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Structured Finance and Its Effects on Macroeconomic Stability

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STRUCTURED FINANCE AND ITS EFFECTS ON MACROECONOMIC
STABILITY

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A Thesis

Presented to

The Faculty of Social Sciences

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Masters of Arts

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by

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Title: Structured Finance and Its Effects on Macroeconomic Stability
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Abstract

The tools and techniques of structured finance have changed banking remarkably over the past twenty years. This area grew to become larger than the sum total of traditional banking deposits in 2007. Despite this, the field is poorly understood and its connection to macroeconomic stability was underestimated until the credit crisis. This paper explores the structured finance market in three phases. First, the market is broken into parts based on the incentives and motivations of each of the three major agents in the field. Next, a critical review of pricing models that are used to justify the valuations of the products of structured finance is discussed using actual market data. Finally, the connection between structured finance and the real economy is explored. It is the conclusion of this paper that structured finance can increase economic efficiency, but thus far the risks that its employment create are greater than their benefit.

Acknowledgements

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CHAPTER ONE: INTRODUCTION TO STRUCTURED FINANCE

The banking sector has changed remarkably over the past thirty years through a combination of financial innovation and deregulation. Within these changes, the rise of structured finance and a growing reliance on the originate-and-distribute banking model has blurred the line between bank and non-bank entities offering credit services. Many new financial products have been developed to meet the constraints of both borrowers and lenders. Under the best assumptions, these products and non-bank entities allow for an increased supply of credit while mitigating the associated risk among various private market entities.

The effects of structured finance on traditional banking and finance are stark. Under the new regulatory regime banking and investing activities can be combined, loans are easily sold to investors in the form of securities, market risk is shared by an increasing number of participants and barriers to entry and market constraints have been removed by deregulation. These changes have allowed the financial sector to account for forty percent of U.S. corporate profits as recently as 2005, up from approximately fifteen percent in 1985. The value added by the industry has remained largely flat during this period, at between fifteen and twenty percent during the twenty year period (Nersisyan, Wray 2010). This large increase in profitability accompanied by little corresponding increase in value added suggests that the revenue generating activities of the financial sector have undergone a fundamental change.

A strong financial sector is crucial to the health and stability of an advanced capitalist economy. However, banking is an inherently fragile activity; this dichotomy requires public sector involvement to lessen the economic impact of banking sector fluctuations. To stabilize the banking sector the Federal Reserve was created to act as a lender of last resort and later the Federal Deposit Insurance Corporation (FDIC) was created to further stabilize the industry and protect it from deposit runs through explicit account guarantees and regulatory oversight.

Structured finance and deregulation have allowed activities that were traditionally conducted by banks falling under the protective umbrella of the Federal Reserve and FDIC insurance to be conducted by any business unit willing and able to enter the market with, but more often without, FDIC protection and access to the Fed discount window. These new units participate in the process of creating products that are protected by various private-market insurance and liquidity guarantees, and in many cases, AAA credit ratings. The implied stability offered by the private market insurance and guarantees allowed the market for structured financial products to grow extremely quickly. The Federal Reserve estimated that the size of all market participants of the structured finance system to be a gross size of nearly $20 trillion in March 2008, which is larger than the traditional banking system. However, the effects of the credit crisis have brought this total down to $16 trillion as of the first quarter of 2010 (Pozsar, et al. 2010).

Despite its incredible size, the system of market participants engaging in the activities of structured finance is poorly understood. Units can be created to specialize in any one of the many aspects of structured finance or several related aspects. Further, the products of structured finance are constantly evolving. The complicated nature of the

market forces some investors to rely exclusively on ratings agencies to guide their portfolio decisions. Other investors may unknowingly participate in the wholesale funding of the structured finance market through the use of money market funds. Participation in this market is often based on assumptions that fail to account for the full level of risk that the investor is bearing. The consequences of the structured finance market's size and impact on economic stability are still largely under debate.

The goal of this paper is three fold. First, it will endeavor to explain the complex market of structured finance and how it is used in what has been dubbed shadow banking. Second, it will explore the difficulties this market has experienced when pricing structured products in light of the stresses of the 2007 credit crisis. Finally, the paper will explore the consequences of structured finance on macroeconomic stability.

The Structured Finance Market

The structured finance market is directed by agents that have been dubbed shadow banks, a term coined by Paul McCulley of Pacific Investment Management Company in 2007. Shadow banks are defined as financial intermediaries that conduct maturity, credit and liquidity transformations without access to central bank liquidity or public sector credit guarantees (Pozsar et al. 2010). According to the Banks of International Settlements, structured finance has three defining characteristics: "(1) pooling of assets (either cash of synthetically created); (2) tranching of liabilities that are backed by the asset pool (this property differentiates structured finance from traditional pass-through securitizations); (3) de-linking of the credit risk of the collateral asset pool from the credit

risk of the originator usually through use of a finite-lived stand alone special purpose vehicle" (Bank of International Settlements, 2005:1).

The shadow banking sector uses structured finance to create highly liquid securities that can be sold in part or entirely to investors. The most common type of security in structured finance is the Collateralized Debt Obligation (CDO). The underlying assets of a CDO can be any type of debt, from consumer loans to commercial mortgages to corporate bonds. There are several types of CDO, but the differentiating aspects are the motivation behind their creation. The main motivations in the creation of CDOs are: balance sheet management, credit risk management and cash flow arbitrage. The general types of CDO are cash and synthetic. With cash CDOs, the investor buys a cash flow based on the underlying asset pool. A synthetic CDO requires the investor to insure the counterparty against capital losses in the form of a Credit Default Swap (CDS).

Typically, all forms of CDO use an entity referred to as a Special Purpose Vehicle (SPV) or Special Investment Vehicle (SIV) to facilitate operations and assume credit risk. Cash and arbitrage CDOs use an SIV to assume ownership of the asset pool in order to free the issuing firm from the legal responsibility of default. With synthetic CDOs, SPVs are used to facilitate operations by directing payments from counterparties as well as buying and holding risk-free collateral such as US Treasuries. They are not, however, used to assume ownership of the asset pool.

Selling interests of an underlying pool of assets to investors does not necessarily create a CDO. If cash flows are passed from the investment pool pro-rata to investors the assets is known as a pass-though security. Tranching of cash flows is needed to create a structured finance security. Tranching deals with how the cash flows from the underlying

asset are 'sliced' to meet the requirements of each level of the debt structure of the CDO, from the senior down to equity levels. These tranches can be developed to meet nearly any requirement, but are most concerned with meeting those of ratings agencies, as investor rely heavily on their guidance.

Typically with cash CDOs, cash flows 'waterfall' from the senior tranches to the subordinated. The senior tranches fully receive their payments before the subordinated (mezzanine, junior and equity) levels are paid. Cash flow is not assigned from a specific loan to a specific security or tranche. Rather, loan payments are pooled and then assigned based on seniority. If the amount of the cash flow from the collateralized loans is less than required to fully make payments to each tranche, the equity and then junior tranches will assume the losses in reverse order of their position in the debt structure. Each level will fully default before the next higher tiered tranche absorbs any losses. By using such a framework, structured finance can create AAA-rated securities from a pool of high credit risk assets, ranging in source from student loans to auto loans or credit card receivables.

With traditional CDOs, each and every level of debt, from senior to equity can be sold to investors, with perhaps only a small junior equity position remaining with the issuing entity to absorb expected losses. One slightly different type of CDO is referred to as an arbitrage CDO. Here the CDO sells senior tranches to fund operations and retains the greatest percentage possible as equity. The arbitrage CDO earns the difference between the total cash flow and the cost of maintaining the senior tranches. The underlying pool of assets can remain stable or be managed, but must remain within the credit constraints of the original rating. These cash flow arbitrage CDOs typically pay each tranche a floating rate of interest based on either LIBOR or Treasuries (Fabozzi,

Davis, Choudhry 2006). Again, with this type of CDO the equity tranches absorb losses before the senior tranches.

It should be noted that junior tranches of multiple CDOs can be combined to create new senior AAA rated tranches that can also be securitized and sold to investors. The rational for this type of security is the same, if many assets are pooled together, the resulting cash flow can be structured in such a way that the likelihood of default for the senior tranches is thought to be very small. This type of security is referred to a CDO squared, but it is possible to repeat the process again and again, creating CDO cubed and so forth.

The same techniques can also be used to create tranches with specific maturity dates that differ from the underlying assets. With any amortizing loan a portion of the payment is interest and a portion is principal. The principal portion of the loans and any prepayments made by borrowers can be channeled into senior tranches rather than distributed pro-rata in order to bring forward the maturity date of a senior tranche. This process ensures that the junior tranches have a longer maturity date then the senior tranches, an important aspect because it means that the junior tranches will mature more slowly than the senior tranches and will therefore be in existence to absorb any losses than might occur, shielding the senior tranches.

There are additional ways the credit quality of the underlying pool can be enhanced. First, the issuer can buy insurance in the form of a credit default swap (CDS), which is a type of credit derivative. Here the buyer agrees to pay the insurer a set fee in exchange for the seller to guarantee a payout of par value in the event of a credit event, which is defined differently in different contracts. Another common credit enhancement

is over-collateralization. This method requires the pooled assets to be greater than the total amount of securities sold from that pool. For example, if the pool holds 100 million worth of assets, only perhaps 90 million of securities will be sold to investors and the pool will hold the junior tranches. Cash flows that exceed the requirements for the securitized tranches can be used to purchase additional assets, or held as cash as a type of self-insurance. One last technique is a buy-back guarantee made by the issuer. In the event of default, the issuer agrees to buy the security from the investor at par value.

Transforming the credit quality and duration of the assets increases the overall liquidity of the securities. A pool of consumer or private issue mortgage loans or credit card receivables is not readily sold to investors without the benefits of securitization. The techniques and credit enhancements of securitization deal with many of the reservations that buyers of such securities typically hold, providing a viable alternative to other portfolio options such as bonds. With structured finance, the senior tranches are thought to have a much higher credit quality than the underlying assets, which allows credit rating agencies to award higher ratings than that of the average loan in the pool. This allows for the creation of AAA-rated securities from even the most lowly rated individual loans.

The market for rated AAA securities is very liquid. According to Fitch, 60% of all global structured products were AAA rated (Fitch 2007). This contrasts sharply with corporate bond issues. Only one percent of corporate bond issues earn a AAA credit rating (Coval, Jurek, Stafford Working paper). Further, CDOs are typically composed of thousands of individual loans from diverse sources, which theoretically allows for diversification with one purchase. When combined with various credit enhancement

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guarantees, structured securities offer an appealing option for investors in search of

additional yield over other AAA securities such as government debt.

Figure 1: AAA and BBB Credit Spreads 2002-2009
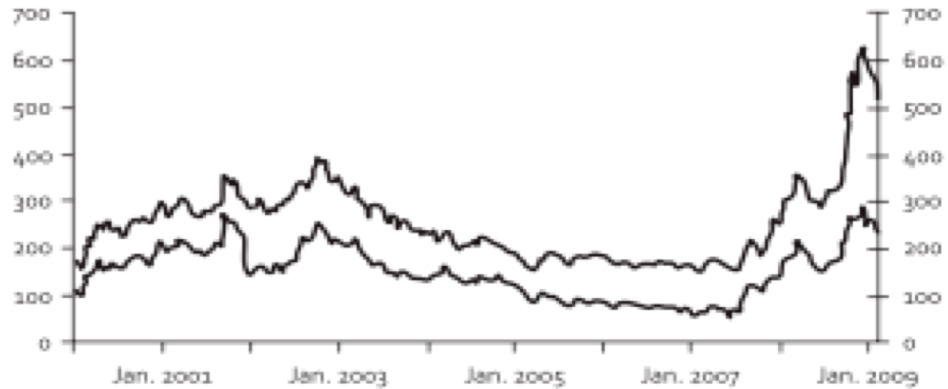
Vertical axis: Basis points.
Top Line: Spread between yield on Baa-rated corporate bonds and 10-year
        Treasury bonds.
Bottom Line: Spread between yield on Aaa-rated corporate bonds and 10-year
        Treasury bonds.
Source: Reuters Ecowin.

Figure 2: ABS Issuance 2001-2009
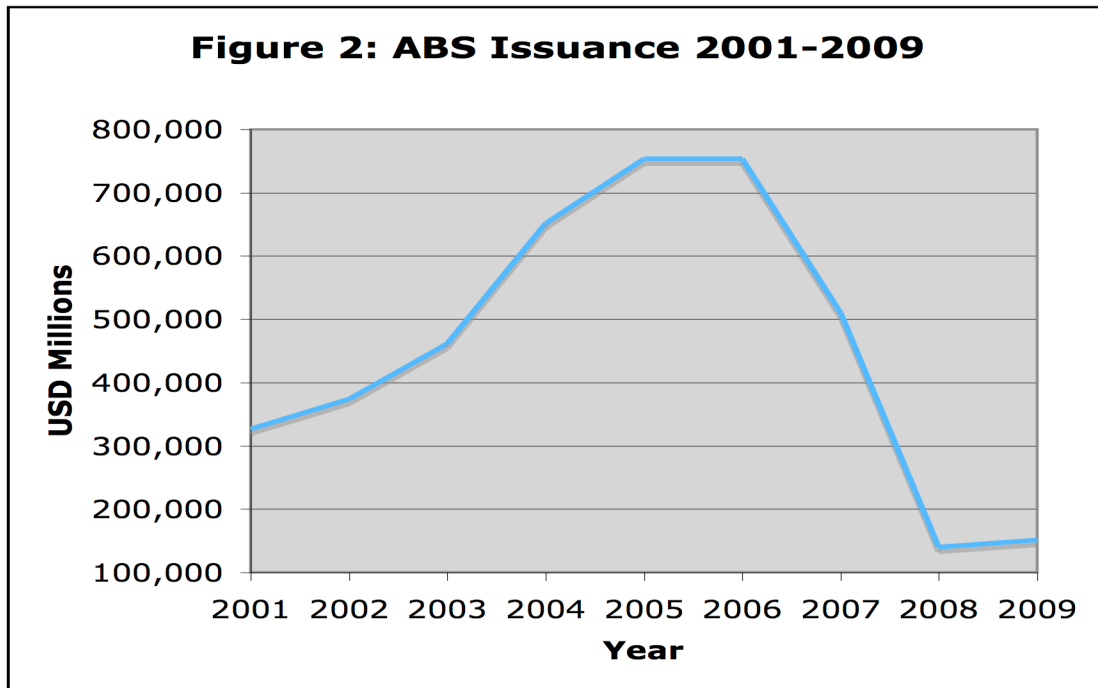
Source: SIFMA Research and Statistics http://www.sifma.org/research/research.aspx?ID=10806

Figures 1 and 2 give context to the above argument. The strong growth of the securitized asset markets was not possible until 1999, with the repeal of the Glass-Steagall Act of 1932. This act prevented traditional deposit holding banks from being active in the securities markets. This regulatory development coincided with loose monetary policy from the Federal Reserve for an extended period, which in turn caused some investors to search for yield in highly rated securities other than government bonds. Figure 1 shows spread (difference in yield) between AAA and BBB securities over ten year Treasury bonds. The declining spreads between 2003 and 2007 indicates that investors believed that risk between government bonds and AAA and BBB securities was becoming less and less of a concern. Clearly, that belief was snapped by late 2007, but that is a topic for later in the paper. The important aspect at this point is that marketability of AAA and BBB bonds was steadily increasing in the period between 2003-2007. This tightening in spreads occurred as the issuance of Asset Backed Securities (ABS) doubled 2001 to 2006, going from 326,205 million to 753,875 million USD (SIFMA Statistics, 2010). This suggests that the market for ABS, which is a general term for various types of CDOs, was robust. This was made clear by the market as narrowing of credit spreads coincided with dramatic increases in supply.

