors. They also generally don't account for changing market conditions or new relationships that may develop, especially with respect to new security types like those created with great frequency in the enormous structured finance market (Kolb, 2010). Moreover, it probably isn't possible to evaluate credit risk exclusively with a computer because human behavior likely can't be modeled using pure statistical data.

Many banks also utilized computerized statistical analysis based on recent past data for purposes of evaluating aggregate company risk using Value at Risk (VAR) models that defied common sense (McDonald, 2009) and that ignored large distributional tails (Ho, Burridge, Cadle, and Theobald, 2000). In particular, since existing mathematical models of risk have "a tendency to underestimate the likelihood of sudden large events" (Buchanan, 2008), the short put positions represented by many credit derivatives makes them lucrative without consideration of those extreme events (Rizzi, 2008). In addition, most statistical models fail to incorporate all the inter-related systematic risks (Jameson, 2008), and they tend to make unrealistic assumptions such as markets always being in equilibrium (NewScientist, 2008a). The result was that leading financial institutions undertook suicidal excessive risk from the point of view of basic business common sense (McDonald, 2009).

Despite their "poor risk modeling" in actuality (Jameson, 2008), the statistical accuracy of the models in predicting backward into the past using historic data resulted in the mathematical modelers developing such a "faith in their models" for forecasting the future that they began to "to ignore what was happening in the real world" (NewScientist, 2008b). Because experts tend to only listen to other experts who utilize similar modeling procedures, beliefs are strongly reinforced without critical questioning (Kolb, 2010). Models were considered "accurate" because they were "sophisticated", which really only means they were "complex and confusing" (Reis, 2010).

These models were utilized to justify more risk-taking (Kolb, 2010). In addition, firms relying on statistics to manage their overall risk even perceived obvious risk reduction activities as excessively risky because of some sample relationships (McDonald, 2009), and subprime loans were perceived as less risky than conventional prime mortgages (Kolb, 2010).

Even after the failure of the purely mathematical models existing in finance and economics, many today feel that mathematical models of markets must merely be refined, such as with gauge theory, which is the mathematical underpinning of the quantum field theories of the standard model of physics (Buchanan, 2009). It is questionable, however, whether credit analysis, even armed with the most modern rocket science, can ever be conducted without some human judgment. Human analysis can incorporate a vast number of variables that are rapidly processed using simple but effective algorithms that are subconsciously developed (Gigenrenzer, 2007). It can therefore help avoid the errors of purely mathematical models that are based on unrealistic assumptions, that take into consideration only a subset of all the relevant variables, and that may be affected by past spurious relationships which may not hold in future environments.

Some have suggested that subjective human judgment opens up the possibility of undesirable human biases and manipulation. However, with or without human judgment, financial models of

credit risk are subject to manipulation, both legally and fraudulently. Just for instance, "soft information" about borrowers' capacity to repay that is difficult to communicate in mathematical models to the final investors of securitized loans is subject to manipulation by lenders seeking origination income (Rajan, Seru, and Zig, 2008). The modeling predictions at the credit rating agencies themselves (such as Moody's and S&P) have, at least recently, been biased toward granting higher ratings than merited in order to compete for revenues from the debtors who pay to be rated, and the result has been a "colossal failure" (Burns, 2008). Based on the recent record of the relative rates of defaults on loans made using strictly "hard information" (Rajan, Seru, and Zig, 2008), it can be concluded that human judgment may, at least within the framework of normal organizational controls, have greater capacity to detect and avoid biases than mathematical models that can be more easily manipulated than thinking human beings.

3. Modeling Away Systematic Risk and Systematic Risk Premiums.

The more sophisticated mathematical models of debt instruments were based on theories that implied the systematic risks of debts could be hedged or diversified away (Duffee, 1999). This modeling framework may have been a significant contributor to the mispricing of CDSs. In particular, many modelers questioned the need to require any yield compensation for systematic risks (Elton, Gruber, Agrawal, and Mann, 2001).

