The Role of ABS, CDS and CDOs in the Credit Crisis and the Economy

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Abstract

The credit derivatives - ABS, CDS, and CDOs - played a significant role in the financial crisis affecting both the financial and real economy. This paper explains their economic roles, using the credit crisis as an illustration. It is argued that ABS are beneficial providing previously unavailable investment opportunities to market participants which facilitates the access to debt capital spurring real economic growth. If properly collateralized, CDS are also beneficial because they enable market participants to more easily short sell debt, thereby increasing the informational efficiency of credit markets. And, similar to mutual funds, CDOs provide investors with desired investments (cash flow streams) at reduced transaction costs. Prior to the credit crisis, CDOs were used to exploit market mispricings caused by the credit agencies' misratings of structured debt. These mispricings were persistent due to both the complexity of the CDOs and the dysfunctional institutional and regulatory structures present in the economy. The regulatory reforms needed in this regard are herein discussed.

1 Introduction and Summary

To understand the role of asset backed securities (ABS), credit default swaps (CDS), and credit debt obligations (CDOs) in the economy, one needs first to understand their role in the credit crisis. To help the reader follow the subsequent discussion a diagram of the credit crisis is contained in Figure 1. In this respect, three issues and their relation to these credit derivatives need to be understood:

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1. Incentive problems: (a) agency problems in the management of various financial institutions and investment funds, (b) the fee structure of the rating agencies, and (c) the effect of ABS and CDOs on the mortgage originators' lending standards.

2. Errors made by the credit rating agencies in rating both (a) corporate debt and (b) structured debt.[1]

3. Government regulation with respect to credit ratings, and government policies with respect to the expansion of mortgage loans to low-income households.

Like the "perfect storm, in conjunction these three forces interacted to create the credit crisis. Incentive problems introduced by the creation of ABS in mortgage origination as well as government policies regarding the desire to increase home ownership for low-income families led to lax lending standards by the mortgage originators. The lax lending standards of the mortgage originators and low interest rates created the excess demand for residential home ownership, fueling the housing price boom in the mid- to late-2000s.

The capital for the growing volume of these subprime mortgage loans came from two sources: government-sponsored agencies and private industry. First, government policies designed to encourage home ownership by low-income families increased the supply of these loan funds from the government-sponsored enterprises Fannie Mae and Freddie Mac. Second, an increased supply of these loan funds was also generated by the sale of credit derivatives (ABS, CDOs, CDO^2) held by financial institutions.

An incentive problem created by the payment fee structure of the credit rating agencies and their use of poor models led to the misratings of both corporate and structured debt. Next, the government's mandated use of these ratings and the complexity of ABS and CDOs lead to their widespread use. Investment managers, maximizing their short-term bonuses and not shareholder's wealth, had an incentive not to do their own due diligence. These short term incentives created an excess demand by financial institutions for investment-grade ABS and CDO bonds (in particular, the AAAs) with high yields. The result was that financial institutions' debt portfolios were exposed to more risk than the ratings of these ABS and CDO bonds implied.

Prior to the credit crisis, ABS provided unavailable investment opportunities to market participants, facilitating the access to capital for mortgage loans thereby spurring real economic growth. CDOs and CDO^2 were created to take advantage of market mispricings caused by the misratings of structured debt, called "rating arbitrage." The trading of these market mispricings should have increased the informational efficiency of debt markets, as the impact of the trades removed the arbitrage opportunities. But in this case, the institutional structures as discussed above enabled the mispricings to persist. As such, these securities facilitated a massive transfer of wealth from financial institutions who overly relied on the credit ratings to the CDO and CDO^2 equity holders in hedge funds and investment banks.

[1] Structured debt is is defined to be debt issued as an ABS or CDO or CDO^2.

With respect to CDS, they enabled market participants more easily to short corporate and structured debt, thereby increasing the informational efficiency of the debt markets. Unfortunately, there was a problem with the usage of CDS. Selling CDS is analogous to selling insurance on a debt issue. For the "insurance" to provide protection, the sellers of the CDS must be properly capitalized. This was not the case prior to the crisis. Due to the misratings of financial institutions, little or no collateral was required for highly rated financial institutions when selling CDS. In addition, the poor modeling of mortgage default risk created the incorrect perception that CDS prices reflected an arbitrage opportunity. This created an excess supply of CDS, resulting in the overselling of CDS.

When the supply of available mortgage borrowers diminished, the housing boom started to end. The existing subprime mortgage holders, mostly holding adjustable rate mortgages (ARMs) with teaser rates, started to default on their loans as interest rates increased and oil prices rose. These mortgage defaults generated significant losses to credit derivatives, wiping out the capital of financial institutions holding them. Financial institutions lost significant value from their investments in ABS, CDS, CDOs, and CDO^2s. The loss in aggregate wealth and the correlated failures of financial institutions froze financial markets with severe negative consequences to the real economy, eventually causing unemployment and a deep recession.

This analysis of the credit crisis clarifies the role played by ABS, CDS and CDOs in the financial and real economy. ABS facilitate the access to capital for loans, thereby increasing economic efficiency and lowering the cost of equity capital with a corresponding positive impact on the real economy. If properly collateralized, CDS are also beneficial because they enable market participants to more easily short sell debt, thereby increasing the informational efficiency of credit markets. And, similar to mutual funds, CDOs provide investors with desired investments (cash flow streams) at reduced transaction costs.

To fully obtain the benefits of these credit derivatives, however, regulatory reforms are needed. Regulatory reforms are needed to first remove the misaligned incentives of the mortgage originators, financial institutions, and rating agencies. This should correct the debt misratings issued by the credit rating agencies. Second, when trading credit derivatives, the participants need to be better capitalized to guarantee execution of the contracts. This can be accomplished via both increased exchange trading of various standardized credit derivatives and increased collateral requirements for customized credit derivatives trading in the OTC markets.

The remainder of the paper explains these arguments in more detail, with particular emphasis on the role of ABS, CDS and CDOs. An outline for this paper is as follows: Section 2 discusses the causes of the housing price boom, two of which were the short-term incentives of management in financial institutions and the credit rating agencies. These form the content of sections 3 and 4, respectively. Section 5 studies the credit derivatives (ABS, CDS, CDOs and CDO^2s) and their role in the crisis and the economy. Section 6 discusses why housing prices crashed. The paper ends in Section 7 with a presentation of the

regulatory reforms needed to avoid the problems associated with the trading of credit derivatives.

2 The Residential Housing Price Boom

The residential housing market and related construction industries are a large and important sector in the economy. In terms of a typical household's wealth, a home is one of the largest components. The recent credit crisis originated in the housing price boom and subsequent crash (see Figure 2). This was alleged to be a bubble, but the proof is still lacking (see Jarrow, Kchia, Protter (2011)).

To understand the cause of the credit crisis, one needs to start with an analysis of the boom and crash of residential housing prices. The key causes of the recent expansion in the housing price boom (early 2000s to the Crash) were low interest rates and a shift towards lax mortgage lending standards and easy credit. The lax lending standards occurred in the mortgage loan origination process, or mortgage lending.

2.1 Mortgage Lending

The market for mortgage loans is characterized by asymmetric information between the borrowers, who know their financial situation, and the mortgage lenders who have only incomplete information on the borrowers. Due to this asymmetric information in issuing loans, the loan origination process involves significant fixed costs related to setting up the infrastructure necessary to evaluate loan applicants, issue loans, service payments, and handle the legal process if default occurs. Consequently, loan origination is performed by financial institutions with the necessary resources and expertise.

The loan originators finance the loans they issue with debt and equity. This is direct lending. To take advantage of the economies of scale in their infrastructure, however, the loan originators often sell these loans to third parties. The third parties are: (i) the government-sponsored enterprises Fannie Mae and Freddie Mac and (ii) the entities that issue credit derivatives (ABS, CDOs, CDO^2)[2]. This indirect lending is called securitization.

There is an incentive problem with originating loans if mortgage originators do not hold the loans in their inventory. If the loans default, the costs are not borne by the mortgage originators, but by third parties. When sold to third parties, the mortgage originators are only responsible for fraudulently issued loans. Hence, under the right circumstances, indirect lending has the potential to generate lax lending standards where loans are issued in vast quantities to borrowers who should not receive the loans.