Further expanding the market for structured securities was the desire to conduct regulatory arbitrage. Under rules developed by the Bank of International Settlements, commonly known as Basel I and II, banks are required to adjust their capital levels to match the risk level of their assets. [1] For example, assume the minimum capital requirement is eight percent. For an asset with a 100% capital charge, a retail loan for

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[1] Basel III is forthcoming

example, eight dollars for every hundred dollars of principal of the loan must be set aside to meet regulatory requirements. This is to ensure that the bank can absorb any potential defaults, which serves to give confidence to the market. This capital charge lowers the return on equity for the bank, so the bank's managers have an economic incentive to minimize this constraint. Cash CDOs do not have a capital charge according to current Basel rules, so by selling one hundred million dollars of retail loans to a SIV for securitization, the banks would gain the use of 800,000 of equity for more profitable uses. The use of CDOs effectively increases the size of a bank's equity by removing assets while providing it with increased profitability for reasons given above. Normally, to increase equity banks would be required to build retained earnings or to enter the capital markets by issuing bonds or equities. Structured finance provides an alternative to these constraints and allows firms and banks to focus their resources in the area(s) in which they are most competitive.

Banks interested in capital relief might be forced to use a slightly different type of CDO commonly referred to a synthetic CDO. This type of security allows for the bank or financial entity to retain ownership of the pool of assets, typically for legal reasons, but also to attain capital relief through the use of CDS and credit linked notes. A SPV is used to manage the flow of funds from the seller of the CDS and the buyer. The interesting aspect of this type of security is malleability. If a counterparty of sufficient credit quality for the CDS can be found, the seller will not be required to post collateral, and will receive income exceeding that of the insured assets, due the increased level of risk the they are accepting. This type of transaction is referred to as an unfunded CDS, since no collateral is posted; it is general only undertaken with OECD banks. This type of

transaction is commonly referred to as being super senior, because in the debt structure it sits above the AAA rated senior tranche. Therefore, the perceived risk for this tranche is considered to be small, as it is viewed as being highly unlikely that all the lower tranches would completely default. If the credit risk of the counterparty is suspect, the buyer might require collateral, typically held as Treasuries by the SPV. This is referred to as a funded CDS, since the SPV holds collateral that will be passed to the buyer should a credit event occur. Note that the buying entity does not receive the collateral unless a credit event occurs. Similar to a bond, the seller of the CDS receives the principal at the end of the period if no event occurs. Typical sellers of this type of CDS are mortgage insurers, mono-line insurers, diversified insurance companies, credit derivative product companies, and credit hedge funds (Pozsar, et al. 2010). Similar to the super senior tranche, the seller receives periodic payments in excess of the interest on the underlying security. If a counterparty for a CDS can not be found, the issuing bank might choose to use a credit-linked note. These instruments operate similar to a traditional bond, making coupon payments. However, any credit events in the underlying pool of assets will cause the credit-linked note to lose principal to the extent of the losses. This principal is transferred by the SPV to the buyer of the insurance. Assuming there are no credit events, the SPV holds the principal amount for the life of the security, typically in some risk-free form.

It is possible for a bank to use all three methods within one SPV, depending on the market. The mechanism for dealing with defaults is structured in a similar manner to that of a traditional cash CDO, where the losses will be absorbed in reverse order of their position in the debt structure, with the equity tranche initially absorbing the value of any

defaults within the pool until it is exhausted. If that occurs, the junior tranches would be

forced to absorb losses, and so on up the debt structure. The lower the tranche's position

in the structure the greater the possibility of a credit event requiring payment to the buyer

of the CDS. For this reason, lower quality tranches are typically funded by either credit-

linked notes or funded CDS. Due to their increased risk, these positions require additional

incentive to be bought in the market; typically adding a floating payment based on

LIBOR or Treasuries provides such an incentive.

The benefits to the bank in using such securities come in terms of balance sheet

management and regulatory capital relief. Corporate loans hold a one hundred percent

risk weighted capital charge under Basel rules (Fabozzi, et al. 2006). In contrast, the

super senior tranche requires a twenty percent risk weighted capital charge and funded

CDS do not hold a capital charge. While the regulatory capital relief is not as great as

with cash CDOs, the assets pooled in synthetic CDOs are typically not appropriate for

such securities. Of course, this regulatory relief is due to the fact that credit risk from the

pooled assets is transferred to the counterparty, which is the main benefit of synthetic

CDOs.

The benefits to being a counterparty with a synthetic CDO are compelling for

some investors. First, they receive the interest payments from the underlying securities

plus a floating payment based on LIBOR that corresponds to their place in the debt

structure, with the lower tranches earning a greater amount. The super senior tranche,

which typically accounts for ninety percent of the ABS CDO's structure, earns only

slightly more than LIBOR (perhaps 15 bps). The reason for this is that super senior

tranche sits above the senior tranche, which is always rated AAA. The possibility of the

super senior tranche being required to pay the counterparty could only happen after the AAA tranche was exhausted, which is theorized to be very unlikely (Fabozzi, et al. 2006). Selling a CDS in such a transaction should allow the investor greater gains than by buying assets from the pool outright, since they are receiving the interest payment from the security, plus the CDS payment from the buyer. Any losses they would be required to bear as counterparty would be the same as if they owned the securities of the pool outright. The key difference between the two being the counterparty will demand payment after a credit event, which is contractually designed to cover a greater range of possibilities than actual default. Therefore, the counterparty holds more credit risk.

The credit enhancements of the structured finance market used in cash and synthetic CDOs are designed to transfer credit risk and to provide protections similar to that of the traditional banking sector, such as the liquidity of the Federal Reserves discount window and the insurance and oversight provided by the FDIC. It is believed that the market for securitized instruments and derivatives will be efficient in their pricing of assets and risk. It is also believed that the associated credit enhancements will be honored, which allows for private enterprise to fill the role of lender of last resort. Judging by the size of the structured finance market, it appears that many market participants strongly believed in the private market's ability to provide liquidity and the credit puts of credit enhancement. The rapid growth in the securitization market, followed by the loss in confidence in these private market guarantees that occurred during the credit crisis of 2007 underscores their importance, but also their vulnerability.

There are many benefits for firms and banks to use structured finance to securitize assets. This process serves to speed earnings by allowing firms and banks to book future

cash flows, it allows for the risk of default to be passed to investors and for firms and banks to better manage their balance sheets in order to focus their attention and capital on their most profitable activities. Borrowers, it is argued, gain access to credit at a lower cost. One study suggested that the size of the secondary market for mortgages, a testing ground for many structured products and techniques, has lowed mortgages rates by 100 basis points (Obay, 2000). Given these perceived benefits and the accommodating regulatory atmosphere since the 1980s, it should not be surprising that so much innovation has occurred within the structured finance arena.

Shadow Banking

The previous section outlined the basics of the structured market securities. This section will discuss the mechanisms of how these securities are created. These mechanisms are used by three subs-groups within the shadow banking sector, they are: government sponsored enterprises, financial holding companies and diversified broker dealers. Each operates with differing competitive advantages and constraints and therefore approaches the process of manufacturing securities in a slightly different manner, often incorporating subsidiaries. However, the general steps required to create structured securities are same for each subgroup.

The activities of shadow banking can be broken down into seven basic steps. Depending on the quality of the underlying asset pool, the process may be longer, as lower credit quality assets require multiple passes through the system before they are of sufficient quality be sold to investors. Exhibit one shows the different steps required to complete the basic process, as well as the possibilities of how each step can be funded.

One of the characteristics of shadow banking is the lack of traditional funding sources, such as customer deposits. Shadow banks use various sources from the private credit market to finance their activities. These sources include Commercial Paper (CP) Medium Term Notes (MTN) bonds, Asset Backed Commercial Paper (ABCP), and Repurchase Agreements (Repo).

From exhibit 1 it should be clear that the shadow banking system relies heavily on market-based funding. This type of funding approach means that participants have the opportunity to select the funding source or sources that best fits their needs. This freedom should allow for a lower cost of funds and more diversified funding sources, as each entity has an incentive to find any pricing inefficiencies that might develop in the yield curve. However, this freedom also means that the shadow banking market is very dependent on liquidity. A short-term freezing of any funding aspect can have very negative consequences, especially given that many of the assets in the system are difficult to price and only gain access to liquid markets after then have passed through the system.

One area of specific consequence is Step 7, where wholesale funding comes from various money market entities. These funds buy structured finance products or provide credit to the entities that manufacture such products. These sources operate in a similar fashion to a bank; they take in short-term liabilities and use those proceeds to fund and maintain long-term assets. Similar to a bank, investors have perceived stable dollar deposits that earn interest and are available on demand. However, unlike a bank, these entities lack access to the Fed discount window and they are not subject to FDIC oversight or insurance. It is possible that these funds, which are available on demand, are used to fund low credit quality long-term assets, such as sub-prime mortgages. This

possibility serves to increase the potential for pricing volatility (Pozsar, et al. 2010).

These differences expose money market entities to market risk that normal bank deposits

do not, but they are treated in a similar fashion by investors. These funds have grown into

a very important supplier of capital for the shadow banks process.

Exhibit 1: The Steps, Entities and Funding Techniques Involved in Shadow Credit Intermediation - Illustrative Examples
Function Shadow Banks Shadow Banks' Funding*
Step (1) Loan Origination Finance companies CP, MTNs, bonds
Step (2) Loan Warehousing Single and multi-seller conduits ABCP
Step (3) ABS Issuance SPVs, structured by broker-dealers ABS
Step (4) ABS Warehousing Hybrid, TRS/repo conduits, broker-dealers' trading books ABCP, repo
Step (5) ABS CDO Issuance SPVs, structured by broker-dealers ABS CDOs, CDO-squareds
Step (6) ABS Intermediation LPFCs, SIVs, securities arbitrage conduits, credit hedge funds ABCP, MTN, repo
Step (7) Wholesale Funding 2(a)-7 MMMFs, enhanced cash funds, securities lenders, etc. $1 NAV shares (shadow bank "deposits")
*Funding types highlighted in red denote securitized funding techniques. Securitized funding techniques are *not* synonymous with secured funding.
Source: Shadow Banking (Pozsar, Adrian, Ashcraft, Boesky (2010)

Entities of various sizes may participate in any one of the above steps, but rarely

participate in each and every step. Some of these entities are partners with larger

institutions, such as commercial or investment banks and broker dealers while others

exist independently. The existence of shadow bank intermediaries operating under the

ownership of traditional banks became possible only after the "abolishment of the Glass-

Steagall Act of 1932, and codified by the Gramm-Leach-Bliley Act of 1999" (Pozsar, et

al. 2010:24). Before Glass-Steagall was repealed, financial entities performing various

aspects of the shadow banking process operated individually in segmented markets, but

today many have been purchased by larger banks looking to access lucrative specialized markets (Pozsar, et al. 2010).

The above chart highlights the complicated nature of manufacturing structured finance securities, as well as the number of funding variables within each step. Bringing a CDO to market requires a host of entities working together. The stage of production that requires the most time and funding is the warehousing of assets. This is due to the diverse requirements of CDOs, which are composed of thousands of individual loans of various credit qualities and regional issuance. These individual loans can be combined in a way that creates a maximum amount of sellable securities in the form of CDOs or simply held as Asset Backed Securities (ABS). As in noted in step six, another option would be to move the ABS to an entity specializing in credit arbitrage.

Many claim that the structured finance market was pioneered by the US Government through the "creation of government sponsored enterprises (GSE) which are comprised of the Federal Home Loan Banks, (FHLB) system (1932), Fannie Mae (1938) and Freddie Mac (1970)" (Pozsar, et al. 2010:20). In this particular sub-system of shadow banking, commercial banks originate mortgages and sell them to the FHLB who warehouse the loans. Fannie Mae and Freddie Mac then issue ABS from those warehoused loans. Note that ABS from GSE are most similar to pass-though securities, they do not have the characteristics of CDOs in terms of how the cash flows from the borrower are distributed to the investor. However, these ABSs can be combined to form CDOs as described above in order to change the maturity of tranches of the collateralized pool, which in turn transforms and increases liquidity. These assets operated under the implicit guarantee of the US Government, which became explicit during the financial

crisis of 2007-2008. This relationship with the US government provides credit risk transformation, but before the events of 2008, without actual access to the mechanisms that provide stability in the traditional banking sector.

This sub-system differs from other areas of the shadow banking system. First, the originating banks are traditional banks with client deposits to fund operations; the GSE steps in only to provide liquidity to those banks wanting to sell their mortgages. For those banks, the economic incentive is to write the mortgage, earn a fee from those services, and then sell the mortgage in order to free capital and repeat the process. The GSE undertakes the market-based funding operations such as selling short-term debt to fund warehousing as well as manufacturing securities to sell to investors. As the originate-and-distribute model pioneered by GSEs was shown to be successful, emulation came from the private sector, which then adapted these basic techniques to a variety of specialized markets.

After the development of the originate-and-distribute model was perfected, private market non-bank entities moved to provide credit to areas that were underserved by traditional banking. These entities proved to be highly profitable, which became an argument for deregulation, as these entities grew to the point that they often provided a more competitive alternative to traditional banking due to their business model and freedom from banking regulations. For example, in 1989 GMAC was able to secure funding using such entities for 130 basis points below the cost of traditional lending (Obay 2000). After deregulation many of these entities became subsidiaries of Financial Holding Companies (FHC).

In many ways, this provides a good manner in which to view modern banking. The traditional banking model generally consists of originating a loan and holding it until maturity. Traditional banks use customer deposits to fund the maturity mismatch between assets and liabilities and work within the constraints of a balance sheet. This has been replaced by a market-based, originate and distribute model where balance sheet risk is held at arms-length as much as possible and securitization greatly expands balance sheet constraints, in part by using several bank subsidiaries. According to Pozsar, Adrian, Ashcraft and Boesky, modern banking might take this form:

> "(1) Originate loans in its bank subsidiary, (2) warehouse and accumulate loans in an off-balance sheet conduit that is managed by its broker dealer subsidiary, is funded through wholesale funding markets, and its liquidity-enhanced by the bank, (3) securitize loans via its broker-dealer subsidiary by transferring them from the conduit in a bankruptcy-remote SPV, and (4) fund the safest tranches of the structured credit assets in an off-balance sheet ABS intermediary that was managed by the asset management subsidiary of the holding company, which is funded through wholesale funding markets and is backstopped by the bank. (2010 p.28)."

This is one example of how a Financial Holding Company (FHC), such as Citigroup or Bank of America among many, might manage its operations. Such a system is not the only possible way to use structured finance to facilitate balance sheet management using the shadow banking system. Another option would be the use of a synthetic CDO, which would be used for assets that can not be sold directly to investors. In the above quote, note that the original loan is moved through four different entities, each of which intends to sell the asset to the next entity in the chain until it reaches its final destination, either an investor or a an asset management arm of the FHC. The only time the FHC takes direct ownership of the loan is when it is originated, and even that is done with the expectation of selling the asset onwards. After the asset leaves the balance sheet of the

originating bank no longer has access to the backstops of traditional banking such as the Federal Reserve discount window and FDIC oversight and insurance. After that point, the owning entity of the asset is reliant on market-based funding and credit enhancement, though FHC subsidiaries do benefit from the sponsoring bank's access to short-term capital markets in the form of CP and ABCP. This is access that often smaller financial entities do not have. By moving the asset through a complex interdependent system the FHC is able to manufacture assets that largely fall outside of regulatory oversight. The process of securitization also allows for the transformation of the credit rating of the underlying asset, further mitigating the impact of regulation, as higher rated assets ensure a small risk-adjusted capital charge. The process outlined above creates a system that is dependent on each step of the securitization process, rather than a diverse system of independent entities operating under the management of a FHC, as is commonly thought.

Many sources, particularly textbooks, suggest that the securitization process ends with all but the lowest equity tranches of the CDOs being sold to investors. According to more recent research, Pozsar, Adrian, Ashcraft, Boesky (2010), Franke, Krahnen (2009), Juliusz, Mateusz (2009), AAA-rated tranches were often maintained by the originating entity, while the lower rated tranches were sold onwards to investors. These assets are deemed to be very safe by regulators and accordingly have a low capital charge of 20 percent. This creation of high quality capital allows the bank to expand its lending operations. Normally to expand a bank would be required to increase equity either through earnings from operations or through capital market funding. By using the securitization process banks can create AAA-rated equity from low-rated assets, while earning fees allow the way.