Debt investors normally receive extra yield for the systematic or beta risk of debts because those risks of systematic losses during periods of market declines or recessions can't be fully diversified away (Murphy, 2000). Without systematic risk premiums on debts subject to default risk, risk-averse investors should optimally invest into default-free U.S. Treasury securities to obtain the same average return without any risk. However, theories have been developed that indicate investors only need to charge sufficient interest to cover expected default losses (Duffee, 1999). These theories are based on unrealistic assumptions, such as no transaction costs and a continuous distribution of returns (Merton, 1974). As a result, the conclusions of the theories are invalid despite the impeccable accuracy of their mathematics.

While most of the failure in requiring sufficient compensation on loans to cover expected default losses in moderate economic scenarios may have been concentrated in the mortgage market, the inadequate yield premiums required for systematic risk became prevalent in most debt markets by 2007. A major contributing factor was the use of copula functions to measure systematic risk based on the correlation of current market prices of debts and related CDS insurance based on past histories of the correlation of defaults (Salmon, 2009). Because such correlation coefficients can't be observed from past data on existing debts, they are often estimated from a debt's correlation with the market values of other assets or with a systematic factor, and such estimation procedures cause "clustering in default correlations" that lead to a greater likelihood of large losses than the copula models indicate (Jorion and Zhang, 2010). Such misestimated functions resulte in an underestimation of the systematic risk of defaults across debts in distressed times and undercompensation for the systematic risk of debt investments. Researchers have indeed come to recognize that the mathematical modeling of default risk using existing copula models need to be adjusted (Burtschell, Gregory, and Laurent, 2009). Although there are alternatives to copula models of CDSs (Zhan, Zhou, and Zhu, 2009), as well as other theories of credit risk in general (Hsu, Saa-Requejo, and Santa-Clara, 2010), copulas have become the industry standard for evaluating credit-related products (Burtschell, Gregory, and Laurent, 2009). Jorion and Zhang (2010) have concluded that such models of portfolio risk have failed badly.

In any event, modeling procedures based on unrealistic assumptions resulted in many CDSs being priced to have the periodic payment compensate the insuring party for average default losses without adequate premium yields being required for systematic risk. Little or no extra yield cushion was required to cover the systematically above-average default losses that inevitably occur in some years. As a result, debt investors had set themselves up for significant losses at some point. Given that many of the insuring parties of CDSs were banks and other financial institutions that were

highly leveraged with large current obligations, suffering losses created the risk of these insurers defaulting on their own obligations under the CDSs,[1] leading to a potential domino effect for their swap counterparties and a possible systematic cascade of defaults.

Failing to charge a systematic risk premium on the CDSs compounded the problem of underestimating average default losses that, as previously mentioned, also emanated from the reliance on statistical models that were applied without human judgment or business common sense. The result has been that debt insurance in the CDS market was very underpriced, and the payments on CDSs didn't even cover expected future default losses in average years.

Such underpricing of CDSs resulted in a credit bubble, as investors were able to hedge their investments in bonds and loans with the insurance of the CDSs to reduce their risk at abnormally low costs. In particular, the hedged positions of bonds and loans combined with CDS insurance were perceived to be virtually risk-free because the insuring parties on the CDSs (such as banks, the federal agencies FNMA and FHLMC, and insurance companies such as AMBAC, MBIA, and AIG) were typically granted the same credit rating by Moody's and S&P as the U.S. Treasury at Aaa. Due to the unregulated nature of the market for CDSs, it was difficult for investors to analyze or question whether the Aaa ratings of the insurers were justified, since lack of regulation resulted in inadequate disclosure. Investors (and the credit rating agencies themselves) may have also perceived (perhaps with some justification) that some of these insurers had implied U.S. government backing either because they were federal agencies (like FNMA and FHLMC) or were too large to fail (like many commercial and investment banks and insurance companies).

The credit premium charged on CDSs was less than on the loans and bonds they insured at least partially because financial institutions like banks didn't have to maintain capital requirements against CDSs, which didn't appear on their balance sheets and therefore tied up less of expensive equity capital (McDonald, 2009). Investors were thus able to take hedged positions on risky debt insured with CDSs that yielded more than U.S. Treasury bonds without any perceived material increase in risk. In particular, arbitragors would purchase higher yielding debts, buy cheap CDS insurance on them, and then earn the difference between the higher spread and the insurance premium as an excess return for little perceived risk. Such activities eventually drove the yield premiums on all bonds and loans down to the cost of the CDSs as competition with lenders engaged in forming such hedged positions forced down borrowing rates.

