The Bear's Lair: Indexed Credit Default Swaps and the Subprime Mortgage Crisis

Richard Stanton and Nancy Wallace*

July 8, 2009

Abstract

ABX.HE indexed credit default swaps on baskets of mortgage-backed securities are now the main benchmark used by financial institutions to mark their subprime mortgage portfolios to market. However, we find that current prices for the ABX.HE indices are inconsistent with any finite assumption for mortgage default rates, and that ABX.HE price changes are uncorrelated with changes in the credit performance of the underlying loans. These results cast serious doubt on the suitability of the ABX.HE indices as valuation benchmarks. We also find that ABX.HE price changes are significantly related to short-sale activity in the option and equity markets of the publicly traded builders, the commercial banks, the investment banks and the government sponsored enterprises (GSEs). This suggests that capital constraints, limiting the supply of ABS insurance, may be playing a role here similar to that identified by Froot (2001) in the market for catastrophe insurance.

*Please address correspondence to (Wallace): Haas School of Business, University of California, Berkeley, Berkeley, CA, 94720. Phone: (510) 642-4732. Fax: 510-643-7357. E-mail: wallace@haas.berkeley.edu. (Stanton): Haas School of Business, University of California at Berkeley, Berkeley, CA 94720. Phone: (510) 642-7382. E-Mail: stanton@haas.berkeley.edu.

1 Introduction

In January 2006, a consortium of investment banks,[1] in partnership with Markit Group Ltd., a data vendor, launched the Markit ABX.HE index CDS. Each index tracks the price of a single credit default swap (CDS) written on a specified basket of subprime residential mortgage-backed securities (RMBS) of six different credit qualities, AAA, AA, A, BBB, BBB- and Penultimate AAA (PENAAA).[2]

While the cash flows of each ABX.HE index CDS are in principle equivalent to those from a portfolio of CDS on each of the 20 individual named tranches of a given credit rating, they allow market participants to trade the credit risk of a portfolio of pools via a single security, rather than via 20 separate CDS (which may not even all exist), and without having to own, or to have borrowed, the referenced obligations. Moreover, unlike individual CDS, the ABX.HE index CDS are supported by a consortium of market makers, ensuring that their liquidity is substantially higher than that of either individual named CDS or (in the over-the-counter cash markets) the referenced obligations themselves. As a result, ABX.HE index CDS have been widely used by banks and investment banks to hedge their subprime residential mortgage pipeline risk, and by investment banks, hedge funds and other investors to make directional bets on the future performance of subprime mortgage-backed securities. In particular, trading in the ABX.HE indices recently delivered two of the largest payouts in the history of financial markets: the Paulson & Co. series of funds secured $12 billion in profits from a single trade in 2007; and Goldman Sachs generated nearly $6 billion of profits (erasing $1.5 to $2.0 billion of losses on their $10 billion subprime holdings) in 2007.[3]

Perhaps most important, with the global collapse of subprime RMBS trading, many portfolio investors in subprime mortgage securities are using the more liquid ABX.HE index prices as a benchmark for marking-to-market their portfolios of subprime securities.[4] Indeed, in March 2008, the Division of Corporation Finance of the Securities and Exchange Commission sent public companies an illustrative letter with preparation guidelines for the Management's Discussion and Analysis (MD&A) statements required for Form 10-K quar-

[1]The sixteen investment banks in the consortium, CDS IndexCo LLC, are: Bank of America, BNP Paribas, Deutsche Bank, Lehman Brothers, Morgan Stanley, Barclays Capital, Citigroup, Goldman Sachs, RBS, Greenwich Capital, UBS, Bear Stearns, Credit Suisse, JP Morgan, Merrill Lynch, and Wachovia.

[2]This is a relatively new ABX.HE security, which is written on the penultimate AAA bond in the MBS structure. This bond has a shorter duration (and hence less interest rate risk) than the longer duration AAA bonds tracked by the AAA ABX.HE index CDS.

[3]For details, see Kelly (December 14, 2007), Mackintosh (January 15, 2008), Zuckerman (January 15, 2008) and Lewis (February 16, 2008).

[4]For example, the Swiss bank UBS AG wrote down its subprime mortgage investments by $10 billion largely based on the ABX.HE indices (see UBS AG 6K financial statements). Both Morgan Stanley and Citigroup cited devaluations in the ABX.HE indices to justify their significant write-downs of subprime securities (see Ng, Mollenkamp, and Patterson (2007)).

terly reports. The letter suggested that:

> "Regardless of how you have classified your assets and liabilities within the SFAS 157 hierarchy, if you have not already done so in your Form 10-K, consider providing the following additional information in your MD&A:
>
> - A general description of the valuation techniques or models you used with regard to your material assets or liabilities. Consider describing any material changes you made during the reporting period to those techniques or models, why you made them, and, to the extent possible, the quantitative effect of those changes.
> - To the extent material, a discussion of the extent to which, and how, you used or considered relevant market indices, for example ABX or CMBX, in applying the techniques or models you used to value your material assets or liabilities. Consider describing any material adjustments you made during the reporting period to the fair value of your assets or liabilities based on market indices and your reasons for making those adjustments. . . ."[5]

The huge size of the ABX.HE market compared with that of the underlying securities, combined with the higher costs of trading in the underlying, makes it difficult to arbitrage away any price discrepancies between the CDS market and the underlying, so the price of the index CDS may deviate substantially from that of the underlying.[6] If such deviations do occur, using the ABX.HE CDS to mark portfolios to market may give misleading results.

We collect detailed credit and prepayment histories from 2006–2008 for all of the roughly 360,000 individual loans underlying the ABX.HE indices, and use these data, plus current prices, to infer the market's expectations for future defaults. Using both a simple, "back-of-the-envelope" model (in which all defaults and insurance payments occur instantaneously) and a full CDS valuation model calibrated to the historical loan-level performance data, we find that recent price levels for ABX.HE index CDS are inconsistent with any reasonable forecast for the future default performance of the underlying loans. For example, assuming a recovery rate of 21%, the AAA ABX.HE prices on June 30, 2009 imply default rates of 100%

[5] See Sample Letter Sent to Public Companies on MD&A Disclosure Regarding the Application of SFAS 157 (Fair Value Measurements), `http://www.sec.gov/divisions/corpfin/guidance/fairvalueltr0308.htm`.

[6] While difficult, arbitrage is not impossible. In March 2009 Amherst Holdings, a Texas firm, sold credit default swaps on a pool of subprime mortgages for 80–90 cents per $1 of principal to investors (including J.P. Morgan, RBS and Bank of America) who expected the bonds to default. The total notional on the CDS was over four times that of the underlying bonds. In April 2009, Amherst bought the underlying bonds and paid them off in full. While they lost money on the bonds, this was dwarfed by the profits they made on the (now valueless) CDS (see "A daring trade has Wall Street seething," Wall Street Journal, June 12, 2009).

on the underlying loans. In other words, if recovery rates exceed 21% (a value well below anything ever observed in U.S. mortgage markets), there is *no* default rate high enough to support observed prices. We also find that changes in the credit performance of the underlying loans explain almost none of the observed price changes in the ABX.HE indices. These results cast serious doubt on the use of the ABX.HE indices for marking mortgage portfolios to market.

While ABX.HE price changes are unrelated to credit performance, we find that they are consistently and significantly related to short-sale activity in the option and equity markets of the publicly traded builders, the commercial banks, the investment banks and the government sponsored enterprises (GSEs). These measures may be proxying for the demand for MBS default insurance, suggesting that, as in the catastrophe insurance market (see Froot (2001)), shifts in the demand for default insurance provided by the ABX.HE indices, combined with limited capital behind the providers of this insurance, may be driving the price of such insurance well above its "fair value."

2 Prior Literature

Despite the importance of the ABX.HE index market and its links to the operation of the subprime securities market, there has been little research that focuses on the pricing dynamics of the ABX.HE indices or appropriate subprime security valuation methodologies based upon the ABX.HE index prices. Early research on the operation of the ABX.HE market was produced by the research departments of investment banks (see Sinha and Chabba (2006), Choudhry (2006), Kazarian, Mingelgrin, Risa, Huang, Ciampini, and Brav (2005), Dubitsky, Mellia, Bhu, Fenske, Guo, Li, Dumitrascu, and Yang (2006)) and primarily focused on the mechanics of the market and hedging strategies.

Two recent papers by Fender and Scheicher (2008) and Fender and Hoerdahl (2008) at the Bank of International Settlements have analyzed possible macro drivers of the five subindices of the ABX.HE-2006-1 vintage indices. They found that market liquidity proxies such as price changes on the futures contract written on the Case-Shiller composite index and the Chicago Board Options Exchange Volatility Index, (VIX),[7] covaried with the returns on ABX.HE-2006-1 indices. Changes in aggregate measures of loan delinquency and rating downgrades on the referenced basket of obligations affected returns on the lower rated ABX indices. Fender and Scheicher (2008) also reported the results of a simplified CDS valuation exercise that found subprime mortgage securities to be undervalued by as much as 60% based on corresponding write-downs on the ABX.HE indices. A Bank of England report also

[7] A measure of the implied volatility of S&P 500 index options.

compared cash flow valuations of subprime mortgage-backed securities of different vintages to write-downs based on a simplified valuation model of CDS written on the ABX.HE indices. The report concluded that the index-based CDS valuations led to potential undervaluations of subprime obligations of about $64 billion (see Bank of England (2008)). These papers suggest the possibility of mispricings in the market, but do no formal modeling.