This capital creation process is in contrast to selling bonds or equities in the capital market, which is a costly process and can potentially hold negative connotations for the bank's financial health. Also, since the FHC can grow faster than retained earnings, the financial sector can grow faster than the overall economy. This is due to the idea that financial sector earnings should represent a fraction of overall economic growth. Without securitization, FHC are constrained by either market sentiment concerning their debt load or constrained by their level of retained earnings, which are likely to expand in correlation with overall economic growth. By lifting these constraints, financial sector growth is only limited by the marketability of structured assets. Therefore, securitization creates an incentive to push further in to more marginal lending, an idea that will be explored later.

The third major component of the shadow banking is Diversified Broker Dealers (DBD). These groups use the same processes that are used by FHC, but they are not limited by the same capital and regulatory requirements as FHC. DBDs differ from FHC in the fact that they lack direct access to the loan originating process. However, DBD are allowed to own Industrial Loan Companies (ILC) and Federal Savings Banks (FSB) as subsidiaries, which are used to originate loans in a similar fashion to how FHC operates, though ILC and FSB lack the ability to access short-term capital markets that fund the warehousing of loans. DBD rely on other entities to provide this service, such as FHCs and entities that specialized directly in this aspect (Pozsar, et al. 2010).

Another significant difference between FHCs and DBDs is that DBDs use internal funding sources such as credit hedge funds and their own trading books as markets for securitized assets. FHC tend to use bankruptcy remote SPV which effectively remove the

assets from the FHC's balance sheet. Using internal sources of funding might be more profitable for DBD, as such a method more closely aligns with their area of specialization, but it also requires that DBD rely on a smaller range of funding mechanisms, mainly repo conduits, which are contingent on the health of the trading book, rather than the greater credit market.

Due to limited access to the loan origination market, DBDs tend to focus on the mortgage market, especially non-conforming and subprime mortgages. These areas have been avoided to some extent by GSE and FHC, which tend to hold competitive advantages over DBD in other areas of the ABS market. FHCs have more penetration in the loan origination market and therefore are active in securitizing other ABS, such as credit card receivables, student loans and small business administration loans as well as mortgages (Pozsar, et al. 2010). Similar to FHC, the DBD model only has access to the Federal Reserve discount window and FDIC protection and oversight at loan origination. All other steps needed to manufacture securities lack access to lender of last resort support. Further, the DBD model requires partnerships with non-subsidiary financial entities to complete the process, exposing DBD to greater counterparty risk. Lastly, DBD leverage their trading books through the use of repo agreements to fund the last steps needed to create and warehouse CDOs, rather than other market based funding options such as ABCP. Repo agreements are generally one day (overnight), which expose DBD to extreme liquidity risk.

While FHC and DBD use the same processes to manufacture securities, they fund their operations in very different manners. FHC use the ABCP market to fund loan warehousing because they have the ability to offer the credit enhancements needed to

make ABCP marketable. DBD lack the size needed to accomplish this, and so they are reliant on counterparties to access ABCP funding. DBD also rely on repo agreements to fund the warehousing of CDOs. While both FHC and DBD need market funding to support their operations, DBD are reliant on a more complicated daisy chain of intermediaries, which limits their access to capital markets to some extent. FHC are able to bypass this counterparty risk both through the use of subsidiaries (Pozsar, et al. 2010).

Another aspect of the shadow banking system is the wholesale funding provided by money markets. The term 'money markets' is somewhat of a catch all term by the Federal Reserve to incorporate traditional money market funds, cash plus funds, enhanced cash funds, ultra-short bond funds and overnight sweep accounts (Pozsar, et al. 2010). The market for these funds has grown with size of the securitization market. These funds provide entities within the shadowing banking sector with access to capital in a similar manner to deposits with a bank, but without the associated regulatory requirements. Many investors treat money market investments as they would deposits at an FDIC insured bank, yet there does not exist a similar backstop for those funds. In fact, money market funds are supporting the efforts of FHC and DBD to avoid the regulatory requirements of the FDIC.

These money market funds support much more than just shadow banking entities, they are also active in Treasuries and municipal bond markets, as well as the short-term cash needs of corporate borrowers. Because of this, the market is broken into three parts, (1) regulated (2) unregulated (3) direct money market investors. Direct investors are large enough to invest into money markets without the use of an intermediary. Examples of this type are corporations and governments. Regulated refers to 2(a)-7 Markets Mutual

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Funds (MMMF). Unregulated refers to sweep accounts, cash plus, enhanced cash funds and ultra-short bonds portfolios (Pozsar, et al. 2010).

The difference between regulated and unregulated funds is mainly duration and risk. Enhanced cash and sweep accounts are unregulated funds at the far end of the spectrum, offering no credit risk or duration risk. Regulated funds offer little duration risk, but do expose investors to credit risk. These funds can invest in a range of short-term debt, from government to prime borrowers. The average duration of these investments ranged from 50 days for prime borrowers to 20 for Treasury debt. Unfortunately, exact data on the size of the market for prime borrowers is not available, but the size of the aggregate market is stunning. At the end of the second quarter 2007, regulated markets had $2.5 trillion under management, unregulated held $1.5 trillion and direct money market investors accounted for $3 trillion, for a total sum of $7 trillion dollars. The sum of all checkable deposits, savings deposits and time deposits in the US banks on the same date was $6.2 trillion (Pozsar, et al. 2010).

Manufacturing rated securities is a credit-intensive process, with each step requiring some level of market-based funding. These funds enable the securitization market to exist in the scale that it did before the credit crisis. In essence these money markets provide funding support for each and every step of the securitization process, from warehousing subprime mortgages and auto loans, to funding arbitrage CDOs. However, this market is based on confidence in private market guarantees and the credit qualities of underlying assets. Given this reliance, the possibility of credit runs should not come as a surprise.

Section one reviewed the securities of structured finance and how various sub sectors of the shadow banking system create those securities. In general, CDOs serve to enable the sponsoring entity to efficiently manage their balance sheet by transferring risk, while the shadow banking system creates a market for their products by providing the necessary capital to create securities, as well as the private market guarantees that are needed to inspire confidence in the market, similar to the protections offered by the Federal Reserve and the FDIC.

Shadow banking takes the traditional process of credit intermediation, normally accomplished by one bank, and uses the techniques of structured finance and a network of intermediaries to turn illiquid loans into liquid, rated securities. These assets can readily be sold to investors or remain with the issuing entity to be used to expand their balance sheet. In theory this process allows for greater economic efficiency, as it deepens the sources available for funding loans and creates entities specialized in specific aspects of the process. It is also argued that the market acts as the best regulator, since investors will require sufficient reward to compensate for any risk they bear in the securities markets. This argument suggests that overly risky investments will be priced out of the market by more stable alternatives for a given unit of risk. When taken together these arguments suggest lower borrowing costs while spreading credit risk to those willing and able to bear it.

The financial innovation used in structured finance bypasses much of the New Deal regulation used to create a stable financial sector. However, the profitability and relative stability of early adopters in the shadow banking market combined with the competition they brought to the traditional banking sector created a strong case for

deregulation. Much of the argument for deregulation and market-based banking is based on the belief in efficient pricing of all aspects of the structured finance market. As the events of the credit crisis shows, this market is not always efficient. This is the topic of the next section.

CHAPTER TWO: VALUATION AND MODELING

The unusually calm credit conditions that persisted from 2002 through the credit crisis of 2007 caused many of the innovations of securitization and structured finance to go untested. The subsequent general collapse of the credit market gave many critics of structured finance and shadow banking ample evidence from which to draw convincing arguments on a variety of fronts. However, before any argument against structured finance can be discussed, it is necessary to understand the methods that were employed in pre-crisis pricing and valuation models. This section will first describe the standard CDO pricing model and then apply that model and its assumptions to the general structured finance market as described in section one, with the goal of identifying any weaknesses.

One of the most complicated aspects of structured finance is pricing. One reason for this is a general lack of data compared to other assets. There exists roughly a century of historic data of single name bonds from which to comb in order to create and substantiate valuation models. In contrast, the market for the products of structured finance, particularly those products based on consumer lending, is limited to roughly ten years of pricing data, of which only five years are readily available to the market. Further, this data spans one business cycle, though it is admittedly a significant cycle.

The data issue aside, also problematic is exactly how to model a structured finance security. With a single name bond the issue is fairly straightforward, ratings agencies assess a firm's ability to maintain their contractual interest and principal

obligations in regards to their projected revenue. Rating agencies focus on the individual firm and are able to ignore state dependent issues pertaining to the general economy. Structured finance securities create several additional issues that need to be confronted. First, CDOs can be composed of thousands individual borrowers, therefore determining the probability of default is far more complex than single name bonds. Further, the quality and accuracy of data available for publicly traded firms is generally not available for borrowers that compose the various types of CDOs.

In addition to the probability of default, another key issue is the joint default correlation among assets in the pool. Default probability is important but, the timing of those defaults is just as important. This is a crucial factor when modeling the distribution of cash flows from the asset pool to tranches of the security. A high degree of correlation would negate the benefits of diversity, which is commonly listed as a selling point for structured finance. With higher levels of correlation structured finance assets behave in a way that more closely reflects the credit quality of the underlying assets and is more vulnerable to systemic risk. High correlation levels mean default risk that is designed to fall within the limits of the equity and occasionally the mezzanine tranches, will spill into the higher rated tranches as cash flows prove to be insufficient. A lower than expected level of correlation creates the opposite problem, potentially creating equity tranches that are larger than needed to absorb expected losses, which again results in an inefficient pricing of credit risk.

The lack of a strong pricing model limited the early structured finance market to corporate borrowers who were able to offer strong credit enhancements that were needed

to overcome the concerns of investors. Even at this early stage, structured finance did show promise, as the 1989 GMAC example from section I shows. However, without an accurate pricing model, investors and ratings agencies were not willing to enter into the market in force.

These valuation issues were largely solved in 2000, when David Li developed this approach in the paper, On Default Correlation: A Copula Function Approach (2000). Although other similar models were in use before this, his technique was hailed as a breakthrough when it was first published. Variations of this approach are used by all three ratings agencies. Fitch's Default VECTOR model, Moody's CDOROM and Standard and Poor's CDO Evaluator all employ versions of this model (Covel, et al. 2008; Heitfield 2009).

The model is derived from Merton's structural debt valuation framework (Merton 1974). The first step in the model is to create a hazard rate function from similar assets comprising the collateralized pool using CDS price data found in the marketplace. While CDS data is the most common, any market-observable information, such as asset swaps spreads or corporate bond prices can be used. From these market prices, the yield to maturity is calculated. It is assumed that all prices used have equal seniority in the debt structure, a necessary prerequisite if using market data from various asset types. Next, a yield curve spread is calculated using Treasuries or LIBOR. This creates the hazard rate function than is relative to the current interest rate environment.

This pricing model relies on market data rather than historic data, thereby solving one of the issues that limited the early structured finance market. There are several

reasons given for this type of approach. Market data is based on the current market information and reflects the "market-agreed perception about the evolution of the market in the future, on which the actual profit and loss depend" (Li 2000:48). Such an approach can adjust nearly instantly to new market information, much faster than traditional ratings agencies. Also, market-pricing information takes into account the probability of default as well as severity of default, making information more accurate, as ratings agencies using historical data generally focus only on the frequency of default.

The other significant issue for the early structured finance market was the joint default correlation. Turning this value into a parameter solves the issue in Li's model. This correlation value is created by the ratings agency during the construction of the CDO based on the diversity of the underlying pooled assets. The exact method used to develop this score varies from agency to agency and is not publicly distributed.

Li's model is the following:

$$Pr[T_a<1, T_b<1] = \Phi_2(\Phi^{-1}[F_a(1)] \; \Phi^{-1}[F_b(1)], \gamma)$$

Where F_a and F_b are the distribution functions for the survival times of assets T_a and T_b, which are determined using market-price data. γ is the correlation parameter. Φ_2 is the bivariate accumulative normal function, but this can be Φ_n to accommodate n-dimensions. Φ^{-1} is the inverse of the standard normal cumulative density function. Of course, this equation does not produce a discrete value; instead a Monte Carlo simulation uses the equation to create an expected payoff value by running thousands of simulations corresponding to the normal distribution.

While this approach does sidestep the problems outlined above, it in turn creates new issues. By using information derived from market prices to determine an asset's expected default probability, the model relies entirely on the efficient market hypothesis. If the collective wisdom of the market for the derivative used to determine the asset's hazard rate function is over or under valued then, in turn the default probability will be over or under estimated. Occurrences of inefficient markets have been well documented, with the credit crisis perhaps being one of the most compelling.

Li's approach was heralded as a breakthrough in 2000 because it shifted pricing issues from the manufacturer of structured finance products to market based information and trusted ratings agencies. With that shift, CDOs could be rated under the same scale as US Treasuries or blue chip company bonds. The theoretical foundation for the hazard rate function of the model is based on the efficient market hypothesis, which despite sizeable challenges has been able to retain prominence in both academic and industry circles. Li's model was an elegant solution to a complex problem, one that market participants embraced. However, nearly every market participant ignored the shortcomings of the model during the boom years before the credit crisis.

Despite the eloquence of the model it potentially holds several shortcomings. One potential issue is the determination of the correlation parameter. The second possible shortcoming is the reliance on market prices to derive the hazard function. Both of these issues will be discussed in the following sections.

Default Correlation Parameter

The model introduces a correlation parameter that is exogenously determined by the rating agency. This approach is not unique to structured finance, in fact, the BIS uses the same approach in Basel II regulations to assist banks in calculating their risk exposures for a variety of traditional assets types (BIS 2004). While this serves to greatly simplify the problem of measuring or estimating default correlation, it requires difficult assumptions to hold true. Primarily, it is assumed that the parameter can be determined ex ante and that it is constant through the business cycle.

Moody's investigated the issue of asset correlation and default probability data in light of the financial crisis in 2008. The study found evidence that default-implied asset correlation changed over time, varied between industries, across various credit ratings and by company size (Zhang, et al. 2008). Default-implied asset correlation is found by combining default probabilities with asset correlations. Specifically, the study solves for the γ parameter in Li's equation. The conclusions from the study suggest that using a single constant correlation parameter to accurately price structured products is not easily done. The below chart summarizes the Zhang study's findings along with the findings of several similar studies. Clearly, the default-implied asset correlation varies significantly between these studies.

Study	Data Source	Default-implied Asset Correlation
Zhang, et all (by EDF)	Moody's KMV 1981–2006	11.46%~22.69%
Zhang, et all (by Industry)	Moodys' KMV 1981–2006	9.22%~29.98%
Zhang, et all (by rating)	Moody's KMV 1983–2006	7.87%~28.74%
Gordy (2000)	Standard and Poor's	1.5%~12.5%
Cespedes (2000)	Moodys' Investor Service	10%
Hamerle et al (2003a)	Standard and Poor's 1982–1999	Max of 2.3%
Hamerle et al (2003b)	Standard and Poor's 1982–1999	0.4%~6.04%
Frey et al (2001)	UBS	2.6%, 3.8%, 9.21%
Frey & McNeil (2003)	Standard and Poor's 1981–2000	3.4%–6.4%
Dietsch & Petey (2004)	Coface 1994–2001 Allgemeine Kredit 1997–2001	0.12%–10.72%
Jobst & de Servigny (2004)	Standard and Poor's 1981–2003	Intra 14.6%, inter 4.7%
Duellmann & Scheule (2003)	Deutsche Bundesbank 1987–2000	0.5%–6.4%
Jakubik (2006)	Bank of Finland 1988–2003	5.70%

(EDF-Expected Default Frequency)

The authors of the Moody study argue that while asset correlations change over time and with different datasets, their results are most likely to be accurate due to the comprehensive and current nature of their data, which includes 5,040 non-financial US-based firms from 1981-2006 with sales greater than 300 million. However, their methodologies do require several assumptions in order to make the data manageable. First, due to the small number of observed defaults, it is difficult to estimate pair-wise default correlation. To solve this issue, the study combines borrowers into homogeneous groups with similar characteristics. It is then assumed that the pair-wise default correlations between firms within each group are equal. Also, it is assumed that all firms within each group have identical default probabilities. These assumptions seem to be manageable if the data is divided into subgroups with care, but it needs to be acknowledged that the default-implied asset correlation in the study is between homogeneous groupings, rather than individual firms.

These datasets do not include consumer data. Therefore it cannot be assumed that these studies exactly represent default-implied asset correlation rates between various categories of consumer borrowing. However, the study shows the difficulties ratings agencies face when dealing with large corporate borrowers. If this dataset is difficult to manage, it seems safe to assume that more heterogeneous consumer datasets that comprise some CDOs will be equally, if not additionally, more difficult to work with.