As a result, risky bond and loan yield spreads above the interest rates on default-free U.S. Treasury bonds plummeted to the level of the cost of the CDSs as risky bond prices were bid up to take the hedged positions in CDS-insured bonds and loans. An extreme narrowing in the spreads between Treasury yields and corporate and other debt yields therefore developed (Issing, 2009). For instance, the credit spread on Lehman Brothers High Yield Index had fallen to an incredibly low 2.50% by early 2005 and fell to a record low of 231 basis points in early 2007 (McDonald, 2009). Credit risk spreads in the real estate, leveraged buyout, and structured credit markets had also fallen to historical lows, with the spread on subprime mortgages, the majority of which were held by U.S. financial institutions, having fallen by 250 basis points (Kolb, 2010).

The drop in credit risk spreads was especially large in portfolios of debts that were packaged into collateralized debt obligations (CDOs). CDS insurance was also provided on CDOs, thereby increasing demand for CDOs backed by riskier debts. This process contributed to rapid growth in the CDO market that occurred around the same time, and the increases in CDOs also provided the opportunity to grow the volume of new CDS insurance, as CDS insurance could thereby be

[1] The required posting of additional collateral when the market value of a swap contract becomes negative to a counterparty minimizes the risks associated with that counterparty going bankrupt and not fulfilling the terms of the contract. The risk of a domino effect remains, however, insofar as one large institution failing can lead to defaults on obligations without collateral requirements that can result in losses to other institutions which might thereby be driven into bankruptcy. Such losses can exist on all over-the-counter trades with brokers and dealers that are not performed through the regulated markets like the futures and stock exchanges (Collins and McMahon, 2008).

profitably made indirectly on smaller loans that were packaged into CDO pools. The CDS market thereby enabled rapid growth in loans to smaller debtors (like homeowners), especially ones with higher default risk (like subprime mortgages) since CDS insurance reduced risks relatively more for such obligations. Packaging of the loans into pools also added to the liquidity of those assets, thereby further reducing the required yield spread on them, although the risk of the liquidity of those structured investments falling substantially in a credit crash that causes yield spreads to widen was underestimated, as was the required return for such systematic risks (Kolb, 2010).

With market prices of publicly traded debts not incorporating adequate premiums for credit risk, new loans, even those not made with direct or indirect CDS insurance, had to be similarly priced to compete with the public markets. Thus, lenders and debt investors in general locked themselves into returns that could be expected to average scarcely above those on default-free Treasury securities. Those yields often didn't provide sufficient compensation to cover average default losses due to inadequate credit analysis, which, because of overemphasis on mathematical modeling, resulted in much larger errors in estimating the probability of default than an expert human would make.

However, for a while, lenders were able to generate profits because initial default rates on new issues of debt tend to be lower in the early years after origination, and because loan originations generate significant fee income to the lenders. Since the economy was still expanding at a healthy pace a few years ago, and since the artificially lower rates resulted in rising lending volume due to increased demand by borrowers (especially the less credit worthy who could manipulate the mathematical models), the short-term profitability was enhanced even more for lending institutions.

Nonetheless, given that no systematic risk premium was being charged, and given that the default risk premium was less than the average default losses over the life of the debt that would be estimated by expert human credit analysts, the profits were almost certain to turn into losses as soon as defaults rose to a normal level. In particular, charging inadequate credit risk premiums can result in negative income even with funding costs at Treasury rates when losses from defaults exceed yield spreads. As a result, without the cushion of a systematic risk premium to cover higher than average default losses that widely occur in some years, highly leveraged firms like banks could systematically experience negative income in those years, leading to liquidity problems related to bank runs and failure. Until then, however, it was possible for individuals and companies to borrow at extremely low premiums to Treasury rates for several years, as the low cost of debt insurance lowered the cost of borrowing.