In another recent paper, Longstaff (2008), analyzes the pricing of subprime collateralized debt obligations, CDOs, and their contagion effects on the market. Longstaff assumes that reported ABX.HE prices are proxies for subprime CDO market prices and finds strong contagion effects from lower rated subprime CDOs, to the higher rated subprime CDOs, and finally to the stock market. Gorton (2008a) concentrates on a possible correlational channel between the ABX.HE index market and the repo markets. He only analyzes the ABS.HE-2006-1 index and finds that the cash basis, the difference between the subprime CDS spread by credit rating and the spread on the underlying subprime tranches by credit rating, is highly correlated with dislocations in the repo market through July of 2007. He argues that the explosive growth in the ABX.HE cash basis reflected fear of counterparty default, especially in the repo market, where defaults would lead to the delivery of bonds that could not be sold (see Gorton (2008a,b)).

Accounting standards for valuing subprime securities have also been identified as an important source of feedback between the subprime crisis and the collapse of trading in the mortgage credit markets. Ryan (2008) notes (p. 2), that as "firms have announced losses on subprime positions, debt markets have become more averse to holding these positions and increasingly illiquid, causing fair values of the positions to decline further and become more difficult to measure." He argues that, although FAS 157 definitions of fair value are clearer than prior GAAP measures, the FAS 157 notion of "orderly" market transactions in the current crisis has become increasingly difficult to identify and apply.

In summary, recent research has focused on only a subset of the ABX.HE indices and has not yet undertaken a thorough analysis of the link between the credit performance of the underlying referenced mortgage obligations and the time series of ABX.HE prices and returns. There is also a tension in the literature between a view that the ABX.HE prices can serve as direct measures of returns in the referenced subprime securities markets and results indicating that the ABX.HE prices may be highly imperfect measures of subprime security values and credit performance.

3 The ABX.HE indices

Each ABX.HE index tracks the price of a single credit default swap (CDS) written on a fixed basket of underlying mortgage-backed securities. The first set of ABX.HE indices began trading in January of 2006, and a new set began trading every six months from then until July 2007.[8] The four currently outstanding vintages of ABX.HE indices are labeled ABX.HE-2006-1, ABX.HE-2006-2, ABX.HE-2007-1 and ABX.HE-2007-2 respectively.

3.1 Index construction

The construction of each vintage of ABX.HE indices starts with the selection of 20 specified pools of subprime residential mortgage-backed securities (RMBS) by Markit. Table 1 presents the contributors to the Markit ABX.HE 2006-2007 indices. As shown, there is considerable concentration in the contributions of troubled originators such as Countrywide, Bear Stearns, First Franklin, and New Century. Less obvious is that some of the deals listed under the larger investment banks, such as Merrill Lynch and Goldman Sachs, are conduit securitization deals for the same troubled lenders: First Franklyn in the case of Merrill Lynch, and New Century in the case of Goldman Sachs. Thus origination is heavily concentrated on relatively few lenders, making it possible to use the index to make targeted bets on specific financial institutions though the CDS market. The ABX.HE contributed deals are slightly smaller than the average deal sizes of the contributors, while the coupons and the maturities of the underlying mortgages appear to be quite representative.

The subprime RMBS included in the ABX.HE indices are required to meet fixed criteria concerning composition and loan quality. Markit Group Ltd. and the consortium of member dealers constrain the basket to include only four deals from the same originator, and no more than six deals can have the same servicer. The minimum deal size must be $500 million, the pools must consist of at least 90% first liens, and the average FICO score of the borrowers must be 660. The referenced AAA tranche is the longest cash flow position within each RMBS deal, and it must have an average life greater than 5 years. The average life for the referenced subordinated tranches must be 4 years. Although the composition of each of the ABX.HE indices is made up of the same twenty referenced obligations, over time the notional balances of the underlying CDS amortize following the principal pay-down structure of the respective referenced classes.

[8] The ABX.HE indices were originally designed to be issued every six months. However, due to the severe recent disruptions in the market for subprime RMBS, the ABX.HE-2008-1 series (due to be issued in January 2008) was cancelled, and no subsequent ABX.HE indices have been issued.

Table 1: Contributors to the Markit ABX.HE 2006-2007 Indices

The table presents the total origination for mortgage-backed originators who placed at least one bond in the ABX index from 2006 through 2007. The data for this table were obtained from Markit, Bloomberg, Wells Fargo Trust, and LaSalle Trustee.

Contributor Name	Contributor Abbreviation	Contributor Means				ABX Deal Means			
		Deals	Weighted Average Coupon WAC	Weighted Average Maturity WAM	Original Balance Average (000)	Deals	Weighted Average Coupon WAC	Weighted Average Maturity WAM	Original Balance Average (000)
Asset-Backed Funded Certificates	ABFC	11	8.12	316	961,432	1	8.77	338.00	675,393
ACE Securities Corporation	ACE	54	8.75	288	670,907	4	8.21	328.33	688,292
Ameriquest Mortgage Securities Inc.	AMRSI	12	8.23	310	1,514,963	1	7.85	316.00	802,916
AMRESCO Securities Inc.	ARSI	10	8.20	352	902,916	2	8.36	323.00	1,046,348
Bear Stearns Asset-Backed Securities Trust	BSABS	82	7.55	309	502,028	4	8.13	350.25	469,066
Carrington Mortgage Loan Trust	CARR	17	8.21	324	1,060,439	2	8.04	331.50	960,125
Credit Based Asset Services	CBASS	36	8.45	290	491,498	1	8.31	334.50	460,153
Citigroup Mortgage Loan Trust Inc.	CMLTI	76	7.07	322	741,912	7	7.91	339.71	1,653,558
Countrywide Asset-Backed Trust	CWL	106	8.27	310	973,097	4	8.24	341.86	1,089,040
First Franklin–Merrill Lynch	FFMER	7	9.18	321	1,057,885	6	8.21	449.00	1,663,430
First Franklin Mortgage Loans	FFML	41	8.37	302	1,044,185	4	8.07	343.00	827,887
Fremont Home Loan Trust	FHLT	15	8.20	323	1,300,721	1	8.03	330.00	1,027,570
Goldman Sachs GSAMP Trust	GSAMP	48	8.49	301	586,051	4	8.38	331.89	791,727
Home Equity Asset Trust	HEAT	17	8.47	317	978,412	3	8.36	381.35	767,223
J.P. Morgan Mortgage Acquisition Trust	JPMAC	25	7.97	318	970,400	4	7.81	324.80	801,370
Long Beach Mortgage Loan Trust	LBMLT	19	8.21	357	1,907,743	3	8.14	361.50	913,593
Master Asset-Backed Securities Trust	MABS	28	8.16	319	782,548	3	8.24	328.27	504,965
Merrill Lynch Mortgage Investment Trust	MLMI	56	7.90	302	674,256	3	8.19	337.00	774,442
Morgan Stanley Capital Inc.	MSAC	40	8.26	318	1,342,828	3	8.87	333.00	1,190,837
New Century Home Equity Trust	NHET	10	7.94	316	1,781,766	2	7.76	316.26	745,077
Novastar Home Equity Loans	NHEL	11	8.85	315	1,527,146	1	8.19	342.24	674,657
Option One Mortgage Loan Trust	OOMLT	17	8.20	328	1,278,233	1	8.16	342.00	1,214,732
Residential Asset Mortgage Products Inc.	RAMP	38	7.98	313	644,034	2	8.12	322.47	313,055
Residential Asset Securities Corp.	RASC	39	8.67	316	655,766	3	8.62	339.99	659,494
Security Asset-Backed Receivables Inc.	SABR	27	8.48	322	898,713	4	8.23	327.54	522,528
Structured Asset Investment Loan Trust	SAIL	19	8.28	314	1,896,950	2	8.35	326.13	997,958
Structure Asset Security Corp.	SASC	21	8.15	353	952,142	4	8.00	333.26	826,901
Soundview Home Equity Loan Trust	SVHET	30	8.48	314	901,195	4	8.31	333.59	1,242,287
WAMU Asset-Backed Certificates	WMHE	3	8.01	342	1,075,185	1	7.74	392.75	1,283,495

Each ABX.HE index tracks the price of a CDS contract written on a basket of specified tranches of a given credit quality. Originally, each vintage of the ABX.HE included indices of five ratings. The first, the ABX.HE.AAA, references a specific AAA-rated tranche from each of the reference RMBS pools, the second, the ABX.HE.AA, references a specific AA-rated tranche from each of the reference RMBS pools, and so on down to the fifth index CDS, ABX,HE.BBB-. The tranches referenced by an ABX index of a given rating are selected based on their ratings at the time the indexes are issued. Since the reference pool of obligations is fixed, subsequent changes in the ratings of the underlying referenced tranches can lead to a lack of correspondence between the rating of the ABX.HE index and the credit ratings of the referenced obligations. The AAA tranches referenced by the ABX indexes are usually not at the top of the capital structure of the RMBS pools. Since the senior part of the capital structure of sub-prime RMBS deals usually includes a number of AAA-rated tranches, the ABX.HE AAA referenced obligations tend to be selected from the longer duration AAA positions. Although these bonds benefit from the subordination structure of the mezzanine bonds, they have more interest rate and default risk than the shorter AAA tranches.