The disparity between these studies show there is not clear-cut asset-implied default correlation within the literature using ex post datasets. It can be understood that the level of correlation might change slightly from dataset to dataset. However, the results from these studies vary widely, from as low as 0.5% to as high as 29.89%. Further, these observations are made ex post, while the issue with the pricing models is forecasting correlation levels ex ante. The level of correlation between assets is critical in evaluating the products of structured finance. If this value cannot be known ex ante, then there is little to be gained by using the techniques of modern structured finance.

The consequences of this point are far reaching. Knowing the correlation parameter ex ante is vital to the current methodology of pricing the products of structured finance. This aspect is not a minor detail that can be over looked by the market; it is a key requirement to the pricing model. If this parameter is not known ex ante, and the historical evidence suggests that is the case, the model can not function accurately.

Despite these challenges, rating agencies believed that they could accurately predict correlation rates of structured products by being deeply involved in their creation. Several facts cast this conviction into doubt. First, the Zhang study finds correlation

levels "much higher than has been previously reported" (Zhang, et al. 2008:5). The study found that borrowers with higher credit ratings tend to have higher asset correlations. This is likely due to the fact that there are few highly rated firms, and these firms tend to be large and therefore are more likely to hold systemic economic importance. Also, the study found that defaults tend to be "clustered during periods of deteriorating credit quality" (Zhang, et al. 2008:5).

These observations have significant consequences when applied to structured finance. The obvious problem is the dataset used in the study produced correlation levels that a respected ratings agency calls "much higher than has been previously reported". If this is the case, then several of the marketing points of CDOs do not apply. First, there is little credit enhancement achieved by the structuring of cash flows of a CDO, because all tranches are likely to exhibit the credit characteristics of the underlying pool. Next, the tranches within these products are likely misplaced in the sense that the attachment points designed to create tranches of various credit risk profiles are too narrow for the level of actual risk bared by the investor. This means that the equity and junior tranches, which are designed to absorb a bulk of the credit risk of the asset pool, are too narrow to achieve their goal. It is also the case that the AAA-rated tranches are too wide for the cash flows that will likely be observed during times of economic stress, increasing the likelihood of default.

The second observation made by the Zhang study that is problematic for the modeling of CDOs is the level of correlation between assets becomes greater during periods of economic stress. Recall the model used for pricing these products assumes a

constant correlation parameter. The consequence of this finding makes the pricing model inaccurate during the trough of an actual business cycle.

The sensitivity of the expected payoff of a CDO tranche to changes in the correlation parameter needs to be discussed. In their paper, The *Economics of Structured Finance*, authors Coval, Jurek and Stafford (2008) look at the consequences of changes in the correlation parameter to the expected payoff of different CDO tranches. The study uses Fitch's Default VECTOR model, which is the firm's off-the-shelf CDO pricing model based on Li's model. For a time, this model was available for free on Fitch's website as a plug-in to MS Excel.

The authors begin by constructing baseline CDOs that falls within the typical standards for such products. They create "40 CDO pools each comprised of 100 bonds with a default probability of 5% and a recovery rate of 50% of the face value conditional on default" (Coval, et al. 2008:11). Each asset pool is structured in the same fashion. The junior tranche has attachment points of 0-6%, meaning that it will absorb the first six percent of defaults observed in the pool. The mezzanine tranche has contact points of 6%-12% of defaults and the senior tranche absorbs all losses greater than 12%. The all important default correlation for each individual pool is set at 20% as a baseline value. The default correlation between pools is assumed to be zero.

In addition, the study creates 40 CDO^2, which are composed of the mezzanine tranches of the original CDO using the same contact point structure. These CDO^2 reflect a desire by participants in the structured finance market to create the greatest nominal amount of AAA CDOs possible. By packaging mezzanine tranches from the original

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CDOs, market participants are able to create additional AAA-rated securities from the original asset pool. According to Moody's, in 2006 55% of the total nominal value of securitizations were partially comprised of repackaged assets (Hu 2007).

Using Fitch's VECTORS model, the theoretical collateralized pool with the above listed characteristics creates tranches with the following characteristics:

	Tranche	Default Probability	Expected Payoff	Rating
CDO	Junior	97.52%	0.59	NR
	Mezzanine	2.07%	>0.99	BBB+
	Senior	<0.00	>0.99	AAA
CDO^2	Junior	56.94%	0.93	C
	Mezzanine	<0.00%	>0.99	AAA
	Senior	<0.00%	>0.99	AAA

Source: Coval, et al. 2008:33

The theorized benefits of structured finance are clearly displayed here. The overall asset pool has a five-year default rate of 5%, which is similar to a single-name BBB rated bond (Fitch). Yet these assets create securities where 88% of the collateralized asset pool becomes AAA-rated senior tranche assets. Nearly all of the credit risk of the pool is held within the junior tranche, which is essentially designed to fail. Using a Monte Carlo simulation, the remaining CDO tranches earn their excepted payoff more than 99% of the time. The mezzanine and senior tranches of the CDO^2 also have, in this model, been stripped of their credit risk.

The critical value in this simulation remains the default correlation parameter. As one might theorize the expected payoff for most tranches falls as default correlation

increases. However, the CDO junior tranche actually increases its excepted payoff value

as the correlation increases. This is due to the fact that as correlation increases above

20%, default risk is being shifted to the higher rated tranches and risk is moving into the

tails of the default distribution, improving the value of the equity tranche.

The pricing behavior of the junior tranches deserves additional attention, as at

first glance this seems counterintuitive. It is important to recall that during the creation of

the CDO, it is the originating firm's intent to place as much of the default risk as possible

in the junior tranche. If the assumptions of the firm constructing the CDO are correct, the

junior tranche will be of sufficient size to absorb the likely cash flow shortages over the

lifetime of the CDO. In other words, the junior tranche is designed to fail. Under baseline

assumptions, junior tranches are expect to have irregular and insufficient cash flows, as

the assumed defaults occur over the life of the CDO. This severely limits the market

value of the tranche. However, if the underlying assets perform more poorly than baseline

expectations, the market value may rise. This is because in the Coval model the future

cash flows from the assets are highly correlated and more closely resemble a single-name

bond. The baseline assumption creates a security with a low level of correlation, which is

assumed to be many defaults scattered over the life of the security, rather than having the

default clustered together Coval's model shows in the above tests.

The mezzanine tranche exhibits a similar and interesting, but non-monotonic

result; as the correlation increases the expected payout initially falls, but the expected

payout begins to increase as the default correlation nears 100%. As the authors state, "in

the limit of perfect default correlation, each tranche faces the same 5% chance of default

over five years as each of the securities in the underlying portfolio" (Coval, et al. 2008). For equity level tranches, a default rate of 5% is actually an improvement over the baseline scenario.

The results of increasing the default parameter are as follows:

		Initial Rating	Final Rating					
			Default Correlation			Default Probability		
			40%	60%	80%	7.50%	10%	12.50%
	Junior	NR	D	C	CC	NR	NR	NR
CDO	Mezzanine	BBB-	BB-	B+	B+	B+	CCC	CC
	Senior	AAA	A+	BBB-	BB	AAA	A+	BBB-
	Junior	C	D	NR	NR	NR	NR	NR
CDO^2	Mezzanine	AAA	B+	C	CC	BBB-	NR	NR
	Senior	AAA	AAA	AAA	AA+	AAA	AAA	B-

Source: Coval et al. 2008:34

The CDO^2 are more sensitive to changes in default correlation rates than CDOs. The mezzanine CDO^2 expected payoff falls 25% as the correlation parameter is increased from baseline to 60%. Due to the high granularity of investment grade rankings, even small changes in the expected payoff cause large changes in the rating. The range of investment grade ratings extends from AAA to BBB- and includes 10 separate ratings categories, but the annual default rate only varies from 0.02% to 0.75%. A small change in default correlation quickly moves a tranche from investment to speculative grade. The CDO senior tranche for example, falls to the lowest investment grade rating as the correlation increases to 60%.

Also included for comparison purposes are results from changing the default probability of the underlying asset pool. In this study, the default probability is determined by the authors to have a baseline value of 5%. As you can see, the CDO

structure is sensitive to even small changes in default probability, meaning that the model relies heavily on the market's ability effectively and efficiently price credit risk.

This study shows that the CDO model is very sensitive to even small changes in the default correlation. The earlier conclusion from the Zhang study that corporate defaults tend to be clustered in times of economics stress suggests CDOs should also suffer from increased defaults during the same time period. The recent crisis gives us actual CDO pricing data to confirm this suspicion. Markit, a financial data firm, compiles pricing information on various structured finance products, such as CDO tranches and CDSs. The CDO series, ABX.HE.BBB 07-01 is an index based on the average value of 20 BBB-rated residential mortgages CDOs created in the first half of 2007. At its high point, the tranche traded for 98.35 cents on the dollar. These tranches correspond to mezzanine tranches in the above illustration. By August 2008, after the stresses of the credit crisis, the same tranche held a rating of CCC and a value of under $0.05 (Coval, et al. 2008).

This high level of volatility in observed pricing suggests that CDOs do not behave in a manner similar to the single name bonds, as the practice of rating them on the same scale would suggest. A high likelihood of clustered defaults combined with a high sensitivity to default correlation means that CDOs embody significant systemic risk. Due to these observed characteristics, it has been suggested that CDOs should be thought of as digital call options on the S&P 500, rather than credit instruments (Coval, et al. 2008).

The process of manufacturing CDOs might actually be more akin to creating a diverse portfolio of equities than a single-name bond. In expansionary economic times, it

will appear that the portfolio has a great degree of stability. Some equities will outperform, some will not, but on average the portfolio will perform in a manner that is in line with the degree of risk undertaken as measured by conventional means, such as CAPM. This risk level can be designed to correspond to various rated CDO tranches. However, there always exists the possibility of a low probability high impact event. Such an event causes all equities to behave poorly and negates the benefits of diversity. Reinhart and Rogoff make a convincing case that such events are commonplace in capitalist economies that extends over eight centuries (2008). Coval et al. suggest that CDOs embody this type of systemic risk. However, CDO investors do not receive the 'equity premium' that they could if they wrote an S&P 500 call. CDO investors bear significant systemic risk, but without the corresponding reward that would be found in equity markets. It has been suggested that investors would earn 4-5 times more by writing calls on the general market index than investing in CDOs (Coval et al. 2009). This observation may account for changes in the general relationship between equity market and the CDO market.

It has been shown that the exogenous determination of a constant correlation parameter in CDO pricing models is vitally important to its performance. It is also shown that this parameter is very difficult to determine ex ante and is unlikely to be constant. This consequently makes CDOs very vulnerable to systemic risk. Yet, this risk is not accurately priced into the model. In fact, by making the correlation parameter constant, the model places the responsibility for pricing systemic risk on the hazard rate function,

which is based on market prices. At this point, we turn our attention to the formation of the hazard rate function.

CDS Market and the Hazard Rate Function

The development of the CDS market represents a major innovation in the financial system, especially for the purposes of structured finance. Of the many potential market credit instruments that can be used for the creation of a hazard rate function, CDSs represent a deep and active market. In 2006, CDS index tranches amounted to $ 1,736 USD billion in trades (BIS 2007). This deep market is composed of agents with interests in limiting or adding credit risk to their portfolio. These factors make CDS a good choice in which to analyze and price credit risk transfer.

This section will analyze the CDS market from 2005-2010 in order to determine if it performs as the CDO model assumes. The main CDS index is the CDX Markit index, which began compiling data to form indices in 2005. Markit compiles this data by surveying market participants because trading takes place over the counter, rather than on a central exchange. This index is accepted as the industry benchmark, largely due to a lack of competition.

While there are several CDS indices, this paper will review the CDX.NA.IG, which is comprised of 125 North American investment grade firms and CDX.NA.HY, which is composed of 100 North American high yield firms. Both indices roll semi-annually, with the most liquid single name CDS in a specific credit range joining or leaving the index. In the event that three firms from within an index fail, three new firms

are added to replace them. Fewer than three failures within an index does not trigger a special roll, but the value of the index falls accordingly.

These two indices can be thought of as synthetic single tranche CDOs that are discussed in section I. The investment grade index (IG) corresponds to a rated-AAA senior tranche. The high yield (HY) tranche can be thought of as being roughly equal to a mezzanine tranche.

The index is shown in basis point spread terms. For example, if the spread is 120, the index is suggesting that an investor wanting to buy credit protection would need to be willing to pay 120 basis points (BPS) multiplied by the amount to be insured. The 120 bps spread is determined by the seven member firms submitting their median spread from that trading day. Markit then compiles an average in a manner that is similar to how LIBOR is calculated, which is based on dropping the high and low price observations, assuming enough participants respond.

Markit's approach is simple, but can potentially create misleading information. The index is based on average price and is not weighted to account for large trades away from the mean. Also, all that is required for a daily price is one bank reporting a trade. Member banks have the option to abstain from reporting trades. It is possible, and even likely, that trades can take place without being recorded by the Markit index. These are a few of the many CDS issue that will be addressed when CDS trading is brought onto an exchange due to provisions in the Dodd–Frank Wall Street Reform and Consumer Protection Act. However, when analyzing the economic environment surrounding the credit crisis, the Markit CDX indices represent the best data available.

CDX.NA.IG is composed of firms that hold a credit rating of A and above, which represents the middle to high end of the credit rating scale. According to Fitch the 10-year default probability for an A-rated bond is 1.85%. The same probability for an AAA-rated firm is 0.19%. Examples of firms that fall into this index are AT&T, Capital One, Caterpillar, Kraft Food and Wal-Mart.

The range for CDX.NA.HY is the low end of what is considered investment grade as well as the high end of speculative grade (BBB+-BB). The range of 10-default probabilities is significant, from 3.13% for BBB+, to 13.53% BB, according to Fitch. Firms falling into this category are: Advanced Mirco Devices, The Neiman Marcus Group, Ford Motor Company. While this index is referred to as high yield, its components are still relatively stable; excluding BB- through C rated firms.

The data available extends from January 1, 2005 to November 17, 2010. This roughly five-year period includes some of what was coined as being "The Great Moderation" years by Bernanke (2004), but also fall of Lehman Brothers and the ensuing credit crisis. This time period is important because it shows both the calm years leading to the crisis, as well as the crisis itself and the tentative attempts at recovery. However, five years of data and one business cycle is a short period from which to derive meaningful conclusions.

CDS data is assumed by the CDO pricing model to follow the assumptions of the efficient market hypothesis, which need to be discussed. EMH has been the leading theory in financial economics since the late 1950s (Mandelbrot 2004). This theory also led to the creation of the Capital Asset Pricing Model (CAPM), which allows investors to

value all financial assets prices in risk/reward terms based on price volatility and the risk free rate. The creation of the hazard rate function used in the Li model is very similar to the ideas used by CAPM. The EMH model makes several main assumptions that allow it to function smoothly. First, the model assumes that all agents are profit maximizing, risk adverse and rational. In the application of the model and CAPM, this means that for a given unit of risk, measured by variance around the mean, all investors will require the same return. This risk/reward utility function is referred to as the efficient frontier. Any asset that is above the frontier is considered by all agents to be overpriced for the amount of risk it embodies. The reverse it true for asset below the frontier. Since the market is assumed to be informationally efficient, the prices of assets that are off the frontier will adjust instantly as investors analyze new information.

The second assumption of EMH is that all investors are homogeneous. All investors have the same time-horizons and given identical information and risk profile, will make the same decision. Assumption one forces all agents to value assets in terms of an efficient frontier. Assumption two forces all agents to respond to that information in the same fashion when constructing an investment portfolio. Under these assumptions no agent is limited by exogenously determined constraints in regards to valuation of assets, investors are free to compose portfolios based on their desired level of financial risk. In application, this means that agents are highly competitive price-takers. In the structured finance market, this assumption means that a credit hedge fund would be just as likely to buy or short a CDO or a CDS if one asset was monetarily priced off the efficient frontier. This type of arbitrage activity is vital for EMH to function properly.