The recipients of the periodic insurance payment on the CDSs themselves were also able to initially report large profits from the contracts, despite the underpricing of the insurance, as the early defaults on new debt issues were lower than the insurance payments (Morgenson, 2008). That situation was especially prevalent in the residential mortgage market because newly issued mortgages tend to be characterized by especially low default rates compared to more seasoned ones. In addition, many of the newly originated mortgages had adjustable rates that offered a low teaser payment for the first 1-5 years of the loan before they were contracted to rise according to a formula based on market rates of interest, and default rates naturally rise significantly with such adjustable-rate mortgages (ARMs) when those artificially low rates expire.

4. The Foreclosure Catalyst for the Bursting of the Credit Bubble

The mortgage crisis itself seems to have been largely caused by the mispricing of CDSs. A major contributor to the lack of subjective judgment and verification of the model inputs was the fact that mortgage brokers were motivated by loan origination commissions to just maximize the volume of issued mortgages because they were to be owned by other investors who took positions in them through collateralized debt obligations or CDOs (Buchanan, 2008). One factor causing CDO investors, many of which were highly leveraged hedge funds (McDonald, 2009), to accept such uncertainties may very well have been that such mortgage-backed securities were widely insured against losses from default by insurers like AIG via CDSs (Morgenson, 2008). As a result of such

blurring of risks to final investors, many mortgage loans were made to borrowers with no money down and no proof of income (Buchanan, 2008).

Insurers of mortgage-backed securities justified their pricing by applying purely statistical credit scoring procedures using a limited number of factors that didn't incorporate the effects of requiring no documentation for the inputs to the models and that ignored the fact of no human credit analyst providing a subjective judgment. In many cases, the unverified inputs to the models were even widely recognized to be false or misleading. For instance, Alternative-A mortgages (alt-As), many of which required no documentation of income or assets, were widely referred to as "liar loans" but developed into a very large market because they generated large fees for mortgage bankers, who sold them to other investors (Zibel, 2008).[2] Some of the mortgage loans were even made with the principal exceeding the purchase price of the homes because of an expectation of continued rising prices for residential real estate (McDonald, 2009). The process was self-reinforcing initially since it generated very low costs for borrowers and large profits to lenders and insurers in the early years before default losses rose above credit premiums charged.

Moreover, the hundreds of billions of dollars of home equity loans, which enabled homeowners to borrow more cash against the rising home prices as an ATM for consumption purchases, contributed to strong economic growth, and such prosperity kept loan defaults relatively low as long as housing prices and the economy continued to boom (McDonald, 2009). Sufficient liquidity provided by the U.S. central banks also contributed to an economic environment that kept default rates low initially despite the decline in loan underwriting standards. Such accommodative money policies were enabled because of the low overall inflation that was promoted by inexpensive consumer imports from countries like China, even while the housing boom triggered by easy credit policies resulted in rapidly rising home prices that enabled refinancing of existing mortgages from the rising home equity (McDonald, 2009).

The problem of underpricing the insurance payments on CDSs for mortgage paper may have been at least partially exacerbated by the mathematical models of the insurers not fully allowing for the rising defaults that normally occur on adjustable rate mortgages as the interest rate invariably rises following initially low teaser rates. Most of the subprime mortgages, many of which were even guaranteed by FHLMC and FNMA (Frame, 2008), had introductory "teaser" rates, which, although already incorporating a large credit risk premium, were contracted to be raised to even higher levels after the expiration of the introductory teaser period of typically 2-5 years (McDonald, 2009). Repayments on these loans effectively depended on rising real estate prices to enable the refinancing of both principal and high prepayment fees to avoid defaults because of the borrowers inability to afford the payments at the end of the teaser period (Bhardwaj and Sengupta, 2009). After residential real estate prices peaked in 2006, the subprime mortgages couldn't be refinanced by homeowners, and massive defaults began as the payment increases couldn't be made after the contracted date of the interest rate reset (McDonald, 2009).