Figure 1 shows, as an illustrative example, the structure of two of the twenty pools underlying the 2006-2 ABX.HE indices, contributed by Goldman Sachs and Merrill Lynch respectively. The figure portrays the bond subordination structure for these two securitized mortgage pools. The bonds in these deals receive principal and interest payments by ratings priority, starting from the two classes of AAA bonds, and are exposed to losses from defaults in reverse ratings priority. Each arrow in the figure identifies the priority placement of the bond that is contributed from the deal to the similarly rated ABX.HE 2006-2 basket of twenty bonds. As is clear from the diagram, the priority placement for the lower rated bonds differs across the two deals. In addition, the overall principal balance of the Goldman Sachs securitization, GSAMP 2006-HE3, is approximately \$1.6 billion whereas the Merrill Lynch securitization, MLMI-2006-HE1, is only \$764 million, so the bonds allocated to the ABX.HE 2006-2 CDS from GSAMP are also approximately twice the size of those from MLMI 2006-HE1. Table 2 shows the proportion of total principal allocated to these six tranches. In both cases, only 15–20% of the total principal is allocated to the ABX.HE portfolio, leaving 80–85% of the principal unrepresented.

Figure 1: Example of two bond structures underlying the ABX.HE 2006-2 indices

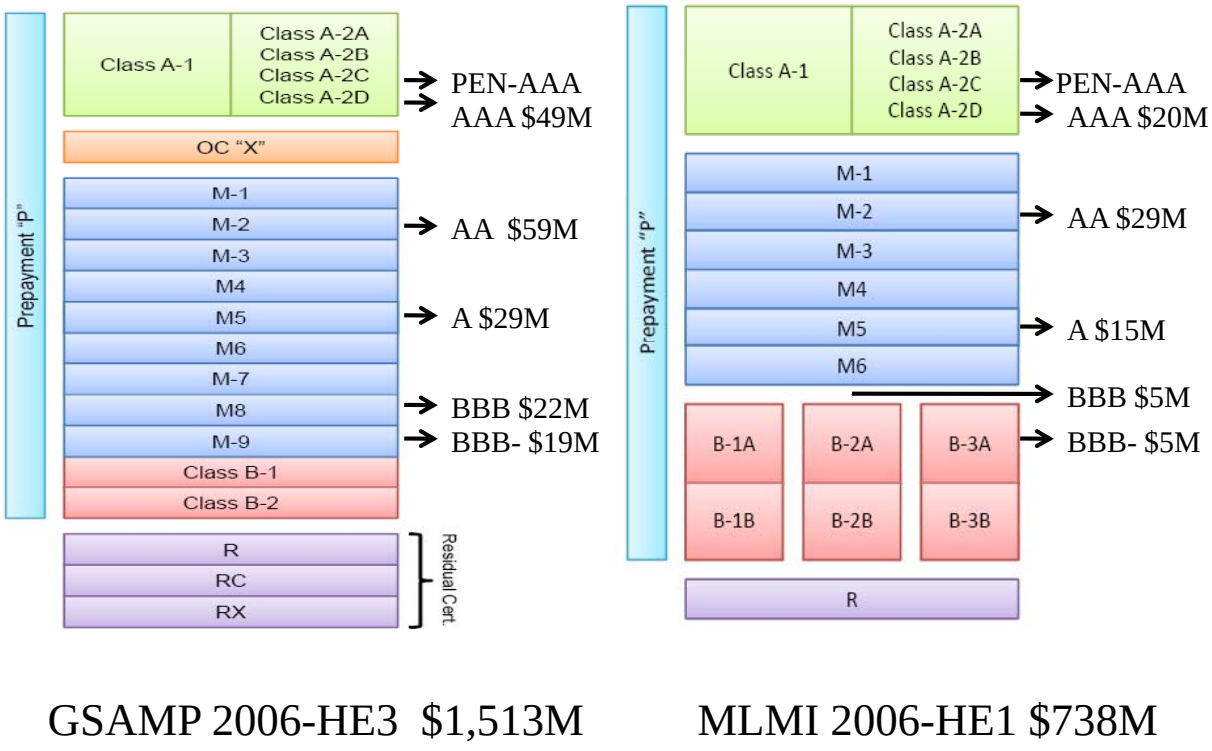


Table 2: Example of principal allocations

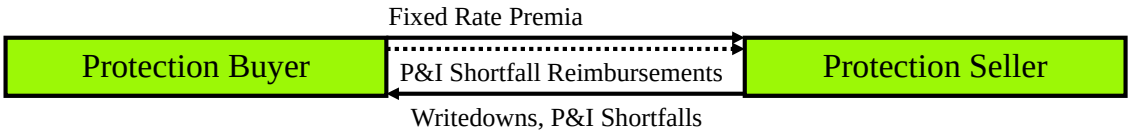
This table shows the allocation of principal to tranches from two of the 20 bond structures underlying the ABX.HE 2006-2 indices.

	MLMI 2006-HE1 (Merrill Lynch Investments)	GSAMP 2006-HE3 Goldman Sachs Trust)
PEN-AAA	5.37%	9.52%
AAA	2.65%	3.11%
AA	3.91%	3.70%
A	2.06%	1.85%
BBB	0.85%	1.40%
BBB-	0.69%	1.20%
Total	15.52%	20.78%

3.2 ABX.HE index cash flows

Initially, the protection buyer (i.e., the purchaser of a newly issued ABX.HE index CDS of a given credit rating), agrees to pay the seller a monthly premium (the "fixed leg"), equal to a fixed multiple of the remaining principal on the underlying referenced obligations; ABX.HE indices referencing obligations with lower credit ratings have higher fixed premia. In exchange for these payments, following the International Swaps and Derivatives Association pay-as-you-go (PAUG) structure, the ABX.HE protection seller pays the protection buyer amounts equal to the write-downs and principal shortfalls of the referenced obligations each period, called the "floating leg".[9] Figure 2 shows these payments schematically.[10]

Figure 2: Payout structure on an ABX.HE CDS



As time goes by, the composition and default risk of the underlying baskets of referenced obligations change, in turn changing the value of the insurance provided by the ABX.HE index CDS. The premium rate on the fixed leg (i.e., the multiple of principal paid by the protection buyer) for an ABX.HE index of a given vintage and credit rating remains fixed until the vintage expiry date (when the notional balances of the referenced obligations have fully amortized, defaulted, or been prepaid). Therefore, to match the buyer's payments to the value of the insurance provided, at any time after the issue date, as perceptions of default risk change, the protection buyer has to pay a one-time up-front fee to the seller in addition to the fixed leg of the CDS.

The PAUG structure is different from the cash settlement structure of CDS on corporate names, where realizations of credit events require the protection seller to pay the full notional amount of the reference obligation to the protection buyer in exchange for the protection buyer's delivery of the reference obligation. The lack of physical settlement in the CDS index market means that there may be important disparities in the size of the cash and derivative markets, since protection buyers are never required to deliver the referenced entity to the protection seller. It also means that there is no risk of short squeezes in the ABX.HE

[9]Markit Group, Ltd. defines "write-downs" as a reduction in the outstanding principal amount of the reference obligation or the forgiveness of any amount of principal by the holders of the obligation. "Principal shortfalls" are defined as a failure to pay principal on the part of the reference obligation.

[10]If credit events are subsequently reversed, the protection buyer reimburses the protection seller for previously paid principal and interest shortfalls.

Table 3: Outstanding ABX.HE Indexed CDS Positions and the Outstanding Principal on the Referenced Basket of subprime Residential Mortgage-Backed Securities Sorted by ABX.HE Subindices and Credit Rating

The table presents the total outstanding U.S. dollar amount of ABX.HE indexed Credit Default Swaps (CDS) for gross and net notionals and the number of outstanding contracts by class. We also report the aggregate current outstanding balances for the basket of twenty bonds that comprise each of the ABX.HE subindices and compute the percentage of CDS coverage per dollar of outstanding bond principal for the 20 component tranches. These data were obtained from the Depository Trust & Clearing Corporation (DTCC) website, `http://www.dtcc.com/products/derivserv/suite/tradeinfo_warehouse.php`

	Gross Notional ($000,000)	Net Notional ($000,000)	Contracts	Current Tranche Notional ($000,000)	Ratio Net ABX.CDS to Bond Notional
ABX.HE.AAA 2006	29,159	6,999	1859	2,978	2.35
ABX.HE.AA 2006	13,821	3,451	773	2,195	1.57
ABX.HE.A 2006	15,281	2,184	570	1,115	1.95
ABX.HE.BBB 2006	13,560	3,570	590	630	5.66
ABX.HE.BBB- 2006	23,545	3,237	1244	478	6.78
ABX.HE-PENAAA 2006	10,220	2,550	609	4,604	5.54
ABX.HE.AAA 2007	14,951	4,623	1045	2,867	1.61
ABX.HE.AA 2007	6,656	2,179	409	2,034	1.07
ABX.HE.A 2007	4,300	1,650	248	955	1.73
ABX.HE.BBB 2007	2,796	947	201	471	2.01
ABX.HE.BBB- 2007	4,481	947	368	472	2.00
ABX.HE-PENAAA 2007	7,639	1,389	401	6,206	.22
Totals	146,409	33,724	8,317	25,005	1.35
Total CDS	14,328,232	1,276,228	224,706		
ABX.HE % of Total	1.02%	2.64%	3.70%		

CDS market. Table 3 reports recently released information on the current gross and net notional outstanding interest in the ABX.HE indexed CDS, and compares these notionals to the current outstanding principal balances of the baskets of referenced subprime RMBS. As shown, as of December 28, 2008, the net notional amount of ABX.HE indexed CDS was $33.7 billion dollars, and these swap position were written on a referenced subprime RMBS notional value of about $25 billion. For almost all of the indices, the net notional amount of CDS significantly exceeds the underlying principal balances, in some cases by over 6 to 1.