That the lending standards became lax has been well documented in the financial press[3], the academic literature (see, for example, Demyanyk and Van

[2] The details of mortgage related credit derivatives are discussed below.

[3] For example, see *New York Times*, "Lax Lending Standards Led to IndyMac's Downfall," Vikas Bajaj, July 29, 2008; *Los Angeles Times*, "Countrywide deal will pay off, BofA's to

Hemert (2011) and Purnanandam (2011)), and government reports (see U.S. Senate Report (2011)). Traditionally, mortgage loans were only issued to good credit borrowers, requiring large down payments, with a requisite documentation of income. In contrast, in the late 1990s and 2000s, loans were given to higher credit risk borrowers, called subprime borrowers, with little or no down payments and often without an adequate documentation of income. Although there is no standard industry definition of subprime, a working definition is a borrower who has a FICO (Fair Isaacs Corporation) score of 650 or less, a debt to income ratio of 40% or more, and a loan to value rate of 80% or more (see Nomura 2004a). Most subprime borrowers used adjustable rate mortgages (ARMs) in which the interest payments varied with short-term rates. Furthermore, to induce homeowners to borrow, teaser rates and/or no principal prepayments for a couple of years were common. When the teaser period ended, as long as home values kept rising, the mortgage could be refinanced at new teaser rates, keeping the mortgage payments low and affordable.

2.2 The Excess Supply of Funds for Subprime Mortgages

The right circumstances for the lax lending standards was caused by an unusually large excess supply of funds available for such mortgage loans in the 2000s. This excess supply of funds for subprime mortgage loans was generated by two interacting forces.

First, government policies were introduced that were designed to encourage home ownership by low-income families. The American Dream Downpayment Act of 2003 was introduced to provide financial assistance to lower income and minority households in order to increase the homeownership rate[4]. This increased the supply of funds available from the government-sponsored enterprises Fannie Mae and Freddie Mac.[5] Second, an unusual excess demand for subprime mortgage credit derivatives (ABS, CDOs, CDO^2) held by financial institutions and investment funds occurred. This excess demand generated, in turn, an increased supply of funds available for subprime mortgages through the credit derivative creation process[6]. Table 1 (in the appendix) shows the total outstanding mortgage backed ABS, both agency and private, in billions of dollars, for the years 2004 - 2010. As shown, agency-related ABS comprise the dominant percentage of this total, greater than 65% in all years. Also, note that the rate of increase in non-agency ABS from 2004 - 2007 is greater than that of the agency related ABS. It is an open question whether the government-sponsored enterprises' or the private institutions' securitization had a larger impact on the housing boom and the lax credit standards (see Belsky and Richardson (2010)).

There were two root causes generating this excess demand for subprime mortgage related credit derivatives by financial institutions and investment funds.

exec says," E. Scott Reckard, July 10, 2008.

[4] See www.hud.gov/offices/cpd/affordablehousing/programs/home/addi/.

[5] See E. Pinto, Acorn and the Housing Bubble, The Wall Street Journal, November 12, 2009.

[6] The process that generates these credit derivatives is discussed in a subsequent section.

One cause was the short-term incentives inherent in the compensation structures for the management of financial institutions and investment funds. The second cause was the incentive problems inherent in the way credit rating agencies are paid for their services. Each of these causes is discussed in turn.

3 Short-Term Bonus Incentives

Proprietary trading group managers at financial institutions and investment fund managers receive a significant portion of their compensation through a yearly bonus based on their short-term trading performance. This compensation scheme drives a wedge between the interests of the shareholders and those of the management, called the "agency problem." It is called the agency problem because managers in their activities act as agents for the firm's shareholders. The managers in those firms investing in investment-grade bonds[7] sought the highest yield to maximize short-term profits. The idea, of course, is that the credit ratings hold risk constant. Prior to the crash, AAA-rated ABS, CDO and CDO^2 bonds were paying significantly higher yields than equivalently AAA-rated Treasuries. Consequently, AAA-rated ABS, CDO and CDO^2 bonds were in great demand. In addition, as discussed in the next section, SEC and the Labor Department "prudent man" rules limited acceptable investments by money market funds and pension funds, respectively, to investment-grade bonds, and banking regulators restricted some financial institutions from holding speculative-grade debt. These regulations artificially increased the excess demand for investment-grade ABS.

Investment fund management depended on the rating agencies' ratings to judge the quality of the structured debt. They did this, partly, because the CDO and CDO^2 bonds had complex payoff structures, difficult to understand and to model. Hence the investment fund managers, motivated by their short-term bonuses, did not do their own due diligence. Nonetheless, they invested in these securities because the yields on AAA-rated ABS and CDO bonds exceeded those on similarly rated Treasuries. Although no one believed they were of equal risk, the majority of the market did not comprehend that the risks were as different as they really were.[8]

Although proprietary trading groups at large financial institutions had more expertise available to evaluate the securities, their incentive structures motivated their decisions, and they also invested heavily in the ABS and CDO bonds, examples include Merrill Lynch and Bear Stearns.

[7] For S&P's ratings, investment grade bonds correspond to the ratings AAA, AA, A and BBB. Speculative grade or junk bonds are those rated BB, B, CCC, CC, C. Default is rated D. Moody's ratings are investment grade (Aaa, Aa, A, Baa) and junk bond (Ba, B, Caa, Ca, C). Fitch's ratings are investment grade (AAA, AA, A, BBB), junk bonds (BB, B, CCC, CC, C), restricted default (RD), and default (D).

When discussing ratings in the text, S&P are used.

[8] Of course, there were some market participants and hedge funds who did recognize these risk differences, see for example, "Paulson's Hedge Fund Made Billions on Subprime Crisis," Monday, April 19, 2010, moneynews.com.

A similar situation occurred with the management of money market mutual funds, which invested in highly rated commercial paper issued by structured investment vehicles (SIVs). SIVs invested in ABS and CDO bonds, financing much of these purchases with short-term commercial paper. The money market funds invested in higher yielding SIV commercial paper to earn a spread above similar maturity Treasuries.

These investment strategies generated portfolios of bonds that were much riskier than portfolios of similarly rated maturity Treasuries. When the housing boom crashed and the underlying mortgage pools started defaulting, these bond portfolios lost significant value. If the portfolios had been in the similarly rated maturity Treasuries, no significant losses would have occurred.

4 The Credit Rating Agencies

Credit rating agencies evaluate corporate and structured debt issues, assigning them ratings of their credit quality. Information on a borrower's credit worthiness is costly to obtain with economies of scale in its collection. Once obtained, however, there is little if any cost to disseminate this information. As such, this asymmetric information market structure provides a natural setting for the existence of credit rating agencies.

4.1 Government Regulations

In the US, credit rating agencies are those firms designated by the SEC as "national statistical rating organizations" which include Moody's, Standard and Poor's (S&P), and Fitch Investor Services, among others. Across time, various government regulators have introduced rules that include credit ratings. For example, SEC regulations require the use of ratings in the issuance of certain types of debt. Both the SEC and the Labor Department have "prudent man" rules that limit acceptable investments by money market funds and pension funds to investment-grade bonds. Banking regulators (see the Basel I and II capital requirements) determine capital requirements for debt issues based on their ratings, with prohibitions on holding speculative-grade securities. This creates an artificial market segmentation in the financial institutions that can hold investment-grade versus speculative-grade debt. Ratings are also used to determining the eligibility of securities used as collateral for margin lending. These regulations mandating the use of credit ratings accentuate the importance of credit ratings in market activity. (For a more in-depth discussion of the credit rating industry see Cantor and Packer (1994).)

4.2 Incentive Conflicts

Rating agencies are paid by the entities that issue the debt. This payment is not a one-time fee, but better characterized as a stream of future payments for continued credit evaluations. It is quite common, therefore, that borrowers

choose among rating agencies based on the ratings obtained (see Coval, Jurek, Stafford (2008)). This payment fee structure creates a conflict of interest for the rating agency between issuing accurate ratings and retaining business clients (see U.S. Senate Report (2011); and Jarrow and Xu (2010) for an economic model of this conflict of interest).

4.3 Misratings

The credit rating agencies misrated both corporate and structured debt prior to the credit crisis. The evidence of corporate debt misratings are the failures or near failures (saved by government assistance) of the large investment and commercial banks Lehman Brothers, Merrill Lynch, Citigroup, the insurance company AIG, and the government-sponsored enterprises Fannie Mae and Freddie Mac, among others (see Table 2). The evidence of structured debt misratings are the massive downgrades of AAA-rated CDO debt to junk status in a couple of months during the midst of the credit crisis[9] (see also U.S. Senate Report (2011)).