Unrealistic expectations of ever-rising home prices that would enable refinancing mortgages when the introductory teaser rates rose after a few years may have also contributed. Given the sensitivity of mortgage defaults to home price declines (Rajan, Seru and Vig, 2008), the existence of evidence of a possible bubble top in real estate prices at that time (Shiller, 2005) would make the latter expectations appear to be especially implausible.

However, Rajan, Seru and Vig (2008) have documented the fact that mortgages originated for sale in securitized packages ignored such deficiencies in credit analysis because of inadequate incentives for the originating lenders to do more than consider data inputs into models that were based on imperfect evaluation of the past history of default rates on loans with a limited set of specified criteria. Those criteria ignored the very lack of motivation lenders had to conduct independent credit evaluation with "soft information", which includes "information about a

[2] That market may never have existed without guarantees against default by insurers like AIG, AMBAC, and MBIA.

borrower's income or assets that is costly for investors to process".[3] Many mortgage originations were made with little or no verification of income, employment, or assets (low- and no-docs, respectively), and by 2005 nearly half of all home loans were made with no money down (McDonald, 2009). Poor underwriting standards have been found to be the major cause of the high mortgage default rates that eventually occurred (Mayer, Pence, and Sherlun, 2009).

For the initial years of the mortgages, however, insurers of mortgage paper like AIG were able to record large profits from its insurance scheme until the higher default rates on the securitized mortgages materialized (Morgenson, 2008). Loan defaults tend to be lower in the early years after origination, but default losses on subprime mortgages in 2007 began to exceed the credit premiums that had been charged on them.

The resulting rise in foreclosures brought an excess supply of homes onto the market that caused residential real estate prices to fall, further inhibiting the refinancing of unaffordable mortgage payments and thereby contributing to further mortgage defaults. Mortgage defaults tend to rise especially strongly when home equity (or the difference between the home value and the mortgage principal) turns negative, and the nationwide drop in real estate prices brought many mortgages into that risky position, causing severe declines in the market prices of those mortgages (especially the subprime ones that were often issued with very little homeowner's equity). As the market value of mortgages fell, it became difficult for investment banks and other financial institutions to refinance their commercial paper debt that was needed to pay for their mortgage investments while they were being packaged into pools for resale (McDonald, 2009). The viability of many banks and other financial institutions was called into question, resulting in a wholesale bank run that required the Federal Reserve to bailout the system with several hundred billion dollars in liquidity in August of 2007 (Gallagher, 2007).

As investors began to perceive that defaults could spread beyond mortgages, the systematic risk premiums began to rise across all debt instruments, resulting in a fall in debt prices across the board. Systematically falling debt prices led to further increases in perceived systematic risk and further rises in systematic risk premiums in a cycle that brought us to the 2008 financial crisis. Also contributing to the crisis was the widespread massive financing of portfolios of long-term assets with short-term debt (in what are called "carry trades") by financial institutions which thereby profited from the difference between the long-term yields and the short-term cost of borrowing (McDonald, 2009). That spread evaporated when the yield curve flattened out after the Federal Reserve raised short-term interest rates as 2008 approached. The latter phenomenon, combined with rising defaults and falling prices of mortgages and real estate, led to reports of reduced profit growth at financial institutions that spooked the stock market and made it difficult for firms to raise sufficient capital to meet any liquidity needs.

5. The Liquidity Crisis

Exacerbating the cycle along the way were the failures of several large financial institutions such as Northern Rock, Countrywide, Bear Stearns, FNMA, FHLMC, Lehman Brothers, and AIG (Kolb, 2010). These failures were related to the investments of those institutions into debt contracts of various types that had fallen in value to the point where their liabilities exceeded the market value of their assets. At that point, holders of the short-term liabilities of those institutions discontinued rolling over the institutions' liabilities, and there was insufficient cash for the institutions to make payments on those obligations (Shin, 2009).

While the first major liquidity crisis occurred on August 7, 2007, it was averted by heavy injections of cash by the Federal Reserve (Cecchetti, 2009). That crisis was preceded earlier in the summer of 2007 by the failure of several institutions, including two Bear Stearns hedge funds, whose leveraged investments into risky mortgages had fallen in value below that of its liabilities, resulting in holders of the firms' short-term liabilities to demand cash that wasn't available (McDonald, 2009).