4 ABX.HE prices and implied default rates

As described in Section 3.2 above, the buyer of an ABX.HE CDS pays a one-time up-front fee plus a monthly premium, in exchange for payments in the event of defaults. The quoted "price" is defined as par minus the up-front fee. Thus, for example, a quoted price of \$100 means the up-front fee is \$0 (as is the case on the issue date), and a quoted price of \$70 means the up-front fee is \$30.[11] When the ABX index trades below par, the market cost of default risk protection on subprime mortgages has increased since the issuance date of the index. For example, if the price of the ABX index was quoted as 80% of par, the protection buyer would pay the protection seller an up-front fee of 20% of the notional amount to be insured in addition to the monthly fixed premium on the index.

For the CDS contract to be fairly priced at some date t, the present value of the fixed leg plus the single up-front payment paid by the protection buyer must equal the present value of the floating leg paid by the protection seller, i.e.,

$$\frac{B_t\left(Par - P_{ABX}\right)}{100} + E^Q\left[s\sum_{k=1}^{n} B_{T_k} e^{-\int_0^{T_k} r_\tau\, d\tau}\right] = E^Q\left[\sum_{k=1}^{n}\left(r\left(B^A_{T_{k-1}} - B_{T_{k-1}}\right) + \left(B_{T_{k-1}}\left(\frac{B^A_{T_k}}{B^A_{T_{k-1}}}\right) - B_{T_k}\right)\right) e^{-\int_0^{T_k} r_\tau\, d\tau}\right], \quad (1)$$

where all expectations are under the "risk-neutral" probability measure. The first term of the left-hand side of equation (1) is the protection buyer's up-front fee payment. It is the difference between par and the quoted market price of the ABX.HE, P_{ABX}, times the current notional amount of the insurance, B_t. The second term is the value of the protection buyer's fixed payment leg. This comprises a coupon, paid at the end of each month T_k, equal to a fixed coupon rate, s, times the current notional, B_{T_k}, of the referenced bonds. The right-hand side of equation (1) is the value of the floating leg of the ABX.HE CDS, paid by the protection seller to the protection buyer. It includes a payment at each date T_k to compensate for any lost interest, plus reimbursement of lost principal. B_{T_k} denotes the notional value at date T_k and $B^A_{T_k}$ denotes the scheduled notional (taking amortization into account). Any difference between these values reflects loss of principal due to default, which is governed by the likelihood of default on the underlying mortgages and the structure of the pool underlying the ABS. On the issue date of the new ABX.HE index ($t = 0$), the fixed coupon rate is set so the market price of the ABX.HE equals par, i.e., $P_{ABX} = 0$. As expectations of default rates vary over time, the market price, P_{ABX_t} varies to keep the

[11] If the market price of the ABX.HE contract is at a premium, the protection seller makes a one-time payment to the protection buyer

values of the two sides of the swap equal.

Figures 3 through 5 show quoted market prices from 2006 to 2008 for the four vintages of the ABX.HE indices by credit rating;[12] Figure 3 shows the AAA and AA ABX.HE CDS, Figure 4 shows the A and BBB CDS, and Figure 5 shows the BBB- CDS. We shall focus primarily on the AAA prices, shown in the top panel of Figure 3. It can be seen that there was little variation in these prices until July 2007, when initial revelations concerning the poor performance of two Bear Stearns' subprime CDOs became public. After July, the prices continued to fall until the end of the sample on November 7, 2008. Although our sample does not extend beyond this date, we have obtained price data for the AAA securities on June, 2009, shown in Table 4, and we shall focus on these prices in the rest of our analysis.

Table 4: Prices of ABX.HE AAA CDS, June 30, 2009

This table shows market prices for the four vintages of ABX.HE AAA index CDS on June 30, 2009.

Vintage	Price
2006-1	\$69.110
2006-2	\$33.165
2007-1	\$25.784
2007-2	\$25.675

Recollect that the 2006-2 quoted price of \$33.165 means that protection buyers are paying \$66.835 per \$100 of principal for the privilege of making additional periodic payments to insure themselves against default losses on the AAA tranche. To see that something needs explaining here, consider that, as of July, 2009, the cumulative loss rate on the pools underlying all of the 2006-2 ABX.HE CDS was under 11%. Of course, even though the current financial (and real estate) crisis is the worst the U.S. has seen in decades, these are only *realized* default rates, and it is possible that current market expectations are for much worse to come. We therefore now infer from these prices what they imply for expected future default rates.

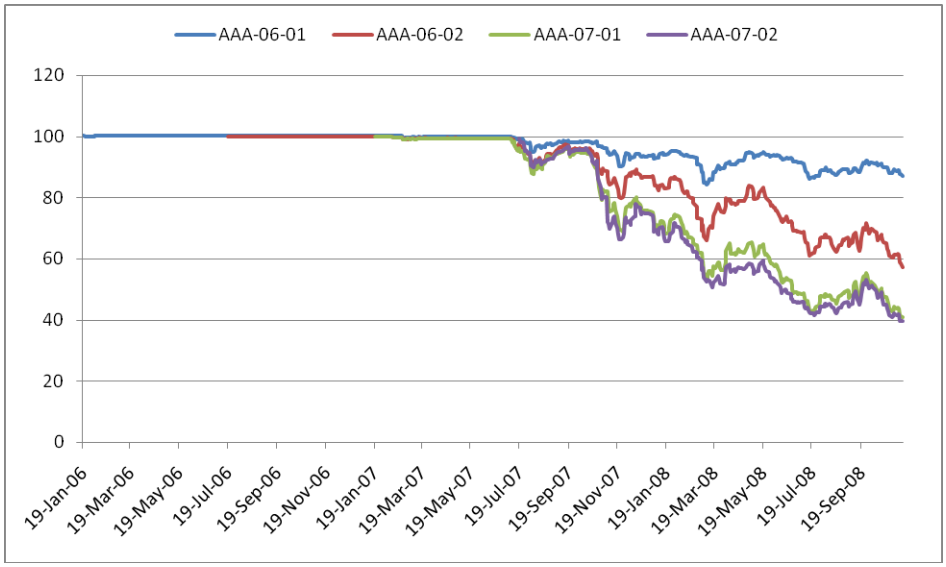
4.1 A simple model of implied default rates

Given a valuation model and assumptions about default rates, we can calculate the fair up-front payment for the ABX.HE CDS. Conversely, given a valuation model and a market price, we can infer something about the market's expectations about default rates. Before

[12] In calculating these prices, Markit collects CDS prices from the market makers, who have some discretion in reporting trades. They drop the highest and lowest of the reported prices, and average the rest.

Figure 3: Prices for the Bonds with AAA and AA Credit Ratings for the 2006 and 2007 Markit ABX.HE Indices

This Figure plots the Markit ABX.HE indices for the ABX.HE-2006-1, ABX.HE-2006-1, ABX.HE-2007-1, and ABX.HE–2007–1 Series.