The misratings occurred both because of the conflict of interest and because the rating agencies used poor models to estimate default risk (see Jarrow (2011b)). In addition to the poor models, the parameters estimated in their structured debt models were based on historical data that did not include the changed and more lax lending standards discussed below. This fact was knowable but conveniently ignored by the rating agencies.

Given the importance of accurate credit ratings in the industry, these misratings resulted in excess demand for subprime mortgage credit derivatives. This, in turn, resulted in investment funds having riskier portfolios than the ratings of the bonds indicated and in financial institutions having insufficient capital to cover the losses eventually realized in their loan portfolios. The latter caused the failure of these financial institutions and the financial crisis.

5 Credit Derivatives

This section discusses the economics of the credit derivatives used in the residential mortgage market: ABS, CDS, CDOs and CDO^2s. To understand the economics of their use, first consider an ideal debt market which satisfies the following "perfect market" assumptions:

1. frictionless (no transaction costs) and competitive (perfectly liquid),
2. no restrictions on trade, in particular, shorting is allowed,
3. a complete market, and
4. no arbitrage opportunities.[10]

[9] See *New York Times*, "Triple-A Failure," by Roger Lowenstein, April 27, 2008; *The Washington Post*, "Credit rating firms grilled over conflicts," by Amit Paley, October 23, 2008.

[10] There is a technical assumption that with the asymmetric information inherent in credit markets, all market participants must agree that the probability a borrower will repay is either strictly positive or zero. If non-zero, they do not need to agree on the magnitude of the

Frictionless markets and no short sale restrictions are self-explanatory. A complete market is one in which any cash flow pattern desired by an investor at a future date can be obtained by trading the available securities, perhaps in a dynamic fashion across time. For example, suppose an investor wants a cash flow of $1 in exactly one year if the 3-month Treasury bill rate is between 50 and 100 basis points at that time. In a complete market, the investor can construct a portfolio of traded securities, perhaps changing its composition across time, that would generate such a cash flow. The debt market is therefore complete if any such debt related cash flow at any future date can be so constructed by a dynamic trading strategy in the underlying debt issues.

An arbitrage opportunity is an investment portfolio that costs zero dollars to construct, never incurs losses, but with positive probability generates a positive cash flow at some future date. Such investment portfolios are "free-lunches" and assuming no arbitrage opportunities is consistent with a dynamic market where arbitrageurs' quickly remove any such mispricings.

Under these perfect market assumptions, credit derivatives play no additional role in the economy and there is no reason for them to exist. In such a setting (due to market completeness), a trader can create any credit derivative desired by trading in the underlying debt. To understand the role played by each of these credit derivatives in actual markets, therefore, the market imperfections that provide the economic rationale for their existence need to be understood.

As is perhaps obvious, the perfect market assumptions are not satisfied by the debt markets under consideration. First, debt markets are certainly not frictionless. The markets are illiquid with significant transaction costs in terms of bid/ask spreads and a liquidity impact on the price from trading. Second, although not prohibited, this illiquidity makes short selling a costly exercise. Third, asymmetric information, the variety of credit risks possible, and the lack of traded debt makes the credit markets incomplete. Fourth, the misratings of structured debt by the credit rating agencies introduced arbitrage opportunities into the economy.

Interestingly, the imperfections that created the need for the different credit derivatives - the ABS, CDS, CDOs and CDO^2s - differ. As will be argued below, ABS exist to make the debt markets more complete. CDS exist to facilitate the short selling of corporate, sovereign, and structured debt. And, CDOs, CDO^2s were created to exploit the "rating arbitrage" introduced by the credit rating agencies misratings of structured debt.

As discussed previously, asymmetric information is a key characteristic of debt markets. Asymmetric information makes borrowing more costly for all participants, and as noted earlier, it provides the economic rationale for the existence of credit rating agencies. When discussing credit derivatives, the role of asymmetric information enters by making equity capital costly. Equity capital is costly because in addition to the standard risk premiums for systematic risk (see Fama and French (2002)), the expected return to capital includes a second component, another risk premium, which compensates for the losses potentially

probability. This reasonable assumption is imposed without further clarification.

generated by asymmetric information. Since capital is costly to obtain (via debt or issuing equity shares), the use of financial instruments to avoid the use of capital will be an additional theme underlying our discussion of each credit derivative below.

5.1 ABS

This section discusses asset-backed securities (ABS), previously called structured debt. For the purposes of this paper, a distinction is drawn between ABS and CDOs. ABS hold untraded loans in their collateral pools while CDOs hold traded ABS bonds. The distinction will become clear once the definitions are provided.

An ABS is best understood as a liability issued by a firm or corporation, although the legal structure of the entity issuing an ABS is quite different from a typical corporation, usually a special purpose vehicle (SPV) (see Fabozzi (2000)). A firm's balance sheet consists of assets and liabilities. Liabilities are divided into debt and equity. Debt are loans, with interest paid for the use of the funds. Equity represents the ownership of the firm's residual cash flows, after all debt obligations are paid.

The assets purchased by an SPV are called the collateral pool. It is the collateral underlying the SPV's liabilities. The collateral pool usually consists of a collection of loans of a particular type, for example, either auto loans, student loans, credit card loans, commercial real estate loans, or residential mortgages. In the discussion of the credit crisis below, the ABS of greatest interest are those with residential mortgage loan collateral pools. The liabilities issued by these SPVs are often called RMBS (residential mortgage backed securities). To simplify our terminology, however, we will still refer to these RMBS as ABS.

To help finance the purchase of the collateral pool, the SPV issues debt. The debt is issued in various tranches or slices, from the senior bond tranches to the mezzanine to the junior bond tranches. These bond tranches have different claims to both the cash flows from the collateral pool and any losses realized on the collateral pool. The cash flows, consisting of interest and principal payments, are paid to the most senior bonds first, then the mezzanine bonds, then the junior bonds, with the residual going to the equity (see Exhibit 1). The cash flow and loss allocation across the various bond tranches is called the "waterfall." The losses are realized in the reverse order, starting with the equity first, moving to the junior, the mezzanine, then the senior bond tranches. As such, the senior bond tranches are the safest with respect to default risk, while the equity are the riskiest securities in this regard.

Assets	*Liabilities*	*Waterfall*	
collateral pool	senior bond tranches	cash flows $\downarrow$	losses $\uparrow$
	mezzanine bond tranches		
	junior bond tranches		
	equity		

Exhibit 1: The Cash Flow and Loss Waterfalls to an ABS.

Before issuing the various bond tranches in the market, because of the government regulations mentioned earlier, the ABS bond tranches need to be rated by at least one of the credit rating agencies, but more often two. Because of the waterfall, the senior bond tranches are rated more highly than the mezzanine, which in turn are rated more highly than the junior bond tranches, which may not even be rated. When constructing the SPV liability structure, the percentage of the liabilities that are senior is determined such that the senior bonds will be rated AAA. The percentage of bonds rated AAA is usually quite high (80 % or more for CDOs, see Nomura (2004b)). This is a key reason that certain ABS, in particular CDOs and CDO^2s, are created.

To understand the economic role played by ABS in financial markets, one needs briefly to return to the loan origination process. To take advantage of the economies of scale in the loan origination process, loan originators often sell the originated loans to third parties, the SPVs. The SPVs pay for these loans by issuing ABS. For the loans sold to the SPVs, the originators service the loans with payments received for this servicing.

Also, as noted above, SPVs are legal entities created by their equity holders to purchase the assets in the collateral pool. Setting up a SPV is a costly exercise, with significant fixed costs paid to third parties (lawyers, rating agencies, and investment bankers). The assets – the loans – are purchased from the loan originators. Unless the loans are purchased below their "true" value and/or SPVs sell their liabilities above their "true" value, setting up a SPV is a negative net present value activity, and would not be done. The existence of SPVs, therefore, prove that there is value in the creation and selling of ABS.

In terms of the perfect market assumptions previously discussed, the value creation is obtained by the ABS completing the market. The ABS provide financial institutions and investment funds (hence, individuals in the economy) the ability to indirectly invest in an alternative asset class - the loans. The financial institutions and investment funds could not invest in these loans directly due to the fixed costs involved in the loan origination process.