To accommodate arbitrage, it is also assumed rational investors have access to unlimited leverage and there are similar alternatives to any one individual asset. The first condition allows for any irrational investment activity to be quickly arbitraged away by rational investors who have the unlimited ability to short overvalued assets. The availability of alternatives allows for the risk of arbitrage to be hedged by similar but correctly priced assets.

The final assumption of consequence is that prices follow Brownian motion. This suggests that financial markets are a fair game, meaning that any given price change is independent from the last. The result is asset price charts that are smooth and continuous. It is also required that the process of generating price changes is constant over time. Finally, this assumption requires that price changes follow a normal distribution and any explanatory pricing models that work in one period will work to the same efficiency in other periods.

The application of these assumptions to the CDO model is far reaching. The most important aspect being that the hazard rate function, which is based on observed market prices, correctly prices risk in terms of default probability and severity at all times. If the markets under prices credit risk, then arbiters will bid up the spreads on CDS until it represent its true value. If the spread is too high, then rational arbiters will gladly sell CDS until the price reflects the true level of credit risk. All price changes are smooth and continuous, meaning that we should not observe any large jumps in pricing. Further, price changes should follow the rules of a random walk, meaning any one observation is independent from the last and is equally likely to be upwards or downwards.

The assumptions that are required to create this type of pricing distribution are also telling about the structure of market participants. Agents are assumed to be homogeneous and free of any exogenous constraints. This means that any asset, whether it be a AAA-rated CDO or risky CDS will be purchased or shorted instantly and in unlimited quantities by any agent if its price falls off the efficient frontier. With EMH, market participants nearly instantly correct any pricing error. By extension, any market price can be used as a building block in a model to price other related assets. It is therefore not necessary, or possible, for individuals to perform risk analysis to greater efficiency than the market; market data represents the best possible tool for pricing credit risk.

The process of manufacturing CDOs is greatly simplified by EMH. The assets that are used to create CDO pools have a known expected value, so they can be easily priced in any condition as they move through the securitization process, this eases liquidity concerns. For the firms that manufacture CDOs, the securitization process allows them to combine low-expected value, high-volatility assets that are not valued highly by the CAPM model and package them using the tools and techniques of structured finance to creates high-expected value, low-volatility assets. These assets are highly valued by the CAPM model and by extension all market participants. Under the assumptions of the EMH, this process amounts to arbitrage. With EMH there should only be momentary arbitrage opportunities, but structured finance is based on systematically manufacturing these opportunities.

There are many statistical tests that can be done to verify that CDS values fall into a normal distribution, as the EMH requires. Given the extreme events of the period in question, the first tests that were done are not considered traditional. Initially, the CDS data was tested for evidence of power laws. Power laws are commonly used in econophysics and physics. Unlike a Gaussian distribution that has regularly distributed observations clustered around the mean, a power law distribution has irregularly distributed observations, with many more observations further from the mean than a normal distribution would expect. One example of such a distribution is Pareto income distribution. Sorting the observations and charting them on a log/log scatter plot is one basic way to test for this type of distribution. The results of this scatter plot will be a linear line with a slope of one if the distribution has clear power law characteristics. The data tested did not show this type of distribution.

Knowing that the distribution of the data is approaching normal, the next step was to test for basic descriptive characteristics, which are presented below:

Summary IG		Summary HY	
Mean	89.54959621	Mean	560.972811
Standard Error	1.414554185	Standard Error	7.864587127
Median	78.06	Median	485
Mode	49	Mode	491
Standard Deviation	54.34539712	Standard Deviation	302.1475707
Sample Variance	2953.422188	Sample Variance	91293.15448
Kurtosis	3.655995673	Kurtosis	4.655548426
Skewness	1.107620599	Skewness	1.469824711
Range	252.625	Range	1440.70003
Minimum	28.875	Minimum	208.99997
Maximum	281.5	Maximum	1649.7
Sum	132175.204	Sum	827995.8691
Count	1476	Count	1476

These statistics are fairly straightforward, perhaps more so than one might expect, given that they include the credit crisis. However, they are not very explanatory. Both indices have positive skewness, meaning the distribution has more observations above the mean that a normal distribution suggests. Both distributions show signs of kurtosis, which suggests that observations are not clustered around the mean in the way a normal distribution predicts. In this case, the distribution is steeper with more observations in the tails of the distribution then expected. This suggests that the distribution is not a smooth bell curve with granular changes, but a rather peaked distribution. A normal distribution has a kurtosis of 3. By contrast, stock market indices have significant kurtosis. From 1970-2001 the S&P 500 had a kurtosis of 43.36. Even without the crash of 1987, kurtosis in the S&P over the same period was 7.17 (Mandelbrot 2004:96). The level of kurtosis in the CDS data is consistent with the relatively large standard deviation. Taken together,

these statistical measures suggest that the data covers a larger range and does not producing clear Gaussian distribution.

These indicators fail to correspond to the idea of Brownian motion, specifically that each observation is independent from the last. The indicators suggest a level of endogeneity within the dataset, meaning that the conditional probability of an upward movement being followed by another upward movement is greater then 50/50, as theory suggests. The result is much more evident with the graphs later in the paper that plot CDS observations by their distance from the mean and normalized by standard deviation.

One of the assumptions of the EMH is that markets follow a random walk, which is again part of the Brownian motion assumption. One way to test for this is to estimate the Hurst exponent. This measure was named after H.E. Hurst, who in the early twentieth century, was charged by the British Empire with designing a dam for the Nile River. Hurst was concerned with finding the range of rainfall and determining if it fell in trends, with rainy years coming after rainy years, because this pattern would require a higher dam. With traditional probability, each observation is independent from the last and there is a simple formula for accounting for the range of a dataset: the range varies by the square root of the observations. There should not be observed clustering or trends in the dataset, since each observation is independent from the last. Hurst studied 51 different datasets with over 5,100 year measurements and found that independence is in not always the case. Sometimes statistically significant trends do develop. His hydrology observations, made the world over, found that range widen not by the square root, but by a power of 0.72 (Mandelbrot 2004:176). Hurst found that wet years are more likely to be

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followed by wet years, meaning that any dam would need to be higher than expected to accommodate for consecutive years of above average rainfall or drought.

A random walk should have a Hurst exponent of 0.50. Anything greater indicates the presence of a positive trend, or more specifically positive autocorrelation. An exponent less than 0.50 would indicate negative autocorrelation. By my estimate, the indices CDX.NA.IG and CDX.NA.HY have a Hurst exponent of 0.52 and 0.56 respectively. This suggests that both indices do follow something resembling a random walk with upward drift.

Given the nature of the data, the Hurst exponent has the potential to be slightly misleading. To find the exponent, we start by first de-trending the returns. Then a running partial sum of each de-trended return's distance from the mean is made starting with the first observation continuing to the last. The high and low observation of the partial sum is the scaled range. This range is divided by the standard deviation of the de-trended data corresponding to the observation. The log of this term is then graphed against the log of n. The slope of the resulting line is the Hurst exponent.

For the data used there are several potential issues. First, there is a lack of observations. It is not clear that five years is sufficient for trends to develop. Hurst used long-run data that often extended for more than one hundred years (Mandelbrot 2004). While a Hurst exponent of 0.52 or 0.56 is not very far from random, it is greater than the EMH assumes. We can only speculate how this exponent would develop over a longer time period. Second, it is important to remember how the data is calculated. Markit asks for the average CDS prices for the day, not the weighted average or a trading range. Also,

investment banks report data voluntarily and only one bank needs to report data for a given day for the index to update. For these reasons, it is possible that the index under reports price volatility. If this is the case, then the partial sum calculation of the Hurst exponent will not accurately capture the trends that are vital to its objective. For these reasons, the predictive ability of the Hurst exponent is limited.

Another assumption of the EMH is that pricing data should be smooth and continuous. For the years preceding the credit crisis this seems to be the case, price changes are small and cluster around the mean in a rather narrow range. After the fall of Lehman Brothers on 9/15/08, this pricing distribution seems to fall apart. The pricing changes are rather large, often exceeding three standard deviations (σ) from the mean. In fact, for CDX.NA.IG, there are 14 observations that exceed three σ, where a normal Gaussian distribution would assume to find one or two for a dataset of this size. CDX.NA.HY has 24 observations that exceed three σ, with a maximum of 3.60 Standard deviations from the mean. These extreme observations are clustered within a period of two months. The following charts normalizes the observations by graph their distance from the mean in standard deviation terms.

NDX.NA.HY Standard Deviations from the Mean
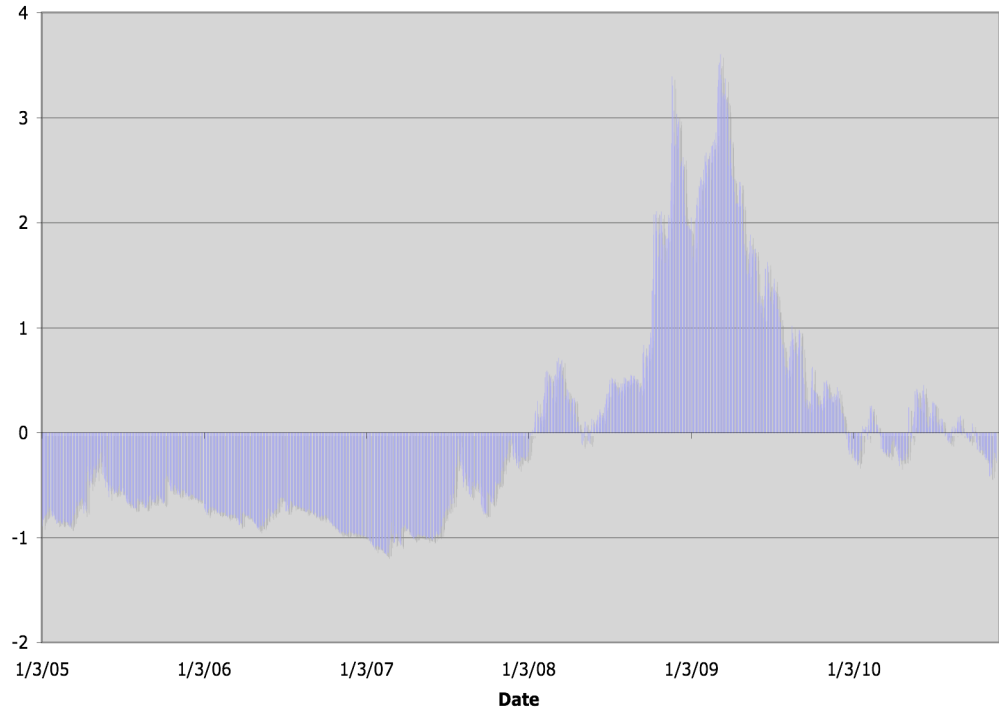
CDX.NA.IG Standard Deviations From the Mean
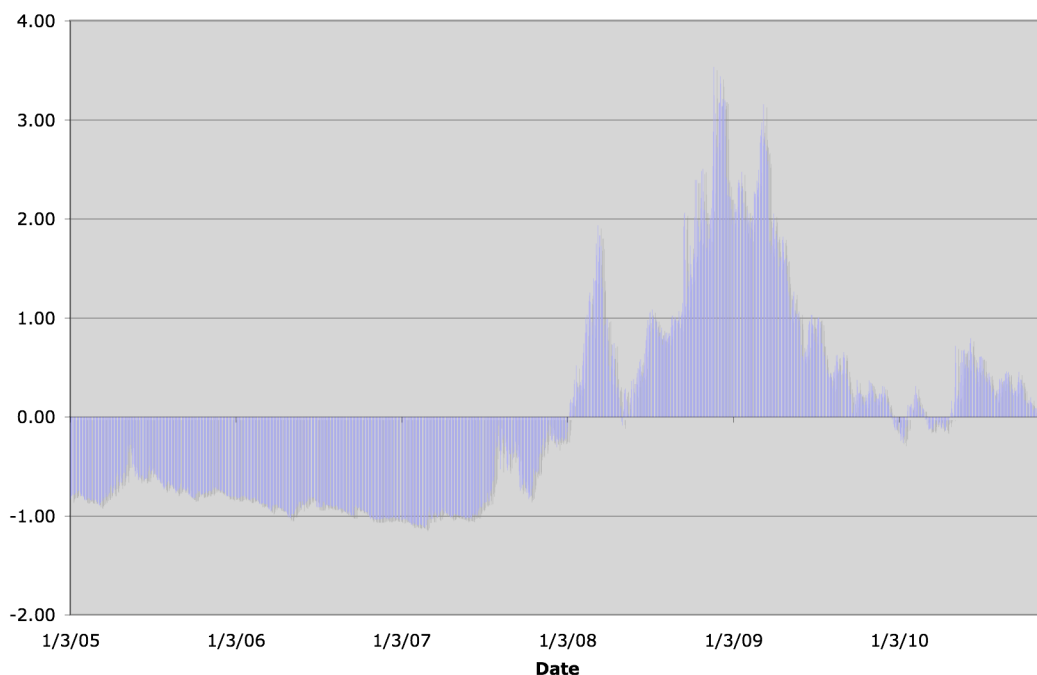
Contrary to the assumptions of the EMH, the distribution of price observations is clearly

not smooth, nor is it continuous. The great moderation years, defined as before the

collapse of Lehman Brothers (9/15/08) are fairly gentle and do resemble what EMH

predicts. However, as the observations move towards 9/08, the distribution becomes

unruly, with observations clustered much further from the mean than should be expected,

which is confirmed by the increased level of kurtosis. Combined with the large standard

deviation, the CDS data does not follow the assumptions of EMH.

The mechanism for EMH to produce a smooth distribution is arbitrage, which is assumed to be an unlimited force that corrects pricing inefficiencies instantly. Without these forces, prices lack a corrective hand and the result can be erratic movements. The unlimited arbitrage activity assumption is not likely to hold in the CDS markets. If a rational agent believes that a CDS is under priced, the response should be to buy coverage, but buying CDS coverage is an ongoing and large expense. For example, in February of 2007 the spread for CDX.NA.IG dropped to 30.00 bps, which in hindsight was too low a price for CDX coverage. For an investor to take advantage of this under pricing of credit risk, they would need to buy coverage at 30 bps per million dollars of coverage. A round lot trade in the credit markets is $100 million; trades for less than this amount are unlikely to be easily filled. That means that the rational investor intending to buy CDX coverage needs to be able to pay the counterparty at least $300,000 annually. This is not a huge sum, but 30.0 bps represents the multi-year low point of CDX.NA.IG pricing. It was not until the summer of 2008 that credit markets began to show clear signs of stress; timing which would have required another payment. Few investors have the risk profile that allows for many years of losses followed by the low probability of large gains in the future. There is some anecdotal evidence to suggest that several hedge funds closed due to losses sustained from incorrectly timing the end of the credit bubble.

CDX are also not as liquid as equities or traditional bonds. The risk of a CDX position is difficult to hedge, as there does not exist an identical alternative to the CDX index as EMH assumes. Contrast this market to equities or bonds. When an equity is undervalued rational agents can buy it with no carrying cost, assuming they are not

borrowing funds to make the purchase. Even if the agent is using borrowed funds to buy the under valued equity, the equity itself can be used as collateral for further borrowing, which is typically not the case with CDS and certainly not to the same extent. Both equities and bonds are generally more liquid and there often exists similar alternatives to individual or index positions to hedge price risk.

The nature of the CDS market may prevent rational agents from acting on price inefficiencies to the extent that is required by EMH. Even if one is willing to assume the CDS market composed of rational, profit maximizing agents, their ability to act accordingly may be limited by the cost required to act rationally. If this is the case, CDS spreads do not represent the true price of credit risk and the key building block for structured finance in undermined.

The highly leveraged nature of the structured finance market makes this type of volatility very consequential. It should be noted that 49% of all subprime CDOs were retained by the leveraged sector of the financial system, meaning that nearly half of all subprime holdings were used by various types of commercial and investment banks, as well as hedge funds, to post as collateral for additional lending or borrowing (Greenlaw et al. 2008). These low-quality pooled assets are very sensitive to imperfections in pricing models and have limited marketability outside of the financial sector. Their performance is more volatile then Markit's high-yield CDX.