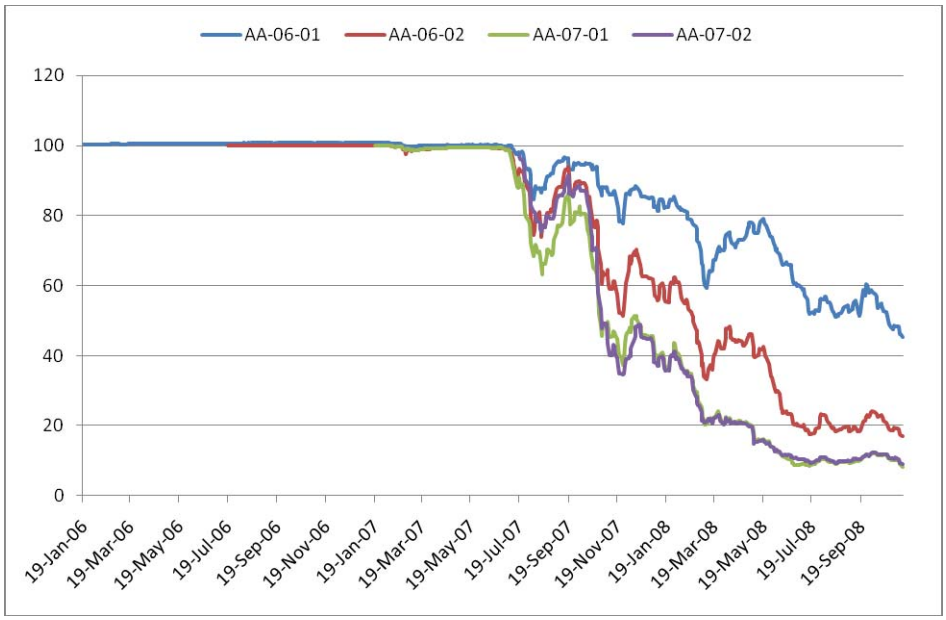
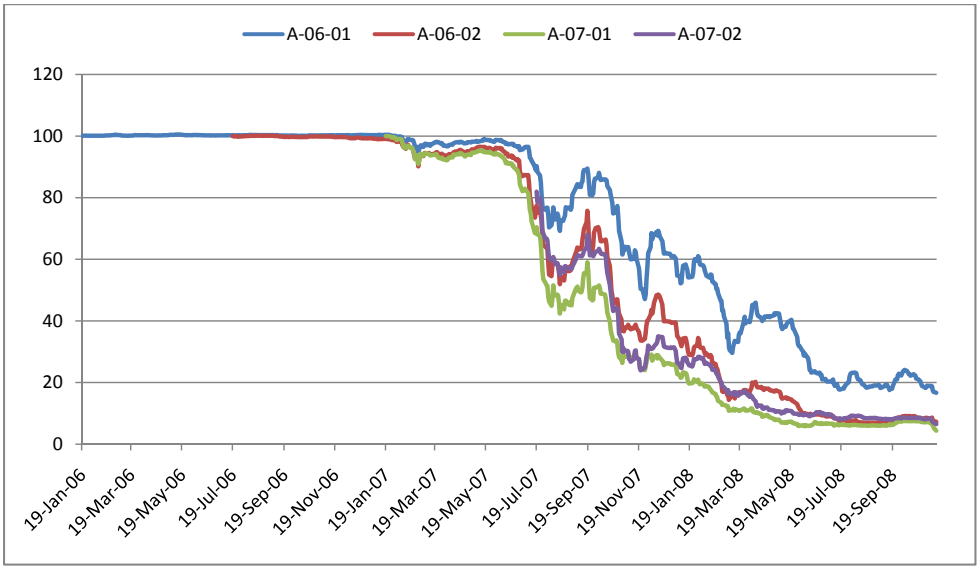


Figure 4: Prices for the Bonds with A and BBB Credit Ratings for the 2006 and 2007 Markit ABX.HE Indices

This Figure plots Markit ABX.HE indices for the ABX.HE-2006-1, ABX.HE-2006-1, ABX.HE-2007-1, and ABX.HE-2007-1 Series.



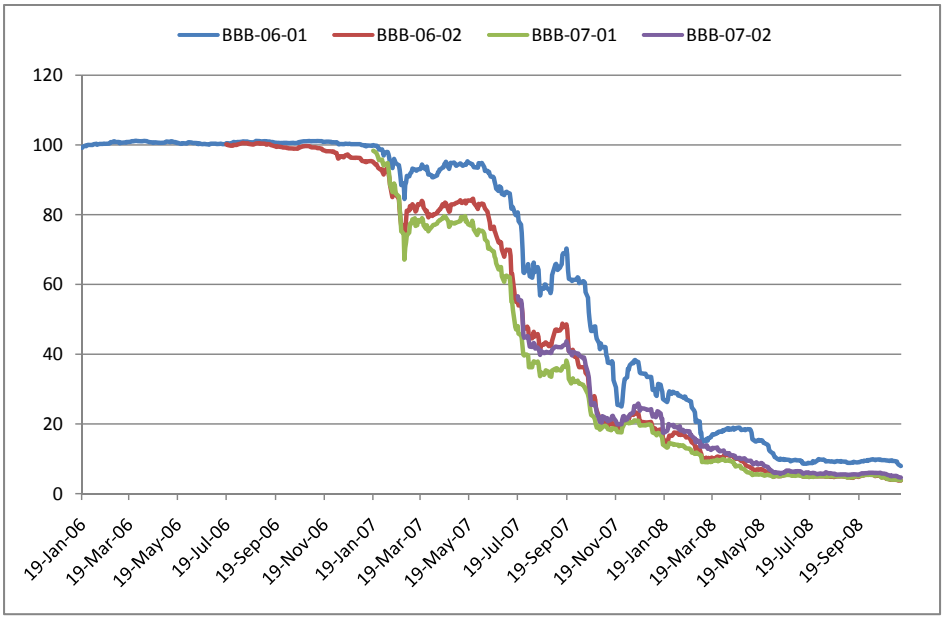
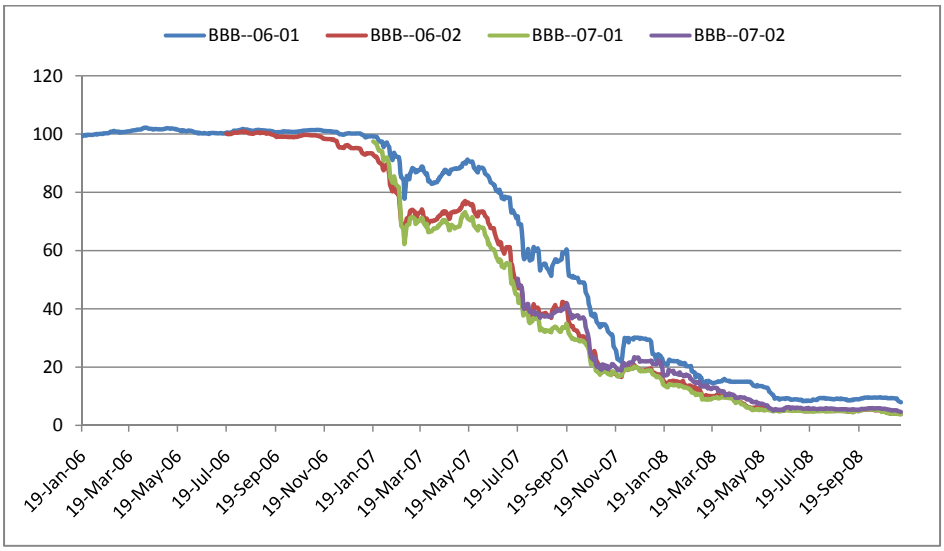


Figure 5: Prices for the Bonds with BBB- Credit Ratings for the 2006 and 2007 Markit ABX.HE Indices

This Figure plots Markit ABX.HE indices for the ABX.HE-2006-1, ABX.HE-2006-1, ABX.HE-2007-1, and ABX.HE-2007-1 Series.



developing a formal model, we start with a very simple "back-of-the-envelope" model, which strongly suggests that expected future defaults are not going to be able to explain the prices shown in Figure 3 and Table 4.

In our simplified model of default, we shall assume that a (known) fraction D of the underlying mortgages defaults immediately, and that there is no further default thereafter. We shall also ignore the periodic fixed payment made by the protection buyer. In this case, if the recovery rate on defaulted loans is R, and the (fractional) subordination level on the AAA tranches is S,[13] the defaults reduce the principal behind the AAA tranches by a fraction

$$\max\left\{\frac{D(1-R)-S}{1-S}, 0\right\}. \tag{2}$$

Assuming $D(1-R) > S$, so some defaults hit the AAA tranches, the fair lump-sum price (per \$1 of principal) for default insurance on the AAA tranches equals the loss,

$$1 - P = \frac{D(1-R)-S}{1-S} \tag{3}$$

[13]In other words, a fraction S of the total principal on the loans must be completely lost before any additional losses affect the AAA tranches.

Rearranging, we obtain the default rate in terms of the quoted CDS price, P,

$$D = \frac{1 - P(1 - S)}{1 - R}. \tag{4}$$

Focusing on the 2006-2 AAA security, we set $S = 0.37$ (the average subordination level on the AAA tranches as of June 30, 2009) and $P = \$33.165$, and we can now calculate the implied default rate for different assumptions about the recovery rate, R, using Equation (4). The results are shown in Table 5. It can clearly be seen that, even for tiny recovery rates, the

Table 5: Implied default rates

This table shows the default rate required to make the given recovery rate consistent with the observed prices of AAA ABX.HE index CDS on June 30, 2009, based on Equation (4) Missing values indicate that there is no default rate high enough to imply the given price.

Recovery Rate	Implied D
10%	88%
20%	99%
30%	——
40%	——
50%	——
60%	——
70%	——
80%	——
90%	——

implied default rates on the entire pool are close to 100%, and for recovery rates in excess of 30% (which is still very low by historical standards), even 100% default rates are not enough to justify observed market prices for the AAA CDS. Another way to see this is to note that a 100% default rate is implied when $D = 1$ in Equation (4), i.e., when

$$R = P(1 - S).$$

In our example, this yields a value for R of 20.9%, the maximum possible recovery rate consistent with the quoted price, even with a default rate of 100%. For any higher recovery rate, even 100% default rates are not enough to support the quoted price.

4.2 A Monte Carlo model of implied default rates

The analysis above shows that (under the simplifying assumptions given) for any reasonable assumption about recovery rates, current prices for the AAA ABX.HE 2006-2 CDS are inconsistent with any possible assumption about default rates. To verify that this conclusion is not merely due to the simplicity of the model, we repeat the analysis using a more sophisticated CDS valuation model. We use Monte Carlo simulation to estimate the expectations in Equation (1), calculating the cash flows along each path using the exact payout structure of each of the 20 subprime deals that underlie the security, combined with assumptions about prepayment, default and recovery rates on the underlying loans. Table 6 summarizes the characteristics of these twenty deals.

Table 6: The Composition of the Markit ABX.HE 2006-2

The table presents all the deals that comprise the ABX.HE 2006-2.