In terms of the real economy, by making more capital available for issuing loans, ABS decrease the cost of borrowing, thereby facilitating real economic activity related to the purpose of the loans. For example, the purpose for the loans could be home ownership - hence, activity in the construction industry is increased. The purpose of the loans could be purchasing a car - hence, activity in the auto industry is increased. The same applies for student loans, credit card loans, commercial real estate, etc. With respect to housing prices, the growth of the ABS market facilitated the growth of the construction industry and residential housing market, increasing the demand for housing and, therefore, housing prices.

With respect to the housing price boom and the financial crisis, the ABS creation process helped provide the funds which fueled the unprecedented issuance of subprime mortgage loans. The incentive problems in the mortgage

origination process (discussed previously) led to the lax lending standards and easy credit which generated the demand for the mortgage loans by homeowners. The demand for the ABS bonds was generated, indirectly, by the excess demand for CDOs and CDO^2 AAA bonds (to be discussed below) by financial institutions and investment funds. The CDO and CDO^2 creation process required the ABS bonds. Before discussing CDOs and CDO^2s, however, one needs first to understand CDS.

5.2 CDS

Simply stated, credit default swaps (CDS) are insurance contracts written between two counterparties insuring the face value of a particular corporate, sovereign, or structured debt issue for a fixed period of time. For selling the CDS, the insurer receives premiums, paid regularly (usually quarterly) over the life of the CDS contract. Typical terms are one through five years. The premium payment is based on the notional value of the contract. The notional value of the contract is the aggregate dollar value of the insured bond. When buying or selling a CDS at the market clearing spread, the value of the contract is zero.

For corporate or sovereign debt, if a default or credit event occurs, the contract terminates and the seller of the CDS either pays the face value of the debt and receives the debt issue (if physical settlement) or pays the difference between the face value and market price of the debt (if cash settlement)[11]. See Exhibit 2 for the cash flows. Physical or cash settlement are specified in the contract terms. A credit event includes events such as a failure to pay or a change in the interest or principal, bankruptcy, and certain types of financial restructuring (see Berndt, Jarrow, Kang (2007)).

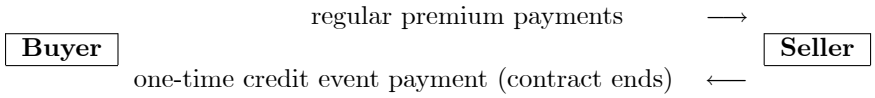

Exhibit 2: Payments to Corporate or Sovereign CDS

For structured debt, called Pay As You Go (PAUG) CDS or ABS CDS, the events triggering a payment by the seller are different. For an ABS CDS there are two types of events: credit and floating payment. For a credit or default event (similar to the standard CDS discussed above), the contract is terminated and the seller either pays the remaining principal value of the debt and receives the debt issue (if physical settlement) or pays the difference between the remaining principal value and market price of the debt (if cash settlement).

[11] If cash settled, the procedure for determining the market price is also written into the contract, usually an auction at a particular date after the credit event occurs.

A floating payment event occurs if the ABS bond incurs a principal write-down or a principal or interest shortfall. For a floating payment, the contract stays in force and is not terminated. These floating payment events are designed to mimic the cash flows risks embedded in an ABS due to their waterfall structure (see Exhibit 3). It is possible, if a principal or interest shortfall is later returned to the underlying ABS, that the buyer needs to reimburse a previously paid floating payment back to the seller (see Deutsche Bank (2005) and Nomura (2005)).

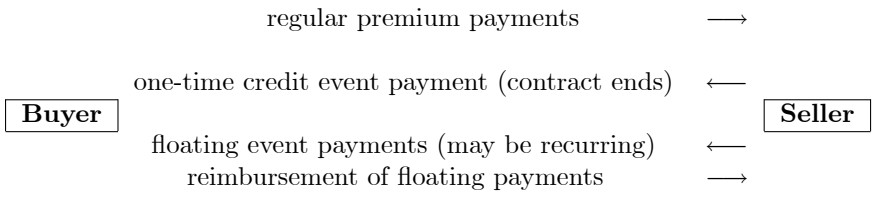

Exhibit 3: Payments to ABS CDS

CDS play an important economic role in financial markets. To understand their role, consider the liquidity of traded debt in the secondary debt markets. Debt markets are illiquid, in general, because debt holders (financial institutions and investment funds) tend to buy and hold debt in their inventories, trading it infrequently. This illiquidity makes it difficult to short-sell debt. This is because short-selling requires the short-seller to borrow the debt from a third party and sell it on the market. Borrowing debt for this purpose is difficult. Although repurchase agreements can be used to borrow debt, this alternative is costly, given the need to post collateral and roll over the repurchase agreements in order to keep the short position open.

In contrast, the buyer of a CDS is effectively shorting the credit (and floating payment) risks in the underlying debt instrument. If the buyer also adds a short position in the appropriate maturity Treasury security, the buyer's aggregate cash flows exactly match those from shorting the debt (see Jarrow (2011a)). Hence, CDS overcome a market imperfection by enabling market participants to more easily short corporate, sovereign, or ABS bonds. This market completion role of CDS make debt markets more informationally efficient with respect to default risk (see Jarrow and Larson (2011)). More efficient markets allocate capital to the appropriate uses, thereby facilitating economic growth.

A naked CDS trade occurs when the CDS buyer does not own the underlying debt issue. Concern has often been expressed in the financial press that the trading of naked CDS is harmful to the economy because it distorts borrowing rates and increases the risk present in debt markets[12]. In fact, quite the contrary is true. There are only two reasons why a naked CDS trades. One is that

[12] See, for example, "EU markets chief questions ban on naked CDS trade," www.reuters.com, Tuesday March 8, 2011, by Huw Jones.

the CDS buyer is trying to hedge a related security's risk, e.g. a long position in the equity of the firm issuing the debt; and two, the CDS buyer is trading on information - speculating. Such speculation increases the informational efficiency of debt markets. But, this is exactly the market completion argument given in the preceding paragraph with respect to shorting debt.

There is a potential problem, however, with the trading of CDS. This problem relates to the risk of contract execution by the CDS seller. If insurance is written, but the seller does not have sufficient resources to guarantee execution of the contract (payment of the claims), then the risk of debt markets is increased, not decreased by the trading of CDS. Indeed, in this case, payments are made for insurance which is worthless. To eliminate this problem, stronger collateral and capital requirements are needed for CDS traders. We will return to this issue below when discussing the financial crisis. Before this discussion, however, it is important to recognize that this contract execution problem is orthogonal to the market completion role of CDS, and therefore does not invalidate any of our previous conclusions in this regard.

CDS also serve a secondary role in financial markets. As noted previously, due to asymmetric information in loan markets, capital is costly to obtain. A highly rated financial institution currently can sell a CDS at zero value without posting any collateral. Hence, a financial institution can assume the credit risk in a bond without posting any additional equity capital to guarantee execution. In contrast, if the bond is bought instead, one needs to put up the present value of the principal. High leverage is an attractive feature of CDS. This high leverage characteristic of CDS played an important role in the construction of subprime CDOs discussed in the next section.

With respect to the housing price boom and the financial crisis, CDS played a significant role as well. CDS enabled financial institutions, especially insurance companies (e.g. AIG), monoline insurers, and Derivative Product companies (DPs) to sell CDS (in order to sell insurance) without posting sufficient collateral or equity capital. This inadequate posting of collateral and insufficient equity capital was partly caused by the misrating of the credit risk of these financial institutions. Highly rated financial institutions need not post collateral to trade in CDS. This is due to the fact that the CDS market is part of the larger over-the-counter (OTC) derivatives markets which have been largely unregulated since their inception. In 1998, there was a push by the Commodity Futures Trading Commission's (CFTC) Chairperson, Brooksley Born, to revise existing legislation to expand CFTC regulatory authority to include OTC swaps. Congress studied this proposal, and due to a unified opposition to more regulation by Alan Greenspan (Federal Reserve Board Chairman) and Robert Rubin (Treasury Secretary), the proposal failed[13].