To illustrate the importance of leverage, imagine a SIV with $100 of ABS securities as assets funded by $5 of equity and $95 of ABCP. The SIV conducts maturity transformation by using the income from its long-term ABS assets to fund its short-term

ABCP debt. As a category, ABCP funded SIVs were valued at $400 billion in 2007 (Jabłecki, Machaj 2008). A SIV as described produces a leverage ratio of 20:1. If the value of the ABS rises to $110, the SIV then has $15 of equity funding $110 of assets, producing a leverage ratio of 7:1. However, the SIV wants to maintain a ratio of 20:1. To do so, the $15 of equity will now support a total of $300 worth of ABS, meaning the SIV will purchase an additional $190 of securities. A ten percent increase in the value of the securities increases the SIV's holding by nearly 300% (Jabłecki, Machaj 2008:316). SIVs have a strong profit incentive to maintain high levels of leverage, which works to the SIV's benefit when asset prices are rising, but can result in fire sales when asset values are falling.

If the value of the ABS holdings were to fall from $300 to $290, then the SIV would have an equity level of $5. To maintain the 20:1 leverage ratio the SIV would return to its original $100 of ABS holdings. Also, the SIV relies on ABCP to fund its operations. If the credit market fails to support the SIV, it will respond by selling additional holdings. These examples, while simple and optimistic, show how important the assumptions of the EMH and its ability to price risk is to agents in the structured finance market. High levels of price volatility can play havoc on leveraged financial agents and their holdings.

The collapse of CDO prices observed during the credit crisis suggests that CDSs do not accurately price credit risk in all periods. For CDS to be a good tool for creating a hazard rate function for the pricing of CDOs, they need to follow all the assumptions of EMH. If they do not, they will fail to behave in a way that allows for their prices to

quickly respond to changes in the economic environment and they lose the ability to accurately predict credit risk. If this is the case, CDSs do not reflect the true level of credit risk and this error is magnified when CDSs are used to price CDOs due the model's potential for errors in estimating the correlation parameter. Because of this potential and the CDO model's sensitively to even minor errors, CDOs are likely to embody systemic risk.

The erratic nature of the two CDS indices suggests that they do not always adjust instantly to new information, or possibly they incorrectly interpret new information. If they did correctly and instantly adjust, we would not see a cluster of observations that fall three σ from the mean. One possible, but crude, way to test the assumptions of EMH on CDS data to find the correlation level between the CDX indices and the S&P 500; if both the CDS market and S&P 500 are efficiently priced, all things being equal, the correlation levels should remain equal when viewed in pre and post crisis terms. If both CDSs and the S&P 500 correctly priced credit risk then there is little reason for correlation relationship to change. If the CDS market anticipated the credit crisis, which is the reason behind using market prices in the CDO model, then the correlation between CDX and the S&P 500 should diverge, since the S&P 500 represents significantly more systemic risk then the CDX indices. The data is taken in log form with pre-crisis data dating from 1/3/05 to 9/15/08 and post crisis extending from that point to the end of the dataset, which is 11/17/2010.

Pre-Crisis		Post-Crisis	
S&P 500		*S&P 500*	
CDX.IG	-0.04	CDX.IG	-0.82
CDX.HY	-0.11	CDX.HY	-0.91
n=933		n=545	

Increased correlation levels between the indices and the S&P 500 is exactly what we find. The correlation levels between IG and HY remain relatively constant before and after the crisis, indicating that both indices responded in a roughly similar fashion to the changing conditions. However, the correlation level between the indices and the S&P 500 increased massively. The correlation levels between CDX and the S&P 500 are negative because an increase in market risk causes CDS spreads to increase and equity prices to decrease. It appears that pre-crisis that there was very little correlation between CDS and the equity markets.

The correlation levels between CDX.IG and the S&P pre crisis are not statistically significant at the 5% level. However, the correlation between the S&P and CDX.HY are significant at the same level, which should be suspected given their similar risk profiles. Post crisis both indices are significant at the 5% level.

The surprising aspect of this correlation increase is that it has persisted well after the crisis abated in the equity markets and in other aspects of the credit market. From 01/05-9/15/08 the two markets seemed to operate independently, since 9/15/08 until the end of the dataset on 11/17/10 the two markets operate as nearly mirror images of each other. One reason for this change is likely to due changing market participants. The credit crisis forced many CDS sellers into liquidation. Removing agents from the market would

result decrease the number of willing counterparties. Also, the remaining agents are likely risk adverse and therefore require higher risk premiums. This data suggests another break in a key EMH assumption. EMH assumes that price changes follow the assumptions of a fair game, meaning that a model that explains pricing movements in one period will be equally as effective in other periods.

It appears that the nature of the CDS market and its perceptions about risk has changed. There are several possible reasons for this, but the key idea is that something in the market has altered pricing correlations. Previous studies looking for links between CDS and equity markets have not found convincing correlations using pre-crisis data (Coudert, Gex 2008; Scheicher 2008). However, post crisis this relationship has changed. "The usual relationships between the two markets, which underpin the spread of innovations from the equity market to the CDS market, are therefore disrupted" (Coudert, Gex 2008). The strong correlation level also suggests that CDS are susceptible to systemic risk in a similar fashion to the equity markets. These observations lead to questions about how CDS prices are determined.

CDS Valuation Model

The modeling conventions for CDS again rely on an extension of Merton's 1974 debt model (Schiecher 2008). The general form for such as model is as follows:

$$X_{it} = ((p_{it}F_t)^{\wedge}(1/2)) + ((1 - p_{it}\pi_{it})^{\wedge}(1/2))$$

Where:

    X_{it} is firms I's asset return at time t
    p_{it} is the correlation of firm i's asset value with F at time t ($p_{it} \geq 0$)
    F_t is the systematic risk factor ($\sim N(0,\sigma)$)
    π_{it} is the idiosyncratic component ($\sim N(0,1)$) and is independent of F_t

This model is very similar to traditional Black-Scholes option pricing model. The CDS pricing model still depends an agent determining the level of credit risk that the individual firm holds, as well as the systemic risk of the general economy. The question then becomes how are these risk levels determined and what factors influence them.

A study done by Martin Scheicher of the European Central Bank (2008) attempted to discover the economic metrics that effect CDX spreads. He used the same Markit CDX pricing data that is discussed above, but his study period ended in January of 2008. He conducted a simple multivariate regression analysis of various factors that are thought to influence the pricing of CDS, such as different metrics of credit risk and market liquidity. It was hoped that the results of such as study would shine a light into the pricing of CDS spreads. The answer could also explain why the correlation between CDX and the S&P 500 increase so dramatically over the past two years.

The study looks across all the CDX tranches in order to build a more complete model that is representative of an entire CDS market and CDO debt structure. The list of individual factors that are taken into account cover a broad range to analyze several different macroeconomic aspects that might influence CDX spreads. They include the include the following: CDS index premium change, credit risk correlation between tranches, the risk free rate, the slope of the term structure, risk aversion, swap spread, bid-ask spread, and the Yen exchange rate.

Several of these factors are used to account for aspects that are directly important to structured finance, such as the CDX index premium, credit risk correlation, the risk

free rate and slope of the term structure. The CDS index premium is intended to be a proxy for the price of credit risk transfer, which is shown as the log of CDS index premium changes. The correlation level of tranches to the equity tranche is used to determine the markets' perception of systemic risk. Higher correlation levels lead to a greater possibility of systemic risk, but this risk impacts different tranches differently. Equity tranches actually see their values increase with correlation levels, while the rest of the debt structure sees losses. This excludes the mezzanine tranches, whose response is non-monotonic. The risk free rate is included and is generally negatively related to CDX spreads, as lower rates decrease the carrying cost of the asset. The study uses a five-year interest rate swap as the market preferred measure of the risk free rate. The CDO model discussed uses Treasuries or LIBOR, as per convention, but this measure accomplishes the same objective. The slope of the term structure is determined as the difference between the one and ten year swap rate. This measure is designed to account for the perception that CDX spreads should account for the yield curve. All of these variables are directly related to the formation CDO models; the other aspects are more indirectly related.

The study captured perceived macroeconomic risk sensitivity using the JP Morgan G-10 Aversion Index. The index aggregates implied volatilities observed in financial and currency market across G-10 economies. It is suggested that this measure is a good leading indicator of sharp declines in equity markets. The difference in the ten-year interest rates swaps between US/German government bonds is used as a proxy for liquidity. This measure contains information about bank operations without including

counterparty risk. The bid-ask spread in CDX prices is also included as a measure of liquidity specifically in the CDS market. An average across all tranches is used. Finally, the Yen exchange rate is included due to the popularity of the carry trade in recent years.

The regression results of changes in the log CDX tranche premia on the variables listed above (also taken in log form) are presented in the follow table. Coefficients marked in bold are significant at 5%. The columns are listed in terms of their attachment points in the CDO debt structure.

	0-3%		3-7 %		7-10 %	
	β Coeff.	t-stat	β Coeff.	t-stat	β Coeff.	t-stat
Intercept	0.00	0.44	0.00	0.34	0.00	0.41
Index	**0.14**	2.84	**0.20**	1.92	0.20	1.54
Correlation	-0.04	-1.11	-0.15	-1.61	-0.15	-1.30
Swap rate	-0.13	-1.31	-0.40	-1.61	**-0.59**	-2.11
Slope	0.01	0.19	-0.04	-0.40	-0.01	-0.15
Risk aversion	**0.03**	5.34	**0.07**	5.25	**0.08**	4.70
Swap spread	0.05	1.08	0.18	1.39	**0.31**	2.07
Bid-ask	**0.05**	2.96	**0.16**	3.05	**0.20**	3.33
Yen	-0.08	-0.55	-0.16	-0.38	-0.05	-0.11
R^2	0.28		0.27		0.27	

|	10-15 %		15-30 %		30-100%	
	β Coeff.	t-stat	β Coeff.	t-stat	β Coeff.	t-stat
Intercept	0.00	0.73	0.00	0.81	0.00	0.74
Index	**0.39**	3.05	0.32	1.87	0.43	1.28
Correlation	-0.17	-1.39	-0.19	-1.74	**-1.13**	-2.26
Swap rate	-0.41	-1.38	-0.37	-1.16	0.05	0.09
Slope	0.01	0.09	0.03	0.33	0.28	1.04
Risk aversion	**0.08**	4.95	**0.08**	4.26	**0.09**	2.70
Swap spread	0.23	1.33	0.30	1.74	-0.09	-0.31
Bid-ask	**0.19**	2.99	**0.20**	2.98	0.02	0.14
Yen	-0.11	-0.21	0.13	0.23	-1.08	-0.66
R^2	0.26		0.20		0.04	

Source: Scheicher 2008

There are several key ideas that are presented in the results. First, each variable has a different effect on various tranches. This confirms the idea that different tranches respond to economic factors differently, suggesting that they can be tailored to match the risk tolerances of the investor. This evidence might be used to confirm the argument that structured finance improves economic efficiency in the credit markets by matching investor credit investments that match their portfolio needs. There is an important caveat; this argument only works if the results are predicable in some fashion, which would require the assumptions of EMH to hold.

Second, the index premia (spread) is the only variable that is significant at the 10% level for all tranches other than the 30-100. This suggests that the premia is an important variable in explaining CDX price variation, as the CDO model assumes, though possibly not to the same extent. The 30-100% loss attachment point tranche does not perform in the same fashion as the higher rated tranches due to reasons explored earlier. Therefore, the premia is not a good explanatory variable for the lower rated tranches, but this is not of particular consequence. This tranche is designed to absorb a majority of the credit risk; while the higher rated tranches are designed to transfer risk.

Risk aversion is an important explanatory variable, as is the bid-ask spread. This is somewhat surprising as the risk aversion is difficult to measure, but this is consistent with the purpose of CDS. The bid-ask variable shows that as the CDS spread increases, so does the distance between buyers and sellers of CDS. Again, this is consistent with what one expects to find during times of stress in credit markets.

Lastly, it needs to be noted that the R^2 score for each of the tranches in the regression is fairly low, suggesting that the model is only accounting for a small fraction of the overall movement in the price of the CDX tranches. The same model is run using data from July 2007 through January 2008 and the R^2 scores nearly double, indicating that the factors of the regression are more telling during periods of economic stress. While the model is not very predictive or precise, it is a good preliminary step in an area of research that has gone surprisingly unnoticed.

The study also estimates the R^2 of block-wise regressions on the CDX Tranches before and after the credit crisis, though the cut off for the crisis here is July 2007, which is the low point in the CDX spread of the dataset.
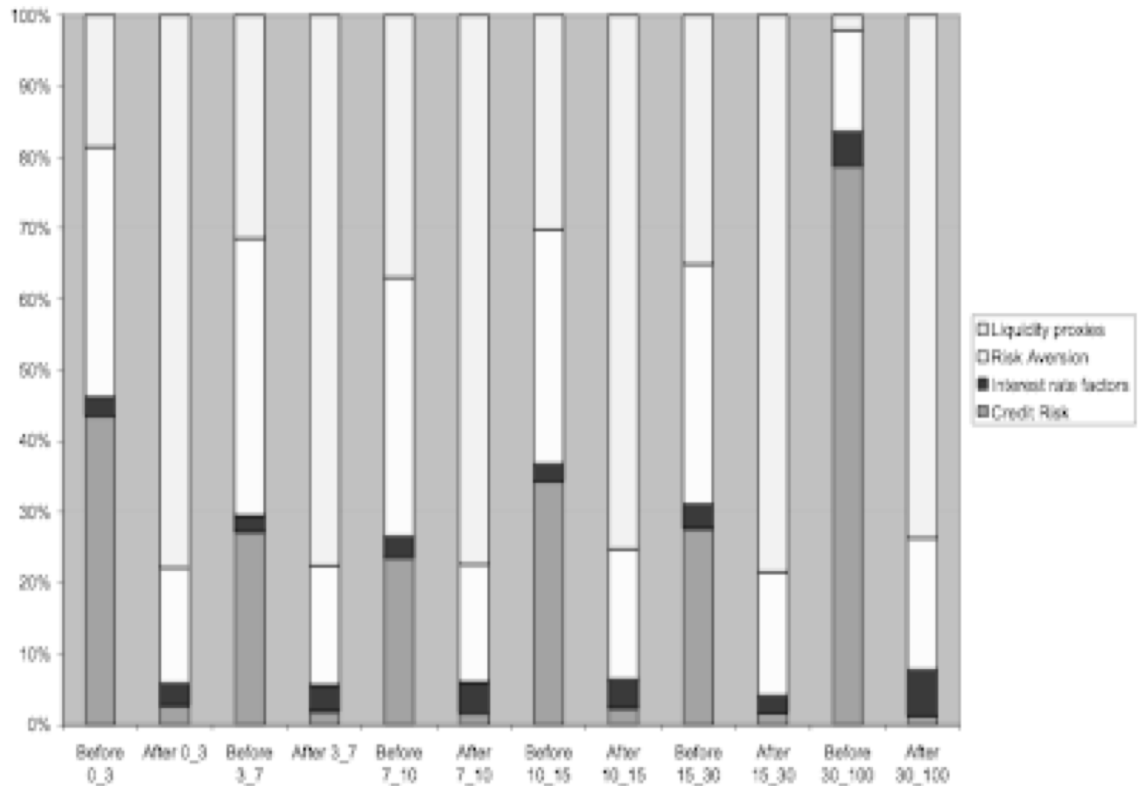
Source: Scheicher 2008

The surprising aspect is the drop in the explanatory power of the credit risk variable and the corresponding increase in liquidity proxies in all tranches. One might expect credit risk to become a greater concern than liquidity during a crisis, but the two are closely related. The risk aversion variable accounts for more R^2 score pre-crisis then post-crisis. The proxy for risk aversion is the JP Morgan index. The liquidity proxies are the swap spread and bid-ask spread. One can understand the change since in the severe crisis liquidity concerns and credit risk are similar to firms. Perhaps the author could have included a variable to incorporate FHCs, DBDs and CDO based SIV balance sheet health into the study as a potentially more accurate measure of the need for liquidity, as these

agents are vital to maintaining a balanced and orderly structured finance market. If CDS

prices represent both credit risk and liquidity concerns then the goal of using them to

price credit risk transfer is not accurate.