Contributor Name	Deal Name	Number of A1 Tranches	Number of A2 Tranches	Number of M Tranches	Number of B Tranches	6/2006 Bond Principal $ M	6/2009 Bond Principal $ M
ACE Securities Corporation	ACE 2006-NC1	1	4	10	0	1,324	485
AMRESCO Securities Inc.	ARSI 2006-W1	1	4	10	0	2,275	824
Bear Stearns Asset Backed Securities Trust	BSABS 2006-HE3	3	0	10	0	793	278
Carrington Mortgage Loan Trust	CARR 2006-NC1	4	0	10	0	1,463	738
Countrywide Asset Backed Trust	CWL 2006-8	1	4	9	1	2,000	1,128
First Franklin Mortgage Loans	FFML 2006-FF4	3	0	8	2	1,534	594
Goldman Sachs GSAMP Trust	GSAMP 2006-HE3	1	4	9	2	1,632	629
Home Equity Asset Trust	HEAT 2006-4	1	4	8	4	1,585	586
J.P. Morgan Mortgage Acquisition Trust	JPMAC 2006-FRE1	1	3	11	0	1,013	340
Long Beach Mortgage Loan Trust	LBMLT 2006-1	1	4	11	0	2,500	849
Master Asset Backed Securities Trust	MABS 2006-NC1	4	0	11	0	915	334
Merrill Lynch Mortgage Investment Trust	MLMI 2006-HE1	1	4	6	6	764	264
Morgan Stanley Capital Inc.	MSAC 2006-HE2	1	4	6	3	2,266	807
Morgan Stanley Capital Inc.	MSAC 2006-WMC2	1	5	6	3	2,603	1,115
Residential Asset Mortgage Products Inc.	RAMP 2006-KS3	3	0	9	2	760	310
Residential Asset Securities Corp.	RASC 2006-OP1	4	1	11	1	1,150	417
Security Asset Backed Receivables Inc.	SABR 2006-OP1	1	4	6	3	1,260	347
Structured Asset Investment Loan Trust	SAIL 2006-4	1	4	8	2	1,699	728
Structure Asset Security Corp.	SASC 2006-WF2	4	0	9	1	1,299	598
Soundview Home Equity Loan Trust	SVHE 2006-OPT5	1	4	12	0	3,100	1,382

As shown, there is considerable heterogeneity in the tranche structure of these deals, and the number of tranches, including the "credit enhancement" (CE) tranche, ranges from fourteen to eighteen. The pools have all experienced considerable prepayment and loss of principal through default, leaving the current outstanding balance on the loans ranging from about one third to one half of the initial principal balance of the bonds outstanding. The

average subordination level for the AAA bonds is 37% as of June 30, 2009.

For each of the twenty subprime pools, we model the mortgage cash flows and the bond allocation cash flows using the payout structures defined in the prospectus for that pool. We model two classes of mortgage, fixed rate and adjustable rate, using the weighted average characteristics of the two types of loans. The monthly mortgage cash flows are determined by the average contractual structure of the loans of each type for amortization, coupons, weighted-average life, loan-to-value ratios, initial balances, and indexing structure (such as the maximum life-of-loan caps and the periodic interest rate caps). We assume a constant monthly prepayment rate of ten basis points,[14] and varying levels of fixed default rates. We use each deal's prospectus to determine the contingent payout structure for the interest and principal distributions to each bond in the deal.

Our Monte Carlo simulations are based on a Hull and White term structure model, which we fit to the observed term structure of interest rates and caplet prices for the end of June 2009. The fixed payment on the ABX.HE 2006-2 is 11 basis points per year, and we assume that the CDS contract pays out one hundred percent of principal and interest losses per dollar of principal. For any given assumption about recovery rates, we can now use the model to work out what default rate is consistent with the observed market price of $33.165. Consistent with the back-of-the envelope numbers above, we find that with an assumed 20% recovery rate, this price implies a default rate of 100% on the underlying mortgages.

5 Empirical analysis of ABX.HE price changes

The results from Section 4 suggest that, whatever is driving ABX.HE CDS prices, it is not just expectations of future default rates on the underlying mortgages. We here investigate in more detail the empirical determinants of changes in the quoted prices for the ABX.HE index CDS. The goal of this investigation is to answer two questions. First, even though we know ABX.HE prices do not *solely* reflect expectations of future default behavior, are they related at all to news about the credit performance of the referenced basket of subprime obligations? Second, given that default behavior cannot fully explain observed prices, what other variables are empirically significant?

[14] This is based on an empirical hazard model for prepayment, fitted to the bahevior of the individual loans underlying the 20 pools.

5.1 The data

ABX.HE prices: The ABX.HE CDS prices used in our empirical analysis are as reported to the market by Markit Group Ltd., who report daily trading prices as an average of a given "depth" of bond trades.

Mortgage credit performance: To examine the significance of changes in credit behavior for the ABX.HE prices, we assemble loan-by-loan performance information for each of the subprime RMBS pools referenced by the four trading ABX.HE indices. Our detailed month-by-month performance data were obtained from Bloomberg and from the two major securitization trustees, Wells Fargo Bank and LaSalle Trustee. Because the tranched allocation of the referenced pools makes subprime MBS payoffs nonlinear in the mortgage cash flow distributions, we also assembled detailed information concerning the subordination structure of the pools from the deal prospectuses, including the performance triggers, over-collateralization, and excess spread characteristics of the waterfalls. This information allowed us to track the payout performance of the referenced bonds conditional on the credit performance of the underlying loans from the date of the ABX.HE index issuance until the end of November, 2008. We then interact the loan-level performance data with the evolution of the subordination structure of the deal to obtain an accurate measure of the loan credit performance channel.

Table 7 presents time-series averages of the percent of overall principal value in the pool that is 30 days delinquent, 60 days delinquent, 90 days delinquent, real estate owned after foreclosure (REO), in foreclosure, or in bankruptcy. The last column of the table reports the average monthly proportion of total pool principal subject to any of these credit events. As shown in the table, the overall percentage of principal at risk is about 24% of current outstanding balance. If the loss rates were 100% on all of these credit events, then the principal balances of the BBB-, BBB, and A bonds would be wiped out.[15] The average 30 day delinquency rates are about 4% over the holding period, the average 60 day delinquencies are also about 2% and the 90 day delinquencies are about 3%. While at the end of the period we see the maximum values in these pools, and these levels are alarming, they never exceed 20%. The average foreclosure levels are about 8% across the indices, REO is about 4%, and bankruptcy is around 1%. The typical progression is for a loan to first be 30 day delinquent, then to transition to 60 days delinquent, and subsequently to 90 days delinquent until the loan ends up in foreclosure, bankruptcy, or REO. Surprisingly, from the loan-level data, we observe a cure rate on the 30- and 60-day delinquency rates of about 30%.

[15]There are currently numerous BBB- and BBB bonds that have experienced total losses

Table 7: Loan Credit Performance for Markit ABX.HE Indices to 11/28/08

The table presents the average percentage of outstanding pool principal balance that was 30 days delinquent, 60 days delinquent, 90 days delinquent, held as Real Estate Owned, in Foreclosure, or in Bankruptcy. These performance measures are measured monthly at the pool level for all deals the Markit ABX.HE Indices. The reported averages in the table are computed over the holding period for each pool in the ABX.HE Index. We also report the sample average of the total principal balance that is affected by all of the above credit events.

		30 Day Delinquent %	60 Day Delinquent %	90 Day Delinquent %	Foreclosure %	REO %	Bankrupt %	All Credit Events
ABX.HE-2006-1	Mean	4.28	2.24	3.31	8.33	4.78	1.33	24.27
	Std. Dev.	1.72	1.32	3.31	6.09	4.62	1.39	15.89
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	8.56	6.37	23.50	28.09	19.70	6.10	65.20
ABX.HE-2006-2	Mean	4.29	2.45	1.69	9.06	4.93	1.13	24.75
	Std. Dev.	1.58	4.24	0.00	6.64	4.68	1.20	15.79
	Minimum	0.00	0.00	14.20	0.00	0.00	0.00	14.20
	Maximum	8.45	0.00	14.13	27.90	21.50	4.05	67.61
ABX.HE-2007-1	Mean	4.92	2.68	3.53	8.43	4.09	1.08	24.66
	Std. Dev.	1.85	1.28	3.20	5.64	4.30	1.12	14.53
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	23.33	6.40	18.45	25.00	14.53	5.85	57.20
ABX.HE-2007-2	Mean	5.09	2.85	3.84	8.18	3.18	0.88	24.03
	Std. Dev.	1.72	1.27	3.30	5.34	3.38	0.83	13.54
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	11.03	5.69	16.29	19.72	13.32	5.52	48.62

House price performance: House prices are a potentially important factor influencing future default rates. We collect the same data available to market participants, quarterly house price indices by state, available from the Office of Housing Enterprise Oversight (OFHEO). To construct our analysis series, we interact changes in the price series with monthly time series giving the percentages by state of the principal outstanding for each pool in the basket for each ABX.HE vintage index.

Short sales data Based on Froot (2001), who found limited capital in the reinsurance market to be the most likely explanation for the fact that prices for catastrophe insurance often exceed seven times expected losses, one likely candidate explanation is lack of capital behind the provision of MBS insurance via the sale of ABX.HE indexed CDS. This explanation is not implausible in this market, given the size of the notional outstanding combined with the fact that, while many institutions are natural demanders of insurance against MBS default, very few are natural suppliers of such insurance. The impact of such capital constraints will vary with shifts in the demand for insurance.