The remaining cause of the inadequate posting of collateral and insufficient equity capital was the poor use of models by these financial institutions in measuring the risk of their CDS portfolios. The existing models caused these

[13] See *New York Times*, October 9, 2008, "The Reckoning: Taking a Hard New Look at a Greenspan Legacy," by Peter Goodman for a more complete historical account of this event.

financial institutions to significantly underestimate the default risk of their portfolios (see Jarrow (2011b)). In conjunction, the misestimation of risk in the CDS combined with the lenient collateral requirements led to the incorrect perception that the pricing of CDS reflected an arbitrage opportunity. This resulted in an excess supply of CDS. Hence, when housing prices crashed and mortgages defaulted, there were unusually large positions in CDS in numerous financial institutions and insufficient equity capital in these financial institutions to buffer the losses. Financial failures occurred. Since the reasons underlying the failures were the same, default contagion occurred, which resulted in the financial crisis.

5.3 CDOs, CDO^2s

There are two types of CDOs: cash flow and synthetic. Both of these CDOs are discussed in this section. To be relevant to the credit crisis, the discussion focuses on subprime residential mortgage ABS. A subprime mortgage is one where the underlying borrower is classified as subprime. As mentioned before, subprime borrowers are the riskiest in terms of default risk.

5.3.1 Cash Flow CDOs and CDO^2s

A cash flow CDO is a type of ABS. The key difference between an ABS SPV and a CDO SPV is in the composition of the collateral pool. A subprime ABS has a majority of subprime residential mortgage loans in its collateral pool. In contrast, a subprime CDO has a majority of mezzanine ABS bonds, rated below AAA, in its collateral pool. The collateral pool of ABS is non-traded loans while the collateral pool of CDOs is traded debt. Another minor difference is that CDOs waterfalls can be more complex with various triggers that redirect cash flows to more senior tranches if certain collaterization or interest coverage ratios are violated (see Lehman 1998).

Given the complexity of the collateral pool and waterfall rules, CDOs are complex securities. An additional difficulty in understanding CDOs is that each deal is slightly different in terms of its waterfalls, making modeling a tedious deal-by-deal exercise. This complexity was a key reason why many financial institutions with limited research staffs depended solely on the credit agencies' ratings. In addition, this complexity in conjunction with their short-term compensation incentives provided the excuse for many financial institutions managers not to do their own due diligence.

CDO^2s are CDOs in which the collateral pool mainly consists of mezzanine, junior or even the equity tranche bonds from subprime CDOs. Thus a CDO^2 is a CDO whose collateral pool consists of other CDO bonds.

The economic role played by cash flow CDOs and CDO^2s is different than it was for either ABS or CDS. The market imperfection that enabled CDOs and CDO^2s to exist was a violation of the no-arbitrage assumption. Analogous to creating an ABS, the costs of creating a CDO are quite large, including lawyer, rating, and investment banking fees. And, the collateral pool's assets trade in the over-the-counter market, unlike the collateral pool of ABS (residential

home mortgages). Therefore, CDOs do not help to complete the market, since the underlying collateral already trades. The CDO equity would have a negative value and the CDOs would not be created, unless the ABS bonds in the collateral pool are undervalued and/or the CDO bonds issued are overvalued. CDOs were created in massive quantities before the crisis (see Table 3), so one or both of these two possibilities were true.

Although the market for investment- versus speculative-grade bonds is segmented due to government regulations, there are still plenty of financial institutions that take advantage of this market segmentation and hold speculative-grade debt, e.g. hedge funds and mutual funds. Consequently, it is unlikely that the mezzanine subprime ABS bonds were undervalued enough to justify the creation of CDOs. In contrast, there is significant evidence that the highly-rated CDO bonds were misrated (see the previous section on the credit rating agencies). Hence, it is reasonable to conclude that the CDO bonds issued were overvalued. This implies that the existence of CDOs was to exploit a "rating arbitrage" due to the rating agencies' misratings of the highly-rated CDO bonds. CDOs existed to transform "junk bonds" into "gold" – AAA-rated bonds with high yields.

Normally, one believes that such arbitrage opportunities are short-lived, since the exploitation of an arbitrage usually hastens its removal as one side of the market loses wealth. But, this need not be the case if the arbitrage's existence is due to institutional structures. Here, the contributing institutional features for the "rating arbitrage" were the payment fee structures of the rating agencies and the short-term incentives of the managers within financial institutions. Before the crisis occurred, financial institutions and investments funds were making unusual profits, even though they were over-paying for the highly-rated bonds in their portfolios.

The economic role played by CDO^2s is similar. When the CDOs were created, there was not sufficient demand for the lower rated bond tranches. Consequently, the equity holders of the CDOs had a difficult time placing these bonds. The solution, of course, was to create another type of CDO which included these bonds in their collateral pool, again turning "junk bonds" into "gold."

In fact, the demand for these AAA-rated CDO bonds was so great that there were too few ABS bonds available to fill the growing collateral pools. To help with this scarcity, ABS CDS were used instead. Recall that an ABS CDS buyer is taking a long position in the underlying ABS bond. In essence, an ABS CDS buyer is creating a synthetic ABS bond which is absent the bond's principal. This use of ABS CDS in the construction of the CDO collateral pool had the additional benefit that it required no equity capital. Consequently, it enabled the issuance of a super senior bond tranche in CDOs that required no up-front cash payment as well, in contrast to a typical bond purchase. Many super senior bonds, therefore, had nearly "infinite leverage." The use of ABS CDS in CDOs increased the correlated default risk across the ABS bonds and CDO bonds traded. The correlated defaults were generated by the same collection of mortgages in the collateral pools of the traded CDOs, and many times leveraged.

Hence, the market imperfection that the cash flow CDOs and CDO^2 exploited was an institutional imperfection - "rating arbitrage." The CDO and CDO^2 equity holders were taking wealth away from financial institutions. Although the creation of CDOs increased the demand for speculative grade ABS, thereby indirectly increasing the capital available for mortgage loans, this increased demand was a result of a market misfunction – the misratings. Consequently, this indirect benefit of CDOs to the mortgage loan market disappears when the misratings disappears.

There is another argument which may justify the existence of cash flow CDOs. Given it is costly for investors to create the CDO bond cash flows themselves, analogous to the reasons for the existence of electronic traded funds (ETFs) or mutual funds, CDOs may exist to provide these cash flows to investors in a transaction cost minimizing fashion. Given the large fixed costs involved in creating the CDOs' SPV, it is an open question as to whether cash flow CDOs will provide enough value creation from minimizing transaction costs to justify their existence when rating arbitrage no longer exists.

With respect to the housing price boom and the financial crisis, cash flow CDOs and CDO^2s played a key role. These securities were held by investment funds at financial institutions, pension funds, and retirement funds operated by corporations and government agencies. First, these funds overpaid for the bonds purchased, although they were making healthy profits prior to the crisis. Second, when housing prices crashed and mortgages defaulted, these CDO and CDO^2 bonds lost significant value. This value loss created severe hardships and/or failures of corporate pension funds (e.g. General Motors), state government pension funds (e.g. California, New York), sovereign nations (e.g. Iceland), investment banks (e.g. Bear Stearns, Merrill Lynch), SIVs (e.g. Citigroup), and indirectly some money market funds (e.g. Reserve Primary Fund[14]). The losses on these AAA-rated CDO bonds was unprecedented by comparison to historical losses of similarly AAA-rated debt issues. The reason for these unprecedented losses, of course, is that the structured debt was misrated from the beginning, for reasons we have previously discussed.

5.3.2 Synthetic CDOs

A synthetic CDO is an ABS where the underlying collateral pool consists entirely of ABS CDS. No physical bonds are purchased for inclusion. The waterfall is, therefore, quite simple. It is arranged into a series of bond tranches, some of which are unfunded (require no initial purchase fee). The tranches have attachment and detachment points, which indicate the percentage of losses absorbed by the bond tranches' notional value. The notional value is the aggregate dollar amount that each bond tranche represents. The equity tranche is the lowest, taking losses from 0% to perhaps 5%. Then, the next lowest tranche takes losses from 5 % to, perhaps, 10%, and so forth. Since synthetic CDO are based on a

[14] C. Condon, "Reserve Primary Money Fund Falls Below $1 a Share," *Bloomberg News*, September 16, 2008.

collateral pool of swap contracts, the cost of construction is smaller than that of a cash flow CDO.