[3] For instance, "the likelihood that the borrower's job may terminate, or other upcoming expenses that are not included in her current credit report" were generally ignored in securitized lending decisions (Rajan, Seru, and Zig, 2008).

Financial institution sponsors of leveraged investments in mortgages often had obligations to provide back-up lines of credit if commercial paper funding possibilities weren't available, and those institutions had their own liquidity drained by such credit line drawdowns when commercial paper financing dried up (Kolb, 2010). The entire investment bank of Bear Stearns itself had to be rescued in March 2008 via a merger with JPMorganChase that was subsidized by the Federal Reserve, as Bear Stearns' had been unable to refinance its own short-term debt which was financing its own extensive investments in subprime mortgages (Brunnermeier, 2009). A major catalyst in this failure was the rise in CDS premiums that led to margin calls on the firm's CDS obligations, for which the firm had insufficient cash to meet.[4]

The risk of default resulting from a similar situation of financial insolvency for FNMA and FHLMC occurred in the second half of 2008, and the U.S. government felt it judicious to provide those federal agencies with a massive bailout in order to lower the credit risk premiums on (and stabilize the prices of) the trillions of dollars in residential mortgages that they had guaranteed (Frame, 2008). In cases of non-governmental institutions without an implicit federal guarantee, there was also liquidity crisis that catalyzed the firm's failure, insofar as the market value of the liabilities of investment banks' massive portfolio of CDSs began to rise so much that the counterparties were able to demand additional collateral be put up as security against payment on the CDSs, as occurred most critically first with Bear Stearns.

A similar liquidity crisis later ensued at AIG, with that insurance company having guaranteed a massive amount of collateralized mortgage obligations with CDSs. As previously explained, much of the mortgage crisis may be attributed to AIG and other insurers of mortgage paper like AMBAC and MBIA. In particular, many of the subprime mortgages may never have been originated and packaged into pools if there hadn't been an agreement by the insurance companies to guarantee the mortgage-backed securities with specified mathematical characteristics against default. The premiums charged on the CDSs do not appear to have provided sufficient compensation for the higher default rates on mortgages with lower (or no) downpayments, especially when no documentation was required and no human credit analysis was undertaken. AIG finally suffered a liquidity crisis in September 2008 when it couldn't make payments on collateral calls on its CDS obligations (Sabry and Okongwu, 2009).

As more institutions failed, market credit risk premiums rose ever further, leading to further calls for collateral on firms that were receiving the periodic payments on CDSs. The gross payouts due on the CDSs guaranteeing Lehman Brothers against bankruptcy totaled $365 billion alone, with over 98% occurring between the bankruptcy of that investment bank in September 2008 and the final settlement a month later (Duyn and Bullock, 2008). The resulting liquidity squeeze caused more defaults and further rises in market credit risk premiums in a vicious cycle. Despite the Federal Reserve's massive efforts to intervene with needed cash, credit risk premiums rose to over 8% on a leading index of CDSs in late 2008 (Moses and Harrington, 2008). The London Inter-bank offering rate (LIBOR) spread above Treasury rates rose from under 1% in early September 2008 to 457 basis points on October 10, 2008 (Sabry and Okongwu, 2009).

With the credit crisis leading to a severe stock market decline and panicked public requests by government leaders for taxpayers to bail out the troubled financial institutions in the fall of 2008, consumer confidence fell precipitously. That factor along with the contraction of credit from the earlier loose standards as mortgage defaults rose caused a serious decline in consumer spending that has resulted in a recession. Because default rates rise in an economic contraction, the problem of having mispriced credit premiums on past debt contracts was magnified further. Large amounts of ARMs scheduled for rising payments after 2008 further negatively impacted consumer spending capacity. The result was further declines in consumer confidence and expenditures that magnified

[4] Callaghan and Murphy (1998) have shown that bankruptcy is typically caused by liquidity problems when external capital is typically not available. Callaghan, Murphy, and Parkash (2010) have demonstrated theoretically and empirically why external capital isn't available during a liquidity crisis for a company.

the economic contraction, and forecasts of a depression in turn exacerbated the credit crisis in a vicious cycle.