Since there was no functioning clearinghouse for CDS contracts until recently, we proxy for insurance demand by looking at measures of short-selling in sectors related to subprime MBS, following prior authors (see Lamont and Stein (2004), Fishman, Hong, and Kubik (2007) and Jones and Lamont (2002)) in the use of two different shorting-related measures. The first is the value-weighted short-interest ratio (the market value of shares sold short, divided by the average daily trading volume) for banks, investment banks, the government sponsored enterprises (GSEs — Fannie Mae and Freddie Mac), and the public home builders. The short-interest ratio is a measure of how long it would take short sellers, in days, to cover their entire positions if the price of a stock begins to rise. The short-interest ratio can also be applied to entire exchanges to determine the sentiment of the market as a whole. If an exchange has a high short interest ratio of around five or greater, this can be taken as a bearish signal, and vice versa.

Our second indirect measure of short-selling demand in mortgage related securities is the Chicago Board Options Exchange's (CBOE) daily put-call ratio. This is the ratio of CBOE open interest in put options to the open interest in call options on stocks and indices for publicly traded banks, investment banks, GSEs, and home builders. While this is a rather noisy measure of the magnitude of shorting, it has performed well in other recent applications (see, for example, Lamont and Stein (2004)).

We obtain monthly data on these measures from Bloomberg and from Shortsqueeze.com. We track the short-interest ratio and the put-call option ratio for thirty-three publicly traded companies, and group them into four categories: banks, investment banks, public builders,

and GSEs.[16].

Control variables We also consider an additional set of macro controls such as the changes the VIX volatility index, changes in the slope of the term structure of interest rates (measured as the difference between the 10-year constant maturity Treasury (CMT) yield and the one-year CMT yield), and changes in the one-year CMT yield. Daily values for these interest rate series were obtained from the Federal Reserve web site. We also control for the performance of the market as a whole using daily S&P 500 returns, downloaded from finance.yahoo.com.

Finally, we have a measure of the number of market makers contributing the prices that underlie the valuation averages reported by Markit Group Ltd. This measure of market depth has been falling over time and now averages about eight. We also include a measure of the percentage of ARMs in the remaining balance of the pool.

5.2 Empirical specification

The frequency of our analysis is daily. The left hand side variable is measured as the daily change in the log of quoted ABX.HE prices. The S&P right hand side variable are also measured daily and we introduce one lag. Our interest rate data is also measured daily and we use the change in the rates and the change in the slope as regressors. All the other regressors are similarly measured as first differences, other than the percentage of ARMs and the number of bonds traded. The house price data is interpolated to monthly and then interacted with the time series of states. The monthly series is brought to a daily series that is constant within months. Similarly, the monthly short interest ratio series is brought to a daily series of monthly first differences that are constant within months. The data structure is stacked for the time series of each cross-section of deals within the ABX.HE basket and the intercepts for these are fixed across CUSIPs. The system is estimated with a seemingly unrelated regression controlling for the contemporaneous correlation of the bonds within a

[16]The public companies that we track are: Ambac Financial Group Inc.; Bank of America Corp.; Bank of New York Company; Barclays PLC; Capital One Financial Corp.; Centex Corp.; Citigroup Inc.; Countrywide Financial Corp.; Credit Suisse Group; Deutsche Bank Aktiengesellschaft; Fannie Mae; Flagstar Bancorp Inc.; Freddie Mac; Goldman Sachs Group Inc.; HSBC Holdings PLC; JPMorgan Chase & Co.; Kaufman and Broad; KeyCorp; Lennar Corp.; Merrill Lynch & Co. Inc.; Morgan Stanley; Pulte Homes Inc.; Sovereign Bancorp Inc.; SunTrust Banks Inc.; The PNC Financial Services Group Inc.; The Ryland Group Inc.; Toll Brothers Inc.; U.S. Bancorp; UBS AG; Wachovia Corp.; Webster Financial Corp.; and Wells Fargo & Company.

basket. The specification appears as:

$$ABX_{it}^{AAA} = \beta_0^{AAA} + \beta_1^{AAA} ABX_{i,t-k} + \sum_{k=0}^{2} \beta_{2k}^{AAA} SP_{j,t-k} + \sum_{l=3}^{37} \beta_l^{AAA} (X_t - X_{t-1}) + \varepsilon_{it}^{AAA} \tag{5}$$

$$ABX_{it}^{AA} = \beta_0^{AA} + \beta_1^{AA} ABX_{i,t-k} + \sum_{k=0}^{2} \beta_{2k}^{AA} SP_{j,t-k} + \sum_{l=3}^{37} \beta_l^{AA} (X_t - X_{t-1}) + \varepsilon_{it}^{AA} \tag{6}$$

$$ABX_{it}^{A} = \beta_0^{A} + \beta_1^{A} ABX_{i,t-k} + \sum_{k=0}^{2} \beta_{2k}^{A} SP_{j,t-k} + \sum_{l=3}^{37} \beta_l^{A} (X_t - X_{t-1}) + \varepsilon_{it}^{A} \tag{7}$$

$$ABX_{it}^{BBB} = \beta_0^{BBB} + \beta_1^{BBB} ABX_{i,t-k} + \sum_{k=0}^{2} \beta_{2k}^{BBB} SP_{j,t-k} + \sum_{l=3}^{37} \beta_l^{BBB} (X_t - X_{t-1}) + \varepsilon_{it}^{BBB} \tag{8}$$

$$ABX_{it}^{BBB-} = \beta_0^{BBB-} + \beta_1^{BBB-} ABX_{i,t-k} + \sum_{k=0}^{2} \beta_{2k}^{BBB-} SP_{j,t-k} + \sum_{l=3}^{37} \beta_l^{BBB-} (X_t - X_{t-1}) + \varepsilon_{it}^{BBB-} \tag{9}$$

5.3 Results

Table 8 presents estimation results for the pooled sample over the four vintages of indices. Surprisingly, the change in the credit performance of the underlying mortgages interacted with the percentage of bond subordination for the each of the referenced obligations on the credit default swaps has no statistically significant effect on the change in the ABX.HE prices, except for two anomalous effects. The subordination interacted changes in the percentage of foreclose and the change in the 30 day delinquency rate are both positively and statistically significantly associated with changes in ABX.HE, suggesting that the greater the incidence of these credit events, the *lower* the up-front payment that was required from the CDS buyer.

Unlike the mortgage performance measures, ABX.HE price changes are strongly related to the short-sales measures, the effects differing across the five index credit ratings. Other than the GSE short-interest effect, the changes in the short-interest coefficients are largely negatively associated with changes in the ABX.HE returns. Thus, larger increases in the short-interest ratios reduced the index returns as the cost of protection on the principal and interest of subprime RMBS rose.

Table 8: Stacked Seemingly Unrelated Regressions for Pooled 2006 and 2007 Vintage Market Indices ABX.HE

The table presents results across the five bond ratings. The ABX.HE is measured as the log difference as is the measure of the S&P return all other regressors except the indicator variables are measured as first differences.