Synthetic CDOs played three beneficial economic roles during the crisis. These three roles will continue afterwards as well. One, cash flow CDOs trade in illiquid markets, as do all fixed income securities. Given the difficulty in modeling cash flows CDOs, when trading became sparse and marking-to-market unreliable, marking-to-model proved useless. In this circumstance, synthetic CDOs provided a more liquidly traded instrument that was easier to model and price based on the underlying CDS. Hence, it provided more accurate market quotes for indexing the cash flow CDO prices. Second, synthetic CDOs provided a more liquidly traded partial hedge for cash flow CDOs, reducing the transaction costs incurred in generating a particular exposure to a portfolio of mortgage related ABS. Because all of the ABS securities trade in the over-the-counter market, this same exposure could have been generated directly by trading in the underlying contracts, but at greater transaction costs due to the market's illiquidity. Third, synthetic CDOs provided a low cost method of shorting the CDO bond tranches, analogous in this regard to CDS, avoiding the need to use repurchase agreements.

6 The Housing Price Crash

The housing price boom was too good to last. Housing prices crashed for three related reasons. First, the supply of subprime home borrowers became exhausted, which removed the demand creating an upward trend in housing prices. Second, interest rates started to rise due to worries about inflation because of increases in the budget deficit from the Iraq and Afghanistan war. And, third, rising oil prices caused an increase in gas prices. Together, these two price increases impacted the ability of many subprime borrowers to meet their mortgage payments (see Figures 3 and 4). Most subprime mortgage holders had adjustable rate mortgages (ARMs) whose interest payments varied with short-term rates. Furthermore, to induce homeowners to borrow, teaser rates and/or no principal prepayments for a couple of years were common. When the teaser period ended, as long as home values kept rising, the mortgage could be refinanced at new teaser rates, keeping the mortgage payments low and affordable. When housing prices started to decline, this refinancing became impossible[15] (see U.S. Senate Report (2011)). In conjunction, these economic forces caused an increased incidence of subprime mortgage defaults. Mortgage defaults led to foreclosures, causing housing prices to fall. This, in turn, led to additional defaults for prime borrowers as well (see Ascheberg, Jarrow, Kraft and Yildirim (2010)).

As mortgage defaults happened, the subprime residential mortgage ABS and CDO bond tranches lost value. The credit derivative losses eroded the capital of financial institutions and investment funds that invested in these ABS, CDS,

[15] See, for example, *USA Today*, "Mortgage crisis: home loans are harder to get," August 6, 2007, by Sue Kirchhoff.

CDO, and CDO^2s. This loss in aggregate wealth and the correlated failures of financial institutions[16] froze financial markets with severe negative consequences to the real economy, eventually causing unemployment and the Great Recession.

7 Regulatory Reforms

First, credit derivatives serve useful economic functions in financial markets. ABS provide previously unavailable investment opportunities to market participants, facilitating the access to debt capital and spurring real economic growth due to the increased financing for the underlying collateral pool. CDS enable market participants to more easily short sell debt, thereby increasing the informational efficiency of debt markets. CDOs and CDO^2 were created to take advantage of debt market mispricings generated by the credit agencies' misrating of structured debt. It is an open question whether CDOs will continue to trade after the removal of the debt misratings, given the costs of constructing the CDOs' SPVs. Synthetic CDOs provide a transaction cost minimizing method for investing in diversified pools of ABS, and therefore, they help to facilitate the efficient allocation of debt capital.

To correct the structural problems that created the misuse of credit derivatives (ABS, CDS, CDOs, CDO^2s), regulatory reforms need to be implemented. First and most important, it was the credit agencies' misratings that created the environment that facilitated the misuse of credit derivatives. Indeed, if the credit agencies ratings had been correct, then even given the various misincentives, the market forces generating the misuses would have disappeared. Indeed,

- financial institutions and investment funds would not have invested in credit derivatives because the securities would have been considered too risky.
- The demand for indirect lending to subprime mortgages would have disappeared, except for the government-sponsored enterprise lending by Fannie Mae and Freddie Mac. This would have partially eliminated the mortgage originators lax lending standards from taking hold.
- The equity capital held in financial institutions would have been more appropriate since the regulators themselves would have had proper information regarding the likelihood and cost of financial institution failure.

To fix the credit agency misratings, various reforms should be implemented. First, the payment structure of the credit rating agencies needs to be changed. The current payment structure where the credit rating agencies are paid by those that are rated creates a severe incentive problem. Instead, we should

[16] As argued in Jarrow (2011)b, the "best-practive" credit derivative models used by the industry did not accurately capture this increased correlation in defaults during times of financial stress, called systemic risk.

return to the original payment fee structure[17] where the rating agencies are paid by the users of the ratings. Since information once purchased is easily passed on at zero cost, for this proposal to be successful, the content of the credit rating agencies information needs to be modified. The credit agencies will need to provide information that is dynamic and constantly updated, so that information becomes "stale" shortly after it is purchased. Although dramatic, this proposal is feasible because such debt market related information providers already exist in the financial markets.

Second, as correctly mandated by the Dodd-Frank Wall Street Reform and Consumer Protection Act, credit ratings should be removed from all government regulations, thereby: (i) removing the need for the designation of a "national statistical rating organization," and (ii) removing the market segmentation in the use of investment- versus speculative-grade bonds. The removal of this "barrier to entry," in turn, would open up the credit risk information markets to more competition. Credit risk information providers would then compete based on the accuracy of their information, and risk assessment would become more unbiased.

Next, to reduce the misuse of credit derivatives, the mis-incentive structures of the market participants need to be reformed. The compensation schemes of financial management need to be changed to be consistent with maximizing long-run performance and not short-term bonuses. This can be done by vesting or delaying payment of yearly bonuses over a multiple year period or clawback provisions. And, mortgage originators should be required to hold some percentage of their originated loans in inventory. A mechanism that avoids the mortgage originators "cherry-picking" the best loans also needs to be included.

With respect to the use of credit derivatives, the problem with financial institution failures was due to too little equity capital and collateral backing the buying and selling of these derivatives. Enough collateral and equity capital needs to be held by these institutions to guarantee execution of all contracts with a high degree of confidence. Various proposals have been made in this regard (see Jarrow (2011a)). Good regulations are contained in the Dodd-Frank Wall Street Reform and Consumer Protection Act relating to the central clearing and exchange trading of these credit derivatives. Although not all credit derivatives can be traded on an exchange, due to customization, it is important to exchange trade as many of these credit derivatives as possible. Greater transparency in the trading of credit derivatives is also needed, which exchange trading will facilitate. Credit derivatives play a welfare increasing role in the financial and real economy, as long as they are properly capitalized. Regulatory reforms should ensure their proper capitalization, not their removal from trading.

[17] See Sylla [21] for a history of the credit rating agencies.

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Year	Agency RMBS[1]	Non-Agency[2]	Total[3]	Agency Percentage
2004	4,397.889	1,532.6	5,930.5	74.2
2005	4,951.171	2,261.6	7,212.7	68.6
2006	5,713.094	2,922.3	8,635.4	66.2
2007	5,947.716	3,195.0	9,142.7	65.1
2008	6,383.726	2,718.2	9,101.9	70.1
2009	6,834.441	2,353.2	9,187.7	74.4
2010	6,839.955	2,071.6	8,911.5	76.8

Table 1: U.S. Mortgage-Related Securities Outstanding in Billions of U.S. Dollars

1. Includes GNMA, FNMA, and FHLMC mortgage-backed securities and CMOs.
2. Non-Agency MBS includes both CMBS and RMBS.
3. Total does not account for overlap of collateral.
4. Non-agency outstandings in non-agency numbers include Re-REMICs/resecuritizations.

Source: www.sifma.org/research/statistics

Company	**Distress Date**	**Ratings**	**One-Month**	**Earlier**
		Moody's	**S&P**	**Fitch**
Bear Stearns	03/16/08	A2	A	A+
Fannie Mae	09/07/08	Aaa/B-	–	AAA
Freddie Mac	09/07/08	Aaa/B-	–	AAA
Lehman	09/15/08	A2	A	A+
AIG	09/15/08	Aa3	AA-	AA-
Merrill Lynch	09/15/08	A2	A	A+
WaMu	09/25/08	Baa3/D+	BBB-	BBB-
Wachovia Bank	09/29/08	Aa2/B	AA-	AA-
Fortis Finance	09/29/08	A1	A	AA-
Dexia	09/30/08	Aa2	AA	AA
Citigroup	11/23/08	Aa3	AA-	A+

Table 2: Corporate Failures and Ratings One-Month Earlier

Source: R. Jarrow, 2009, An Expensive Education, Canadian Investment Review, Winter, 9 - 15.