The drop in credit risk premiums from their incredibly high levels of the fall of 2008 implies that investors began to predict a lower probability of a depression unfolding in 2009 than they did in late 2008. While a financial meltdown was averted in both 2007 and 2008 by massive government liquidity injections and bailouts, the economy isn't expected to fully recover from the crisis for some time.

6. The Size of the Problem

Despite the enormous amount already spent by the federal government to bail out the financial markets, much more may be needed to save the system as it is. In particular, assuming the average debt for the approximately $60 trillion in CDSs outstanding merited a Ba credit rating (as may be generous for many guaranteed debts such as subprime mortgages), and assuming credit risk premiums being charged that equaled only 2/3 that of the expected default losses on those credits, data provided in Murphy (2000) indicate that the contracted underpricing was {{1/3}1.29%)=0.43% below a normal average default risk premium of 1.29% for debts of that quality. Given the widespread failure to require a systematic risk premium on debts, the cost of debt was underpriced by another .36x5%=1.80% in normal systematic risk premiums for a typical Ba debt with a beta of .36. The total credit risk premium was therefore too low by 0.43%+1.80%=2.23% per year. The result is a market value loss of .0223x60.0 trillion=$1.338 trillion per year, or over $6 trillion over the typical 5-year life of a CDS. Those huge market value losses exist even though initially the premium of 0.86% on the CDSs may have exceeded the typical abnormally low default losses on ARMs shortly after origination.

However, a large number of the CDSs were offsetting, and so the estimate of $6 trillion in excessive credit losses may be less if there were not counterparty risk to the CDSs. For instance, some financial institutions acted as dealers in CDSs, whereby they both insured and bought insurance on a particular debtor, making money on a small spread between the periodic insurance payment they receive and the premium they pay to another party. In addition, some investors such as hedge funds may have decided to take their profits (or cut their losses) on CDSs into which they had earlier entered by contracting with another party to take the other side of the contract at the new market price of insuring the risk.[5] In both those cases, the only risk of loss left would be counterparty risk (as long as the two offsetting contracts were identical, as was not always the case since contractual terms varied, such as with respect to payments in default that were set based on an estimated market value in some and dependent on delivery of defaulted securities in others). While the entire amount of the contract would be exposed in the case of a bankrupt insuring counterparty, mark-to-market collateral payments required in many swaps for the losing side (when the midpoint market price of each CDS changes) would even minimize this risk of loss associated with the counterparty of a profitable contract defaulting.

If the financial institutions to be rescued had net exposure on only half of the total $62 trillion of CDSs, the cost of bailing them out would be halved. However, it is quite likely that many of the financial institutions (including investment banks such as Bear Stearns) were merely selling the debt insurance as a means of generating premiums and recording income from off-balance-sheet contracts that were unregulated and lacked normal capital requirements. The only hedging for many

[5] While some hedge funds may have been involved in buying the CDS insurance as a reasonable bet (McDonald, 2009), many of those largely unregulated investors without any capital requirement whatsoever may have also taken highly leveraged positions in selling the CDS insurance in order to earn quick profits in the stable economic environment. Hedge funds may therefore have contributed to reducing CDS premiums and debt spreads. For hedge funds having sold large amounts of debt insurance through CDSs with inadequate capital to back them, such liquidity problems were sufficient to cause their demise, and those having bought the insurance may have taken losses when attempting to replace the defaulting CDS parties, thereby contributing to further liquidity problems among those surviving participants in the CDS market.

of these organizations might have been in the form of diversification across many borrowers that wouldn't be effective in reducing losses in a systematic downturn.