Overall, research into the CDS market has not produced a compelling narrative to

justify its position as the cornerstone for CDO models. If CDS are to be used as an

alternative to historical default data they need to follow the assumptions of EMH. It is

through this theory that the CDS market gains its stability and predictive power, but the

data used in this study has been shown to break every assumption of the EMH. The

distribution of prices does not fall into a normal Gaussian distribution. The data shows

kurtosis, skewness and has far more extreme observations than should be expected. The

ability for arbitrage in the market is limited by the structure of the market as well as the

lack of an appropriate asset with which to hedge. The assumption of independent

observations following the rules of Brownian motion was shown to be invalid through the

estimation of the Hurst exponent. Since the dataset appears to vary the significance of

possible pricing factors when determining spreads and correlations with equity markets,

CDS likely do not follow the assumption of a fair game. Further, there are indications

that concerns other then credit risk effect CDS prices.

Each assumption was then tested using CDS data from 2005-2010, dates that

define two vastly different periods in the credit markets. The results challenge every

assumption of the EMH to some extent. The data suggests that CDS prices are much

more volatile and unruly than the EMH predicts. Given the sensitively of the CDO model

to even small changes in CDS pricing, these conclusions are troubling to overall financial

stability because senior AAA-rated CDO tranches are treated by regulators and the market to essentially be risk free.
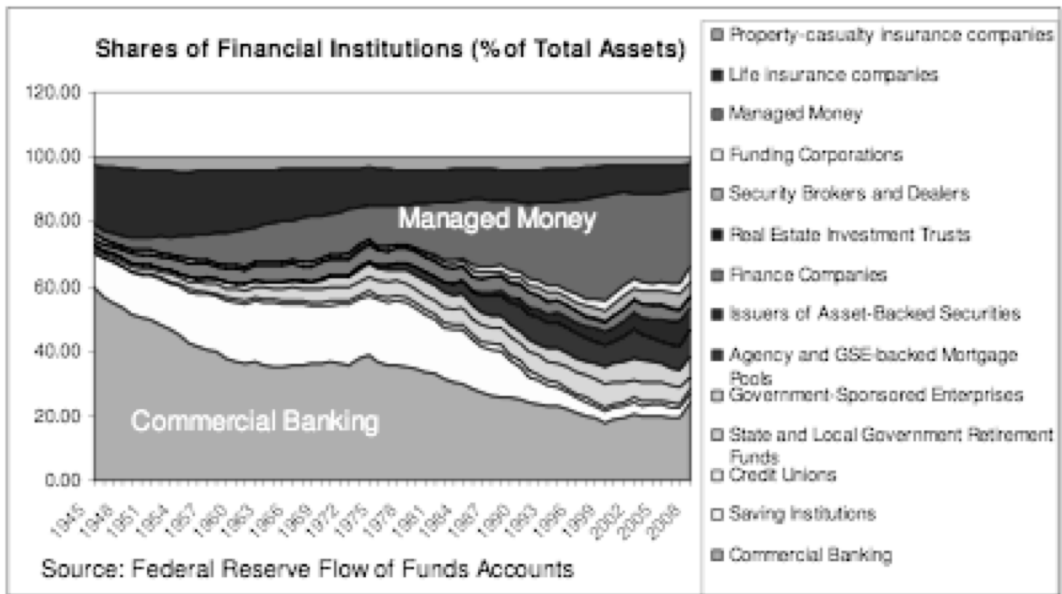
CHAPTER THREE: THE EFFECT OF STRUCTURED FINANCE ON ECONOMICS STABILITY

The purpose of section III is to combine the market structure aspects of section I with the modeling aspects of section II to show how the shortcomings and speculative nature of structured finance can impact on stability of the real economy. Recall that CDSs and CDOs only gained prominence in the financial markets in and around 2000. The credit crisis represents the first major challenge to their development. While the tools and techniques of structured finance certainly hold potential to increase economic stability and efficiency, it is important to understand their limitations in light of the crisis. Also discussed in this section are the tentative first steps by the Frank-Dodd Act and the BIS at reforming the structured finance market.

Structured finance has been an innovative force in financial markets since just before the repeal of Glass-Steagall. There is a good reason for these developments; structured finance can allow risk to be transferred to the investors that are willing to bear it and away from those who are not. When markets function within the baseline assumptions of the CDO model discussed, the result is a complex interrelated financial system where firms use market-based funding options to take on roles that were typically

held by deposit taking institutions. This allows for efficiency gains as firms are able to concentrate their energies on specialized and marginal lending areas, giving borrowers access to credit at a lower cost and greater quantity than is typically available under traditional banking systems. Financial intermediaries are able to manufacture a full spectrum of rated securities, connecting investors with the exact amount of credit risk needed for their portfolio. Financial regulators are largely left on the sidelines in this system, replaced by market-based alternatives that give investors confidence in the form of various credit puts and guarantees.

The tools and techniques of structured finance has allowed the institutions that comprise the shadow banking system to grow at the expense of comparatively stable commercial banking. Commercial banking comprised 60% of total financial institution assets in 1945, but as the regulations of the New Deal were slowly replaced by deregulation and market-based sentiment, commercial banking market share dropped to around 35% of assets. This means that the banking regulations that were devised to stabilize the financial sector of the economy have been either repealed, or effectively circumvented by the financial innovations of structured finance.

Shares of Financial Institutions (% of Total Assets)

Legend:
- Property-casualty insurance companies
- Life insurance companies
- Managed Money
- Funding Corporations
- Security Brokers and Dealers
- Real Estate Investment Trusts
- Finance Companies
- Issuers of Asset-Backed Securities
- Agency and GSE-backed Mortgage Pools
- Government-Sponsored Enterprises
- State and Local Government Retirement Funds
- Credit Unions
- Saving Institutions
- Commercial Banking

Source: Federal Reserve Flow of Funds Accounts

Source: Nersisyan, Wray 2010

This approach to financial policy allows for the greatest amount of freedom for agents to innovate using market based solutions, which is thought to increase efficiency and create a more robust and dynamic system. However, the credit crisis showed that the risks associated with banking, such as credit and maturity transformation are not transferred to the agents who are most able to bear the risk, but are transferred to the agents most willing to bear the risk. Further, these agents are constrained in ways that are not accounted for in the models.

The emphasis that financial institutions placed on CDOs during the credit boom years created further complications in terms of the capital structure of financial institutions. Section I noted that rather than selling AAA-rated tranches to investors, some FHC and DBD intended use these securities to fund their capital structure. In 2006, ABS CDO securities comprised 20% of total bank holdings (Nersisyan, Wray 2010:14). The unattended risks in the CDO model noted in section II make this practice hazardous.

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The private market credit guarantees that FHC and DBD offer, which require firms to buy back securitized assets at par if they fall below a certain value, can serve to further destabilize the financial system.

Another aspect of concern is the heterogeneous nature of market participants. EMH assumes that all participants respond to identical situations in identical ways after their actions are adjusted for risk. This is certainly not the case. Many agents are constrained by ratings, investment goals and legal considerations.

Heterogeneously constrained market participants are likely to create pricing volatility greater than what the EMH would suggest. There have been attempts by economists to model heterogeneous agent behavior in markets. Farmer and Foley argued in their 2009 Nature article that economists should pay more attention to advances in this area and incorporate agent-based modeling techniques into studies of various economic issues, especially in finance and banking.

Thurner, Farmer and Geanakoplos (2009) use a simple agent-based model to show how traders working under two different assumptions of an asset's value, either fundamental value or momentum, can account for market volatility as the market alternates from one pricing mechanism to another. Their conclusions are consequential to the overall structured finance market.

It is important to remember that the market for CDOs is not a homogeneous group of profit maximizing agents as the EMH assumes. Section I of this paper discussed the operational motives for participants in the structured finance market. These participants have differing reasons to hold these products. They range from highly leveraged credit

arbitrage hedge funds who intend to trade various rated CDOs tranches to maximize the fund's return, to DBDs who largely intend to hold highly rated CDOs tranches and use them as collateral to facilitate the firm's CDO pipeline or sell them onwards to investors. Other significant market participants are pension funds that typically hold AAA-rated CDOs with cash flows that closely match future liabilities. Each of these agents has different reasons for buying and holding CDOs and is governed by different constraints when holding these securities. This can account for the high level of volatility observed in the CDX markets.

In addition to heterogeneous agents, there are two other ideas that need to be identified in order to fully describe the structured finance market. When firms hold structured finance products on their books as assets there are certain accounting rules that need to be followed. Specifically, there are the rules associated with mark-to-market accounting. If a firm sells a CDO for 0.80 cents on the dollar, then that firm must also price the remaining similar holdings at the same price, even if they are to be held to maturity and the yield to maturity value it greater than the market value. Further, other firms holding similar CDOs must also price their holdings at the same price until another transaction takes place at a higher price. This is especially consequential for FHCs, DBDs and leveraged hedge funds that use these assets to meet capital or margin requirements.

Another constraining aspect of structured finance is its reliance on ratings. Many market participants are ratings constrained. As mentioned in section I, credit arbitrage SIVs must maintain a certain credit rating of their holdings, which is established at their inception. If the rating of one CDO tranche falls below this predetermined level it must

be sold, even if the long-term prospects for the tranche are positive. Pension funds are often required to do the same, even if a rational investor might determine that holding the downgraded asset is the best option. These constraints mean that market participants are very reliant on the ratings agencies' ability to correctly forecast correlation and default levels between assets. The Zhang study showed empirically that this is a difficult task. It is also shown that correlation, default levels and CDS price volatility tend to be clustered in times of economic stress.

The imperfection of the valuation models used to rate CDOs is evident from the high level of rating downgrades observed during the credit crisis. In 2007 alone, Moody's downgraded 31% of all asset-backed CDOs it had rated. Of those downgraded, 14% were initially rated AAA (BIS, 2008). Further, 27 of 30 tranches underwritten by Merrill Lynch in 2007 saw their rating downgraded from AAA to junk (Craig, Smith, and Ng 2008). This is very consequential for ratings constrained firms.

The shadow banking system, with the shortcomings that have been identified, can create financial issues that can spill over into the real economy. The stability in the credit markets that allowed for the innovations of structured finance to flourish also allowed unattended risk to grow. Consider the following example that ties together the issued raised in sections I and II. First, assume that due to the errors identified in the pricing model, several highly leveraged credit arbitrage SIVs are forced to liquidate their positions due to insufficient cash flows from their CDO portfolio. This could be due to higher than estimated correlation levels among the pooled assets. The defaulting assets

mean that the SIV lacks the cash flow to maintain their commitments to investors, pushing the SIV into liquidation.

Due to high systemic risk that is embodied in correlation levels within CDO assets, nearly all investors in the market are likely to also be experiencing stress from lower than expected cash flows from their structured investments, limiting their ability to absorb the additional supply coming to market. The sale of equity tranches from several SIVs will cause additional CDO investors, credit hedge funds for example, to sell their tranches due to mark-to-market accounting reasons. These assets are now unable to sustain the same level of leverage when being used as collateral, which requires some assets to be liquidated for the fund to meet their margin requirements.

The additional supply of CDOs lowers their market value. Due to the complex and opaque nature of the market, investors are slow to buy CDOs on the secondary market. However, one of the ways shadow banking has been able to suspend investors' concerns about the products of structured finance is to offer credit enhancements. These enhancements come in the form of 'puts'. The enhancements that FHCs and DBDs offered investors come due as the market value of CDOs fall below a predetermined level. This forces FHCs and DBDs to buy these assets at par value.

FHC and DBD holding defaulting CDO tranches purchased at par value must value these securities much lower for mark-to-market and credit risk reasons, effectively diminishing their capital reserves. Also, with these negative developments, the CDO manufacturing process that both DBD and FHC are involved with stops, as the price for their product collapses. This leaves both FHCs and DBDs holding illiquid assets. For

capital requirement reasons, some FHC and DBD will be forced to sell AAA-rated tranches, creating the same feedback loop as with the lower rated tranches.

Rating agencies will also react to the increasing default rates in the CDO market by revising their ratings. This may force any ratings constrained agent to sell their CDO assets, further deepening the negative feed back loop. MMFs of various types discussed in section I will also respond by limiting their exposure to the CDO and ABS manufacturing process. This loss of liquidity will cause leveraged CDO producers to sell assets to meet their margin requirements, further deepening the negative feedback loop.

Early in the credit crisis FHC Citibank was found itself exactly the same position as outlined above. In 2007, the firm was sponsoring seven off-balance sheet SIVs that experienced problems accessing the ABCP market and also faced ratings downgrades on their holdings. Citigroup's sponsorship of the SIVs included put options, which required that they save investors from losses by purchasing the ABCP at above market value prices, as well as funding the SIVs internally from then on. Citigroup booked a $212 million loss by saving these SIVs. By the end of 2007, Citigroup's tier 1 capital ratio fell to 7.16 percent, from 8.6 at the end 2006 (Jabłecki, Machaj 2008). The industry average for a well-capitalized bank is considered to be 8 percent.

This illustration shows the problems created when aspects of the CDO pricing model do not follow the assumptions made. The clustering of default-implied asset correlations observed in the Zhang study, combined with rapidly increasing CDS spreads observed in the Markit data, creates the possibility of significant economic problems due to systemic risk posed by the structured finance system. Even if the modeling of these

products was flawless, the highly leveraged and interdependent nature of the shadow banking model means that one poorly run entity can potentially trigger a collapse in asset prices due to the exogenously determined constraints of market participants. Mark-to-market accounting rules mean that if one firm is forced into a fire sale of assets, then all firms holding that asset are forced to absorb the additional supply. If they can not, or will not, a negative feed back loop may begin.

If a negative feedback loop does begin in the opaque structured finance market, the consequences to the real economy are dramatic. The situation outlined above forces financial sector agents to sell assets that do not fall under the general category of structured finance, such as equities and single name bonds, as they struggle to meet liquidity concerns of the greater market. Keynes mades the following pertinent statement in The General Theory of Employment Interest and Money (1936):

> "Of the maxims of orthodox finance none, more surely, is more anti-social than the fetish of liquidity, the doctrine that it is a positive virtue on the part of investment institutions to concentrate their resources upon the holding of "liquid" securities. It forgets that there is no such thing as liquidity of investment for the community as a whole. The social object of skilled investment should be to defeat dark forces of time and ignorance which envelop our future. The actual, private object of the most skilled investment today is "to beat the gun", as the Americans so well express it, to outwit the crowd, and to pass the bad or depreciating, half-crown to the other fellow (p.155)."

This conclusion is as valid today as when it was first published. The situation observed in the Scheicher (2008) CDS study where liquidity proxies have an increased explanatory value post crisis serves to confirm this idea. This 'liquidity fetish' may be caused by FHC and DBD other market participants leaving the CDO market in order to

redeploy their assets elsewhere due to capital or credit enhancement requirements. The demand for liquidity to shore-up balances sheets becomes more of a concern than risk aversion in such a situation.

This rush to liquidity caused by the unraveling of the CDO market serves as the link to the real economy. When the financial sector as a whole surges towards liquidity the ripple effect causes other assets to fall in value. It also prevents the financial sector from extending loans and lines of credit to the real economy, further increasing the 'fetish of liquidity' to agents that are not directly impacted by the negative events in the CDO market.

Liquidity concerns are of particular importance to FHCs and DBDs as the credit put enhancements that they offer to induce investors to buy CDOs and CLO require them to have the capital ability to purchase those assets at par value if their market value falls. At the same time, their purchasing power is limited by the fact that the structured assets they hold on their balance sheet have deflated in value, limiting their ability to purchase additional assets. When FHCs and DBDs have diminished capital reserves and a legal requirement to purchase assets, they are forced to curtail other activities.

The capital-intensive process of securitizing assets in the shadow banking system is also likely to halt as investors turn to other more liquid assets. The consequences are different for various agents in the market. FHCs will be forced to support their subsidiaries. As noted in sections I, the business model for FHCs is to manage bankruptcy remote pipeline of interconnected subsidiaries that manufacture CDOs. However, this pipeline works under the assumptions that the valuation models are

correct, which has been shown to not be the case. Therefore, the subsidiaries that are considered remote under normal assumptions are actually very near to the FHC at exactly the point in time when they are most vulnerable. However, depending on the strength of the FHC parent, the subsidiary will likely be able to survive the downturn, which is not the case for other entities in the shadow banking system.