Year	Cash Flow	Synthetic
2004	0	0
2005	206,224,0	44,421,2
2006	410,503.6	44,421.2
2007	340,375.8	88,842.4
2008	43,595.8	1,340.9
2009	2,560.9	254.3
2010	7,639.9	42.3

Table 3: Global CDO Issuance in Millions of U.S. Dollars

Source: www.sifma.org/research/statistics

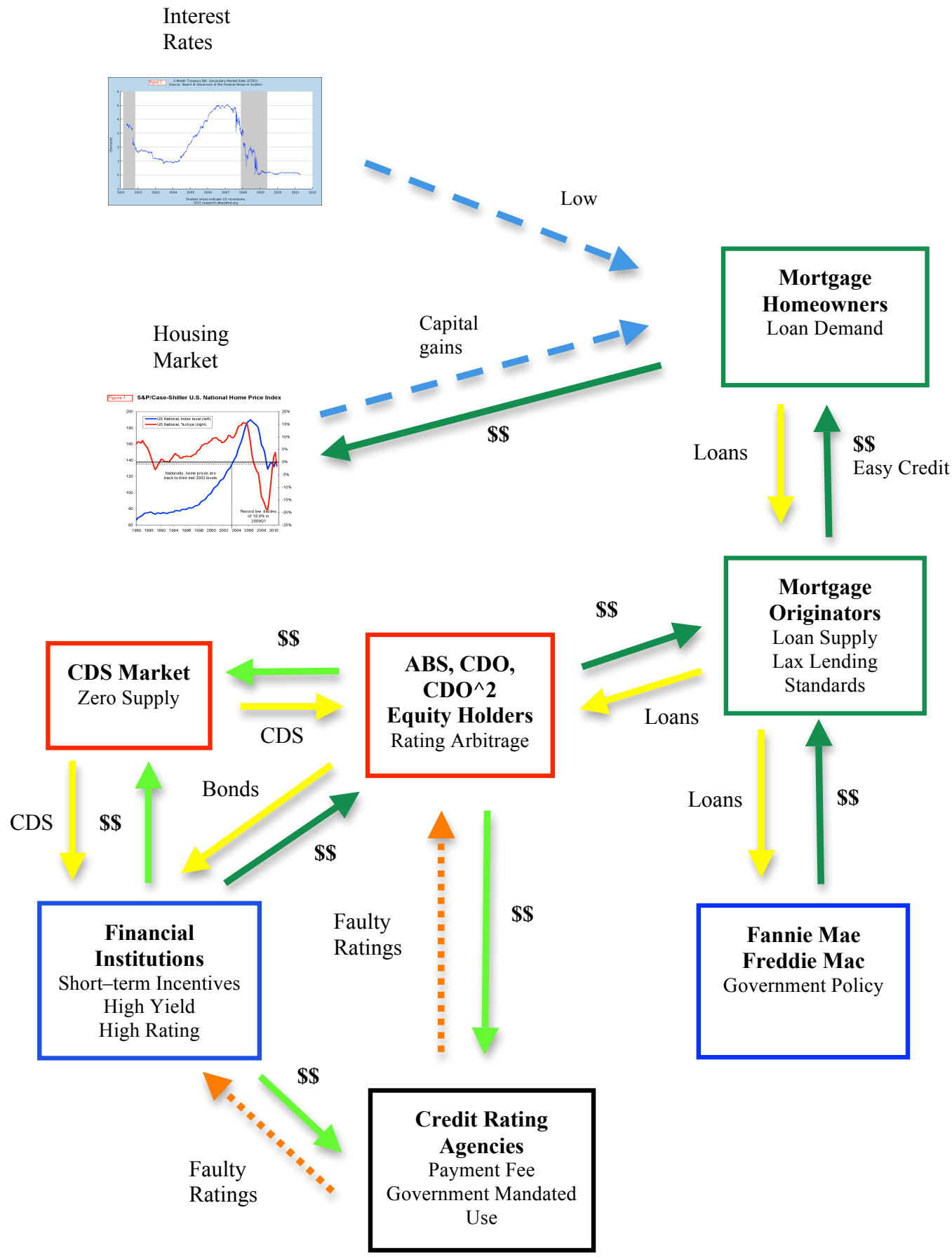
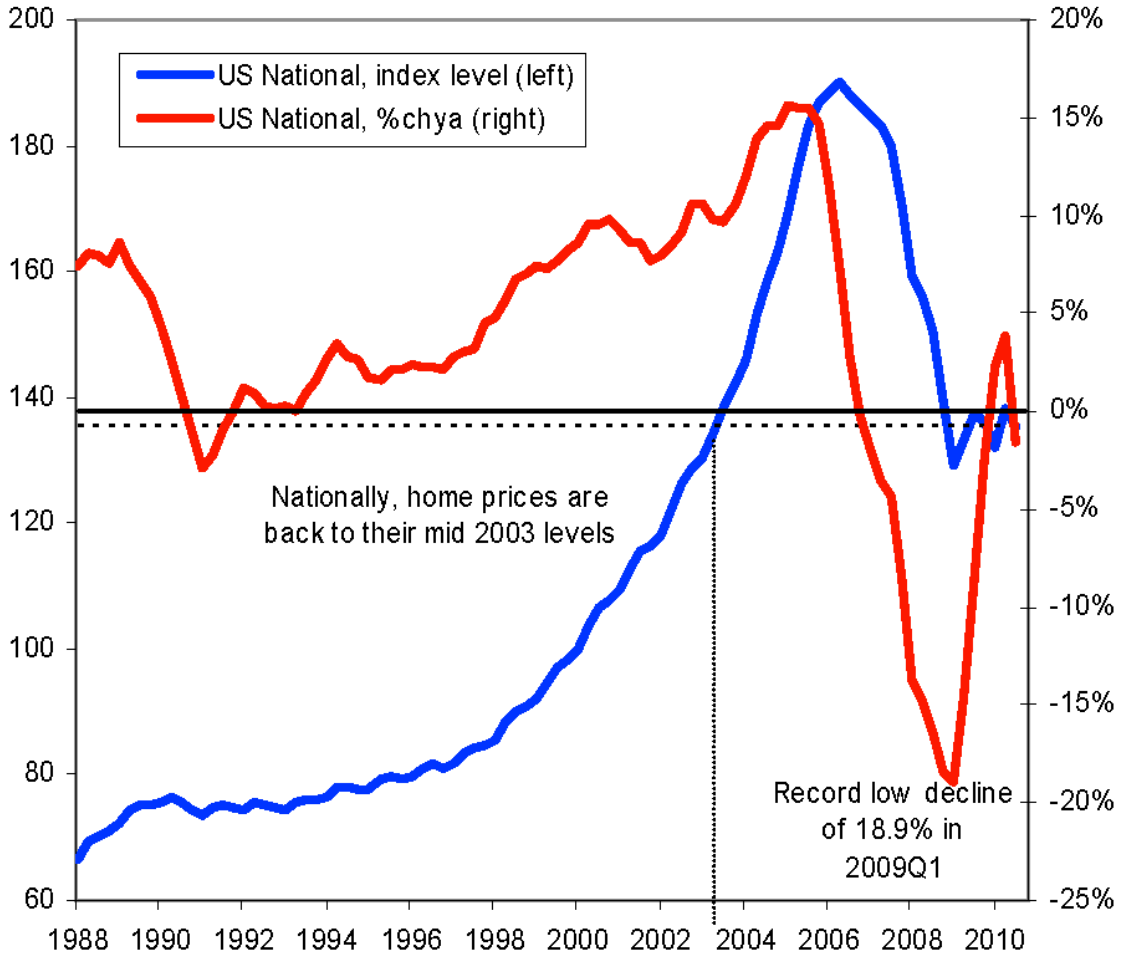


Figure 1: Diagram of the Credit Crisis

Figure 2

S&P/Case-Shiller U.S. National Home Price Index



Sources: S&P Indices and Fiserv. Data through 2010Q3. Charts and graphs are provided for illustrative purposes only. It is not possible to invest directly in an index. Past performance is not an indication of future results.