	AAA Bonds		AA Bonds		A Bonds		BBB Bonds		BBB- Bonds	
	Coeff. Est.	Std. Err.	Coeff. Est.	Std. Err.	Coeff. Est.	Std. Err.	Coeff. Est.	Std. Err.	Coeff. Est.	Std. Err.
Intercept	0.00443	0.00137 ***	0.01118	0.00262 ***	0.01079	0.00310 ***	0.01529	0.00303 ***	0.00933	0.00307 ***
Lag1 ABX Return	0.19351	0.00495 ***	0.22918	0.00460 ***	0.12057	0.00494 ***	-0.01259	0.00484 ***	-0.03612	0.00501 ***
S & P 500 Return	0.86050	0.03220 ***	1.29932	0.06160 ***	1.36634	0.07280 ***	1.06608	0.07130 ***	1.03321	0.07230 ***
Lag1 S & P 500 Return	0.68428	0.02960 ***	1.17334	0.05630 ***	1.08766	0.06670 ***	0.63127	0.06500 ***	0.53784	0.06590 ***
Yield Curve Slope	0.00119	0.00134	0.01783	0.00256 ***	0.02476	0.00302 ***	0.02300	0.00296 ***	0.02098	0.00299 ***
One Year CMT	0.01760	0.00131 ***	0.03780	0.00251 ***	0.06091	0.00297 ***	0.04762	0.00290 ***	0.04679	0.00294 ***
VIX	-0.00033	0.00010 ***	-0.00183	0.00020 ***	-0.00010	0.00023	-0.00023	0.00023	0.00039	0.00023 ***
Short Interest Ratio - GSEs	0.01144	0.00233 ***	0.01684	0.00446 ***	0.00524	0.00527	0.01913	0.00516 ***	0.00752	0.00523
Short Interest Ratio - Investment Banks	0.00069	0.00009 ***	0.00000	0.00016	-0.00117	0.00019 ***	-0.00205	0.00019 ***	-0.00229	0.00019 ***
Short Interest Ratio - Builders	-0.01932	0.00477 ***	-0.05891	0.00911 ***	-0.03630	0.01080 ***	-0.06072	0.01050 ***	-0.02930	0.01070 ***
Short Interest Ratio - Banks	-0.00016	0.00003 ***	-0.00093	0.00005 ***	-0.00144	0.00006 ***	-0.00150	0.00006 ***	-0.00141	0.00006 ***
Ratio Open Interest Put Options to Call Options - GSEs	0.00509	0.00844	0.03988	0.01610 **	-0.00622	0.01910	-0.06127	0.01870 ***	-0.06602	0.01890 ***
Ratio Open Interest Put Options to Call Options - Investment Banks	-0.02347	0.00329 ***	0.01638	0.00628 ***	0.02149	0.00742 ***	0.00597	0.00725	0.02049	0.00733 ***
Ratio Open Interest Put Options to Call Options - Builders	0.00325	0.00465	-0.00145	0.00888	-0.01362	0.01050	-0.00608	0.01030	-0.00075	0.01040
Ratio Open Interest Put Options to Call Options - Banks	-0.00083	0.00612	0.00893	0.01170	-0.02263	0.01380	-0.08377	0.01350 ***	-0.10228	0.01370 ***
% Bond Subordination × 30 Delinquency %	0.00008	0.00039	0.00156	0.00130	-0.00009	0.00263	0.01081	0.00524	0.01471	0.00698 **
% Bond Subordination × 60 Delinquency Rate	-0.00055	0.00050	0.00197	0.00157	0.00262	0.00316	0.00381	0.00614	0.00812	0.00809
% Bond Subordination × 90 Delinquency Rate	-0.00022	0.00031	0.00068	0.00100	0.00315	0.00212	0.00034	0.00424	-0.00079	0.00562
% Bond Subordination × REO %	0.00002	0.00011	0.00045	0.00031	0.00068	0.00058	0.00192	0.00099 *	0.00076	0.00113
% Bond Subordination × Foreclosure %	-0.00020	0.00026	0.00041	0.00080	0.00484	0.00165 **	0.00644	0.00321	0.00606	0.00416
% Bond Subordination × Bankruptcy %	-0.00037	0.00092	-0.00174	0.00276	0.00390	0.00531	-0.00904	0.00946	-0.01205	0.01190
Percentage of Overcollateralization at Pool Origination	-0.00710	0.00569	-0.01467	0.01090	-0.00523	0.01290	0.00734	0.00017 ***	0.01892	0.01280
Percentage of Excess Spread at Pool Origination	-0.00032	0.00014 **	-0.00047	0.00026 *	-0.00040	0.00031	-0.00070	0.01350 ***	-0.00092	0.00031 **
Percentage of ARMs at Origination	0.00000	0.00001	0.00001	0.00002	0.00002	0.00002	0.00003	0.00002	0.00003	0.00002 *
% of Pool in CA × CA House Prices Index	0.00001	0.00000 ***	0.00001	0.00000 ***	0.00001	0.00000 ***	0.00001	0.00000 ***	0.00000	0.00000 **
% of Pool in FL × FL House Prices Index	0.00003	0.00000 ***	0.00007	0.00001 ***	0.00007	0.00001 ***	0.00004	0.00001 ***	0.00004	0.00001 ***
% of Pool in IL × IL House Prices Index	-0.00007	0.00003 ***	-0.00007	0.00005	-0.00001	0.00006	-0.00009	0.00006	-0.00005	0.00006
% of Pool in MD × MD House Prices Index	0.00006	0.00002 ***	0.00002	0.00004	-0.00006	0.00005	0.00000	0.00005	-0.00011	0.00005 **
% of Pool in MI × MI House Prices Index	0.00004	0.00003	-0.00006	0.00005	-0.00015	0.00006 **	0.00008	0.00006	-0.00003	0.00006
% of Pool in NJ × NJ House Prices Index	-0.00001	0.00003	-0.00014	0.00005 ***	-0.00015	0.00006 ***	-0.00006	0.00006	-0.00002	0.00006
% of Pool in NV × NV House Prices Index	-0.00002	0.00002	-0.00008	0.00004 **	0.00006	0.00005	0.00008	0.00005 *	0.00001	0.00005
% of Pool in NY × NY House Prices Index	0.00000	0.00000	-0.00003	0.00001 ***	-0.00006	0.00001 ***	-0.00006	0.00001 ***	-0.00006	0.00001 ***
% of Pool in PA × PA House Prices Index	-0.00012	0.00005 **	-0.00008	0.00010	0.00010	0.00012	0.00035	0.00011 ***	0.00053	0.00012 ***
% of Pool in TX × TX House Prices Index	0.00000	0.00002	-0.00012	0.00004 ***	-0.00026	0.00005 ***	-0.00020	0.00005 ***	-0.00025	0.00005 ***
% of Pool in VA × VA House Prices Index	-0.00008	0.00002 ***	-0.00028	0.00004 ***	-0.00020	0.00005 ***	0.00001	0.00005	-0.00007	0.00005
% of Pool in WA × WA House Prices Index	-0.00004	0.00002 ***	0.00001	0.00003	-0.00004	0.00004	-0.00014	0.00004 ***	-0.00012	0.00004 ***
% of Pool in AZ × AZ House Prices Index	0.00001	0.00003	-0.00001	0.00006	-0.00007	0.00007	-0.00001	0.00007	-0.00001	0.00007
% of Pool in GA × GA House Prices Index	-0.00013	0.00005 ***	0.00014	0.00009	0.00021	0.00010 **	-0.00025	0.00010 **	-0.00016	0.00010
% of Pool in OH × OH House Prices Index	0.00008	0.00039	0.00156	0.00130	-0.00009	0.00263	0.01081	0.00524 **	0.01471	0.00698 **
ABX Depth (Traded Tranches)	-0.00001	0.00008	0.00016	0.00015	-0.00031	0.00018 *	-0.00106	0.00017 ***	-0.00106	0.00018 ***
R Squared	0.14880		0.25940		0.26030		0.15120		0.14450	

For the banks, public builders, and investment banks, the short-interest ratio is mostly negatively related to changes in the ABX.HE returns for all credit ratings, consistent with the notion that this measure is a proxy for excess demand for mortgage default insurance. While the coefficient on the GSEs is counterintuitive, these institutions were nationalized during our sample period. Results for the put-call ratio are inconclusive, but these ratios did not show much variation during the sample period.

The initial levels of overcollateralization and excess spread at origination are significantly negatively associated with changes in the ABX.HE index. Since these credit enhancements should mitigate the credit risk exposure for all the referenced bonds, the CDS should be less sensitive to all exogenous shocks. ABX.HE index returns by credit rating are strongly positively correlated with lagged index returns, and with contemporaneous and lagged S&P returns. The change in the slope of the yield curve has a significantly positive effect on the AA, A, BBB, and BBB- index returns, and changes in the one-year constant maturity Treasury rates have a similar effect. The VIX, or "fear index," increases with more volatility, which in turn increases the cost of the option positions needed to hedge risk. The VIX index is strongly negatively associated with the ABX.HE returns for the AAA, AA, A, and BBB credit rated ABX.HE, since protection sellers should require a higher up-front payment for the ABX.HE CDS protection.

The lack of geographic diversification found in the subprime mortgage pools appears to make them very vulnerable to shocks in the California and Florida housing markets. We find statistically significant positive associations between changes in the OFHEO house price indices in these states and changes in the ABX.HE indices.

Overall, these results suggest that the short-interest demand channel is a more important correlate with ABX.HE returns than are credit events on the mortgages. Fear, as measured by the VIX or volatility index, is also an important factor in the movements of bond returns.

As a further robustness check (unreported), we re-estimate our specification for the individual ABX.HE indices, allowing us to partially control for the mixture of times-series and cross-sectional effects of our estimator. The results of all four specifications are similar to those reported for the pooled sample in Table 7.

6 Conclusions

Despite the rapid growth of the ABX.HE indexed CDS market, and the focus of regulators on banks using market prices for these CDS as the basis for marking their portfolios to market, we find that current market prices of ABX.HE are inconsistent with any reasonable forecast for future default rates, and, moreover, are uncorrelated with changes in the realized

credit experience of the underlying loans. Instead, we find that returns on ABX.HE indices of all credit qualities are significantly related to short-sale activity imbalances in the option and equity markets of the publicly traded builders, the commercial banks, the investment banks and the government sponsored enterprises (GSEs) proxies for demand imbalances in the market for mortgage default insurance.

Besides their immediate policy implications in the mortgage market, our findings add to a growing body of recent research documenting how limits to arbitrage (see Shleifer and Vishny (1997)) and capital constraints can allow prices in many markets to i. diverge significantly from fundamentals; and ii. move with variables unrelated to fundamentals. For example, Froot (2001) studies the market for catastrophe insurance. Losses due to natural disasters are both large and approximately uncorrelated with the state of the overall economy, so we should expect to see large demand for insurance, especially against catastrophic losses, and this insurance should be priced roughly at the level of expected losses. In contrast, Froot (2001) documents that protection tends to be relatively limited, and is always priced well above the level of expected losses, sometimes as much as seven times as high. He concludes, supported by statements by players in the industry such as National Indemnity,[17] that this is caused by the absence of sufficient capital in the reinsurance market. Our results suggest that similar dislocations may exist in the ABX.HE market.

[17]National Indemnity, a subsidiary of Berkshire Hathaway, is one of the largest reinsurance companies.

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