Independent operators will likely face default as they will lack counterparties with which to conduct business and access credit markets. The credit crisis of 2007 caused nearly all independent operators to liquidate, as they lacked the support of a FHC parent (Pozsar, et al. 2010). For this reason, the independent aspect of the shadow banking system is not discussed at length in section I.

DBD are also at considerable risk for default due to any downturns in the structured finance market. The structure of the shadow banking system means that DBD are largely limited to nonconforming mortgages, as opposed to FHCs who are able to access other areas of the lending market. This concentrates their credit risk to non-confirming and sub-prime mortgages, which have the significant sensitivity to CDO pricing models. These lower quality assets require more time to be securitized and have limited appeal to investors. Also, DBDs lack access to wholesale credit markets to support the production of CDOs and instead rely on FHCs and their subsidiaries in order to facilitate this access. DBDs also leverage their trading book to support CDOs either for arbitrage purposes, or to wait for investors to purchase these securities.

DBDs are therefore very vulnerable to problems in the CDO market. First, they need FHCs to support their production of ABS. Any problems in the CDO market that

creates problems for FHCs might cause them to lose their ability to offer this type of credit support. Like FHCs, DBDs use CDOs on their balance sheet to leverage other assets. Any downward pressure on CDOs causes them to lose their collateral value and requires assets to be sold to meet capital requirements. Unlike FHCs, DBDs lack access to the Fed discount window and access to stable consumer savings deposits.

Each aspect of the shadow banking system is vulnerable to instability in the structured finance market. Yet, this market is based on faulty assumptions and baseline conditions that are unlikely to be consistent through the business cycle. The result is not an interconnected system of price-taking agents exploiting any pricing inefficiencies in the credit market, delivering a lower cost of borrowing and thereby increasing overall efficiency and decreasing systemic risk.

Instead, the result is a system that can function as smoothly as described above for some time, but the stability that this creates leads firms to press further into more marginal lending areas, to take on higher levels of leverage or to use unreliable wholesale funding sources such as private money market funds. The perceived stability that structured finance can create makes firms more vulnerable to the instability that structured finance is likely to create for the reasons listed in section II. These issues are further complicated by the concentrated nature of the American banking sector. In 2010, the top four banks held 60 percent of total assets (Nersisyan, Wray 2010). The importance of this concentration is magnified by the banking sector's reliance on non-interest income producing activities, which accounted for 44% of total bank income in 2007 (Mishkin 2007). This includes such activities as the trading and manufacturing of

CDOs. Concentration in the banking sector, combined with a reliance on structured finance cash flows creates a fragile system where each bank depends on only a handful of counterparties to conduct business that is vital to their financial health.

These four FHCs create a situation where there exists a high level of agent homogeneity in financial markets, all operating with nearly identical business models. Their monolithic actions serve to increase cross-market correlations (Eatwell 2008). This creates the potential for market imbalances in asset class to quickly spread to other areas as all FHCs respond to financial stress in identical manners. Agent based modeling studies have shown that financial markets based on a small number of large financial institutions are more stable to small disruption than heterogeneous markets, but more fragile to large disruptions (Stiglitz, Gallegati 2011).

As Keynes states in The General Theory "it is better for reputation to fail conventionally than to succeed unconventionally" (1936:155). This well cited quote helps to explain why structured finance rose to such bubbly highest during the boom years and, in context of the overall market, why the subsequent crash spread from CDOs to nearly every asset class. When the market was functioning as modeled in the 'Great Moderation' period, agents had an incentive to be a part of its growth. During that time CDOs were seen as a safe and highly profitable product and the cornerstone for maintaining capital requirements. Agents responded by increasing production as quickly as possible, relying on leverage to speed the process. Those who saw the potential for excess and paused were pushed aside by more aggressive competitors.

When taken together, the financial sector is fragile on both sides of the balance sheet. The cash flows from structured finance activities that FHC and DBD rely on can be binary in nature, working well in one period only to halt in another period. Using CDOs to meet capital requirements creates a conduit in which financial fragility extends from the financial sector to the real economy. This creates the possibility of a situation where financial institutions will be forced to curtail lending activities to meet other requirements. Private market guarantees on CDOs create a mechanism on the debit side of the balance sheet.

The emphasis of modern finance has been on structured finance and the associated innovations that have allowed it to flourish. The shadow banking system created a steady flow new highly rated CDO securities that appeared to many investors to be risk free. The perceived safety of these securities was based on the prevalent assumption that markets were nearly always efficient. This assumption combined with the development of the CDS market created an excellent tool to price risk transfer. CDO appeal was further increased by various private market guarantees. The credit boom years of the great moderation served to validate these assumptions. With the affirmation of the market, agents pushed further into more marginal lending and increased their leverage.

The repeal of Glass-Steagall allowed for market consolidation, bringing together specialized ABS producing firms with the deep capital pools of FHCs. These new firms were able to increase the production of CDOs, which effectively increased the availability of credit to the market. This success reinforced itself as the financial sector

further consolidated and became reliant on structured finance for income, but also as an alternative to more expensive traditional core-capital assets.

Minsky's financial instability hypothesis suggests that this type of stability hides an underlying instability. As lenders and borrowers become overly optimistic about future economic conditions, they become willing to incur additional debt to take advantage of those conditions. The expansion of credit that the structured finance market creates accommodates just such behavior. The mechanism for moderating this economic optimism in structured finance is CDSs, as rising spreads lower the value of CDO and their appeal to investors. The assumptions for EMH need to hold for this to be the case. Unfortunately, these assumptions have been shown to be transient in nature at best. The stable periods are very profitable for the shadow banking system and serve to reinforce the positive aspects that surround CDOs, allowing them to be viewed by the market as alternatives to traditional single name bonds. The low relative cost of AAA-rated CDOs compared to traditional bonds encourages FHC and DBD to prominently use them in their capital structure. The unattended risks of CDO models, mainly their potential for high volatility, increases the fragility of the financial sector.

Under Minsky's theory, the problem with structured finance is not that it does not work, the problem is that it almost works to well. It appears to some that the risk of lending is transferred to an agent who is prepared to absorb the risk for a fee. This allows for a traditional connection between lender and debtor to be recast, resulting in a system where each agent is able to discount the effects of their actions because nearly every traditional credit market concern can be transferred to another agent. Lenders are willing

to increase the availability of credit because they will not bear the full effects of the credit risk. The borrowers will absorb the increased supply of credit because the lender is not concerned with the borrowers proposed use, allowing for adverse selection to occur. Investors are willing to buy CDOs because they are only buying aspects that theoretically fit their risk profile. This system will grow until something triggers a reassessment of risk in the overall market.

The credit crisis caused this type of risk reassessment. The exact cause is debatable, but the market certainly revalued the products of structured finance. CDSs, the instruments that helped to support the stable nature of CDO pricing models, now have similar volatility to equity markets. Many of the insurance firms and hedge funds that offered credit protection have either liquidated or severely limited their exposure.

The entire shadow banking sector came to a halt at the end of 2007 and was completely reliant on Federal Reserve liquidity programs to stave off disaster. "Indeed, the Federal Reserve's 13(3) emergency lending faculties that followed in the wake of Lehman's bankruptcy amount to a 360 degree backstop of the functional steps involved in the shadow credit intermediation process" (Prozsar et al. 2010). Each step of the shadow banking system outlined in section I was given government-backed access to liquidity. This type of intervention created the equivalent of Federal Reserve discount window access and FDIC insurance that the traditional banking sector enjoys, but without comparable regulatory oversight.

Despite the perceived gains that shadow banking creates in the area of risk management, the only way to resolve the issues of the credit crisis was likely through

government intervention. Shadow banking has been able to sidestep regulation designed to make banking stable, but due to its systemic importance, is still able to receive government support. The result is a financial sector that is able to operate with profitability as the main and unfettered goal, without being limited by stabilizing, but costly, financial regulation

Regulatory Reform Efforts

Efforts to reform structured finance generally come from three schools of thought. The first school sees CDOs and CDSs as a destabilizing force that should be removed from the market entirely. Another school sees structured finance and its associated products as the future of finance, despite the challenges the credit crisis presented. The third school is more pragmatic, neither believing that structured finance is entirely without merit, nor the single answer to all economic and financial problems.

Thus far, most policy makers are siding with the third school of thought. The Dodd-Frank act is probably the best example in financial policy change to date though it does rely heavily on the recommendations of the BIS, in the form of Basel III. The tone of this regulation suggests that policy makers believe that structured finance and the shadow banking system are in need of a few structural changes, such as bringing CDS trading onto a central exchange, but not in need of a complete overhaul. Under Frank-Dodd, the Glass-Steagall act will see another incarnation in the form of the Volcker rule, but the exact details of law are still to be determined. Given the regulatory capture that seems to be prevalent today, the application of the rule will likely be modest.

The Basel III accords will have a greater impact on how structured finance effects economic stability. First, there will be an increase in the capital requirements and restrictions on asset composition. The capital requirement ratio will build to 7% by 2015 and must consist of only common shares and retained earnings. According to BIS studies, this reduces the annual probability of a banking crisis by at least one percentage point (Walter 2010). CDOs are directly targeted by the new regulations. Under Basel II, AAA-rated CDOs had a capital requirement of 20%. Basel III will shift this upwards, perhaps as high as 30%, The Dodd-Frank act requires that CDO producers retain a 5% of the risk-adjusted value of their product (Dodd, Frank 2010). Also, off-balance sheet activities must be accounted for with capital requirements under the new regulations. Basel III does not allow AAA-rated CDOs to serve as Tier I capital, as was permitted by Basel II through the use of CDO-based trust preferred securities. This change will serve to make banks capital structure more stable. Also, banks that issue credit enhancement in the form of 'puts' on CDOs must deduct 50% of this exposure from their common equity Tier I capital requirement (BIS 2010).

One potential area for reform that has received much attention is the 'too big to fail' argument. However, FHCs are more concentrated now than before the crisis. The top four FHCs now account for 60% of bank assets, up from 40% in 2007 (Nersisyan, Wray 2010). In responding to the crisis the Federal Reserve actively encouraged relatively healthy FHCs to merge with or buy less stable competitors. This resulted in JP Morgan buying Bear Sterns and Washington Mutual, Bank of America buying Countrywide and Merrill Lynch, and finally Wells Fargo buying Wachovia. This movement towards

consolidation proved to be a more palatable alternative to bankruptcy, as Lehman Brothers showed. However, the long-term consequences are increased moral hazard concerns, increased cross-market asset correlations, as well as homogeneous financial market agents.

The Dodd-Frank Act does create a resolution authority to wind down failing financial institutions with the creation of the Orderly Liquidation Authority (Dodd Frank 2010). The idea that the Federal Reserve could act in a fashion similar to the FDIC and have the power to orderly wind-down a large FHC or DBD, rather than provide the firm with publicly supplied liquidity is an appealing option. However, this legislation has such a large loophole that it essentially does not provide any meaningful change. The Orderly Liquidation Authority does not apply to cross-border firms (Boone, Johnson 2011). This means that any FHC or DBD that has operations outside of the United States is unaffected by the law.

The Federal Reserve has developed new lending facilities since the crisis to help provide liquidity to the shadow-banking sector. Section I identified money markets as a key source of funds for the structured finance manufacturing process. Because of this importance, the Federal Reserve now operates the Money Market Investor Funding Facility (MMIFF), which essentially opens the Federal Reserve discount window to MMFs holding ABCP and Repos. As a result, this important aspect of funding, which at one point was larger than the traditional banking sector, now has protections to avoid credit runs (Federal Reserve 2009). However, this access does not come with regulatory oversight.

These changes will not solve all the issues that structured finance has created. The experience of the credit crisis has shown the market that assumptions of the traditional CDO model are not valid. Rating firms have responded by turning to alternative models that better account for market volatility, such as GARCH, in response. Overall, the market is slowly adapting to the lessons from the credit crisis. These adaptations have been small and fail to acknowledge modeling limitations. GARCH models still rely ex post observations that might serve to increase herd behavior, for example.

Basel III, Dodd-Frank, modeling changes and new lending facilities are all steps that should help structured finance find its role in financial markets. The regulatory changes outlined above will make the products of structured finance and shadow banking less profitable as the market is forced to fully price their risk levels. However, the financial sector as a whole should be more stable as it again becomes centered on traditional assets to meet tier 1 capital requirements. Lacking from any current regulations are attempts to regulate shadow banking in a way that is consistent with traditional banks.

This aspect is even more troubling today because the market based activities of structured finance now have explicit access to government funds, but without any corresponding regulatory requirements. The increased capital requirements of Basel III should make FHCs more stable, but counteracting this benefit is the increased levels of market concentration. As the works of Stiglitz (2011) and Eatwell (2008) point out, market concentration in the financial sector is a destabilizing force in the long run.

Structured finance has the ability to improve lending efficiency, but it also creates new issues that are not always apparent. These regulatory changes will allow the market to account for these potential issues and also to have a greater margin of error if the market fails to correctly price risk, as they have been shown to do. However, structured finance allows the shadow banking sector to conduct the credit transformation activities of traditional banking without traditional banking regulation. Until this fact changes, the financial system will remain fragile

Conclusion

Structured finance has been an important force in the expansion of the financial sector relative to GDP since the 1980s. From its basic roots in GSE mortgage pass-throughs, the structured finance market has evolved into a complex system that allows for low-quality assets to combined into highly rated securities that earn low capital requirement charges. However, the credit crisis showed that these securities do not always perform as modeled.

The CDO model analyzed in this section was an elegant innovation that drastically simplified the complex nature of the asset in a way that allowed both regulators and investors to suspend concerns they had about these assets and treat them as they would any single name bond. This was done in two steps, first a rating agency would determine the correlation level between assets composing the underlying pool and then a hazard rate function would be created using the information contained in market-priced

CDSs. The calm, placid nature of the credit markets from 2002- 2007 reinforced the idea that CDOs can be treated as single name bonds using these simplifications.

This approach is fundamentally flawed on each and every level. Asset correlations are constantly changing, not constant as assumed. Further, the crisis has shown that correlation levels can be much higher than experienced in the past. The sensitive nature of the CDO model to asset correlations complicates matters further. Using CDS to price credit risk is problematic as well.

CDS are the cornerstone of the CDO pricing model because they are used to create the hazard rate function. The theoretical backbone that ties CDS spreads to the hazard rate function that is used to price credit risk in CDOs is the EMH. This theory is perhaps even more elegant and far-reaching then the CDO model used in structured finance because of its ability to quantify credit risk and effectively price that risk. In fact, EMH can be used as the economic justification for structured finance in general. However, the assumptions that are needed to give this argument strength fail to stand up to quantitative tests. Consequently, most important aspect of pricing CDOs will not perform as anticipated. CDO pricing varies widely and might be influenced by factors other than credit risk. Most troubling is that the credit crisis showed both asset correlation levels and CDS prices both behaved in unanticipated ways at the exact same time.

These factors create a CDO model that is not based on sound theoretical footing, but one that is based on assumptions that, while periodically valid, have also been shown to be spectacularly incorrect. This causes the performance of CDOs to appear stable during times of economic growth, but to be highly unstable during times of economic

stress. Structured finance creates risks that are different from traditional bonds, but the model leaves these risks unattended. If economic conditions vary from the model's baseline assumptions, senior rated CDO tranches do not behave like highly-rated single name bonds. Instead they behave in a fashion similar to the characteristics of the underlying pool, which is an untenable behavior for investors looking for risk-free assets or banks using CDOs to meet capital requirements. Given the risk aversion that AAA security investors hold, this presents a significant problem for macroeconomic stability.

Financial innovation often leads to economic disruption as these new products are stressed and behave in unexpected manners. Past examples of such innovations going wrong are easily found throughout financial history and range from investment trusts in the 1920s, to brokered CDs in the 1970s. When financial innovation has been shown to threaten economic stability, regulators have traditionally responded by adapting to meet the challenges that innovation has created. There is arguably no better example of this than the financial regulations of the New Deal.

The credit crisis has been the greatest downturn since the Great Depression. Yet, there has been little change in the regulatory approach taken by the government. Significant legal changes have been proposed and approved, but so far these changes include exemptions that make these new laws ineffective or even meaningless. The crisis showed that the actions of the financial sector reliance on structured finance can have a very real and negative effect on the greater economy. It is therefore necessary that the government treat structured finance for what it is, an extension of the traditional banking sector.

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