Figure 3

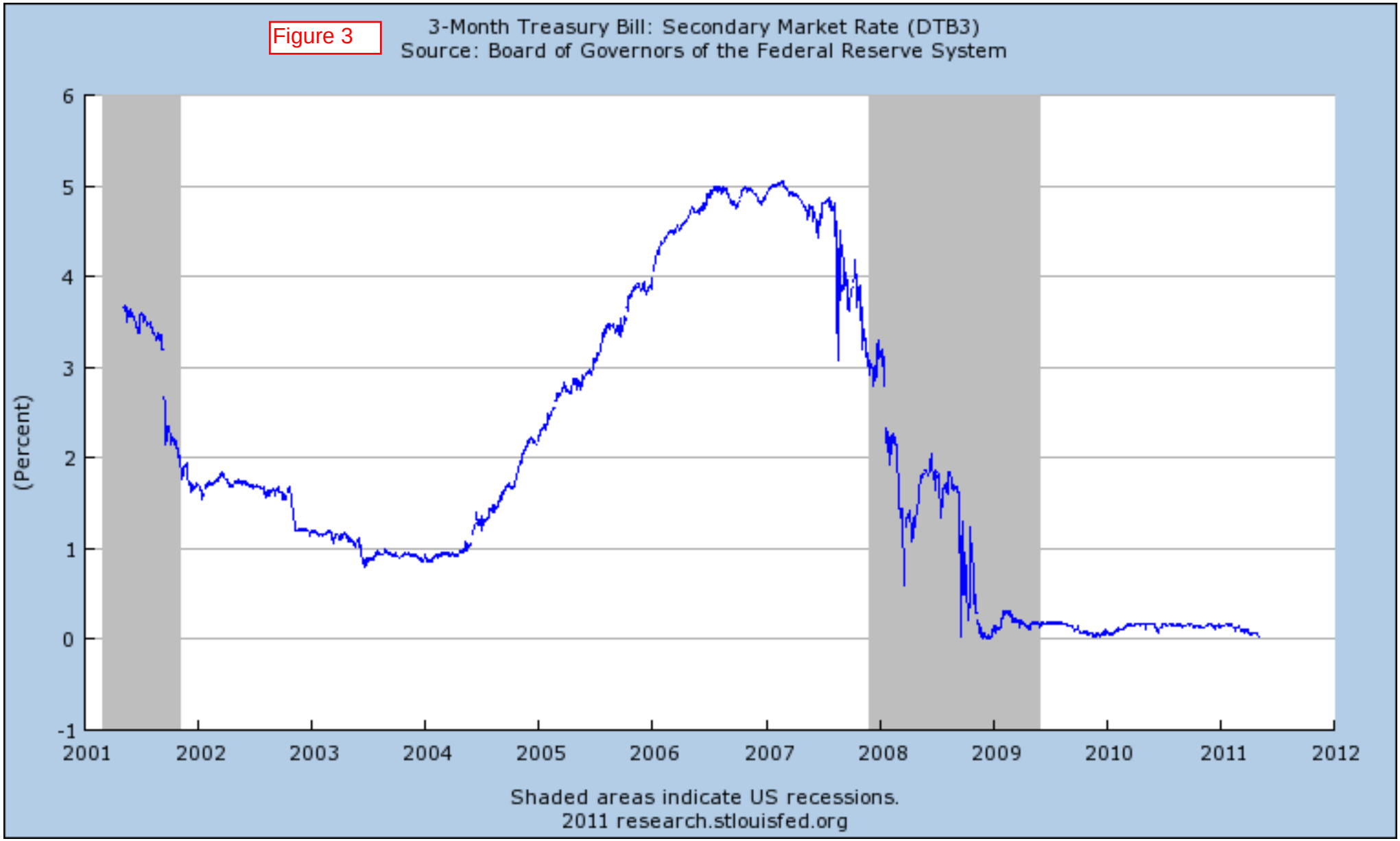
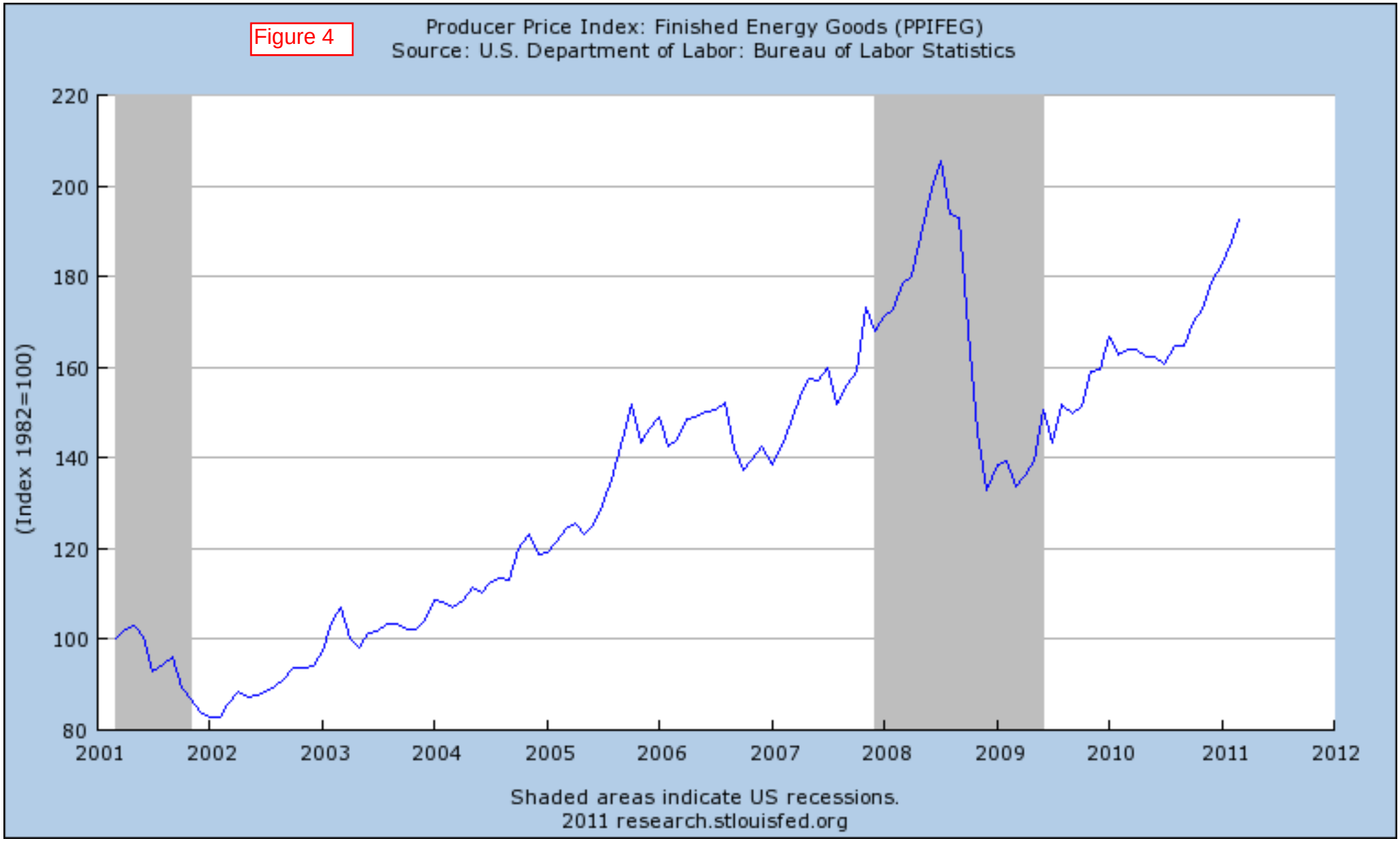

3-Month Treasury Bill: Secondary Market Rate (DTB3)
Source: Board of Governors of the Federal Reserve System
(Percent)
6
5
4
3
2
1
0
-1
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Shaded areas indicate US recessions.
2011 research.stlouisfed.org

Figure 4


Producer Price Index: Finished Energy Goods (PPIFEG)
Source: U.S. Department of Labor: Bureau of Labor Statistics
(Index 1982=100)
220
200
180
160
140
120
100
80
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Shaded areas indicate US recessions.
2011 research.stlouisfed.org