The purchase of CDSs on counterparties with which an investor had a large volume of contracts (such as a dealer in CDSs) could further lower counterparty risk. However, the purchase of such insurance from a third party (such as another dealer) might not be effective in a systematic failure of dealers and other financial institutions selling that insurance. In fact, buying CDSs on such institutions could even adversely affect any reduction in the size of the aggregate credit losses from netting in a systematic failure. For example, assume that a dealer X had $20 million on both sides of a CDS on a company ABC, for a total of $40 million in CDSs held by X that were theoretically offsetting. If the contracting buyer of CDS insurance on ABC purchased $20 million in CDSs on its counterparty X from another dealer Y, there would be $60 million in CDSs outstanding that could result in total losses of $40 million, including $20 million lost by X if both ABC and X's counterparty from whom it bought CDS insurance on ABC (in a separate CDS) defaulted, and $20 million lost by Y if X goes totally bankrupt (partly as a result of its own $20 million loss here). On the other hand, without the purchase of the $20 million in CDSs on X from Y, the total amount of CDSs outstanding would be $40 million, which could result in losses of $20 million (or only 50%) if the contracting seller of CDS insurance on ABC to X went bankrupt along with ABC.

While there may have been some hedging or offsetting contracts that would reduce the scope of the cost of a full bailout, it is unclear exactly how large an offset that would be. A process of "compression" that involves canceling offsetting positions was largely responsible for reducing the outstanding amount of CDSs to $28 trillion by 2009 (Zwick, 2009), and so future costs associated with those contracts might be expected to be $3 trillion cost in a typical economic environment.

However, those figures don't take into consideration the abnormally large default losses that periodically occur during recessions. In a protracted recession or depression, both default losses and market value losses may exceed even fair-value premiums charged.[6] With the financial crisis already having led to such a downturn, the losses on the CDSs will probably be even larger for the duration of that economic slowdown or subsequent contraction. That could easily raise the cost of a bailout by over $1 trillion per year of an economic slowdown. Since the very existence of the financial crisis may negatively affect the economy through reduced consumer spending (caused by the uncertainty), decreased lending (caused by rising credit risk and credit risk premiums), and rising business bankruptcies, such additional costs may be further magnified by a more severe and protracted recession.

In addition, it should be reemphasized that the bidding down of default and systematic risk premiums in the CDS market carried over into the loan and bond markets. A large number of the loans held by financial institutions might therefore have interest payments that don't provide sufficient compensation for the default risks on those assets as well. Losses on those investments could conceivably exceed the risk-reducing effects of any CDSs that were netted out with offsetting contracts. The total cost of the crisis could therefore exceed $10 trillion.

The actual form of the costs of the bailout will vary with the various methods employed. These include payoffs on the debts that are guaranteed by the government (such as those of rescued bankrupt firms and mortgages in default), losses resulting from buying up assets privately or in the markets (such as mortgage-backed securities), and losses on financing provided to bankrupt firms to keep them afloat (that provide inadequate returns to the government in comparison to those available on other assets of similar risk).

While the bailout of the financial system in 2008-2009 appears to have stabilized the economy, $17.5 trillion in new government liabilities resulting from the bailout remain at risk. Although the

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[6] Data provided by Murphy (2000) indicate that typical systematic risk premiums would cover default losses on average in past volatile times which include a 10-year depression every 4 decades, but actual default losses may exceed that by a factor of two in the years of an actual protracted recession or depression.

government may never have to pay on many of these potential liabilities like guarantees, more bailouts may be required to prevent a future total collapse of the financial system. The result may be somewhat similar to the decades of economic stagnation, as Japan has suffered for the last few decades following the popping of its own real estate bubble in the early 1990s that continues to require massive government deficits to keep that country's economy moving forward. The fact that excessive risk-taking behavior in the U.S. returned soon after the crisis (Jacobs, 2009), and that the U.S. regulatory framework hasn't been changed materially implies that another, deeper financial crisis is very possible.

7. Conclusion

By explaining the institutional factors involved in the mispricing of CDSs, it is possible to better understand the causes of the recent financial crisis. That analysis also enables an estimation of the costs of resolving the calamity utilizing current policies of bailing out investors who made poor investment decisions.

In any event, it would seem imperative that the financial managers of the future be better educated in the art of credit analysis. In particular, given that "comparisons between price and value is what much of finance is about", and given that human psychology and sentiment risk are important determinants of market prices (De Bondt, 2008), the enormous deviations between price and value that occurred in the most recent crisis hopefully will prompt financial experts to reconsider purely mathematical models of value that ignore subjective forecasts and the human element in general.

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