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

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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 reasonable assumption for mortgage default rates, and that ABX.HE price changes are only very weakly correlated with observed changes in the credit performance of the underlying loans in the index. 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 related to short-sale activity for 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.

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

[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).

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 quarterly 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 large 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

[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)).

[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`.

away any price discrepancies between the CDS market and the underlying. If such deviations do occur, using the ABX.HE CDS to mark portfolios to market may give misleading results.[6]

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 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 prepayment rate of 25% per year (roughly consistent with historical prepayment rates on these pools), at a recovery rate of 34%, the AAA ABX.HE prices on June 30, 2009 imply default rates of 100% on the underlying loans. In other words, if recovery rates exceed 34% (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 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

[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).

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 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.

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

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

[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 canceled, and no subsequent ABX.HE indices have been issued.

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.

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

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

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

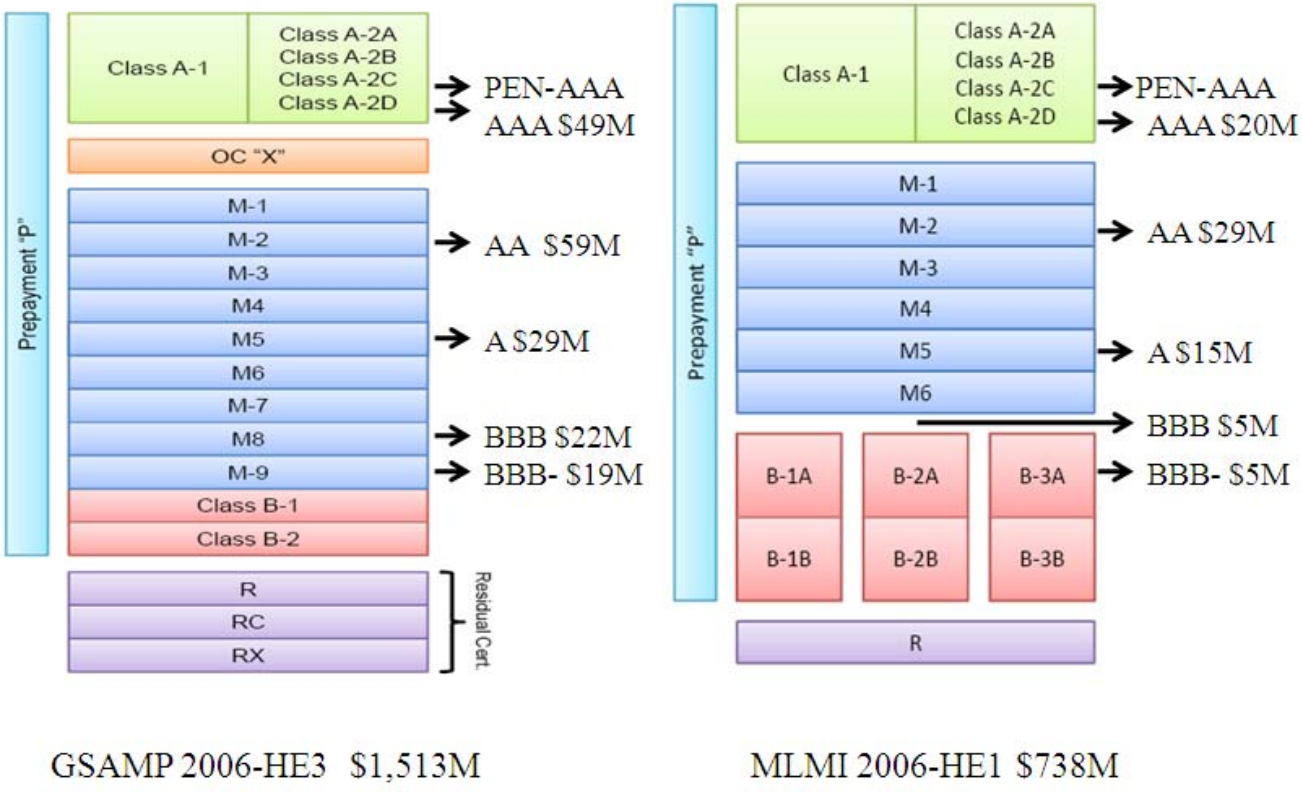


Table 2: Example of principal allocations

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

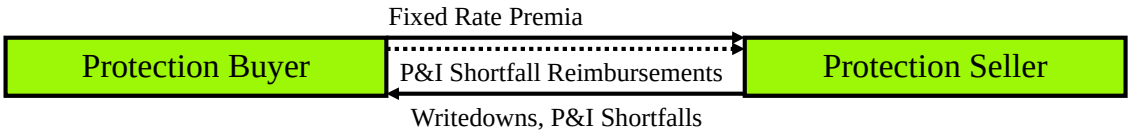
	MLMI 2006-HE1 Merrill Lynch Investments	GSAMP 2006-HE3 Goldman Sachs Trust
PEN-AAA	5.37%	9.52%
AAA	2.65%	3.11%
AA	3.91%	3.70%
A	2.06%	1.85%
BBB	0.85%	1.40%
BBB-	0.69%	1.20%
Total	15.52%	20.78%

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 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

[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 sub-indices 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 make up 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%		

current outstanding principal balances of the baskets of referenced subprime RMBS. 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 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.,

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

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 (starting at date T_{k_t}, the end of the month containing date t) equal to a fixed coupon rate, s, times the start-of-month notional, $B_{T_{k-1}}$, 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

[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

to the protection buyer. It includes a payment at each date T_k to compensate for any lost interest or principal during the prior month. Here, B_{T_k} denotes the notional value at date T_k, $B^A_{T_k}$ denotes the scheduled notional (taking amortization into account), and Prepay_{T_k} is the fraction of the start-of-month principal prepaid during the month. The difference between B_{T_k} and $B_{T_{k-1}}$, adjusted for amortization and prepayment, 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. The ABS pays off the lost principal, net of recovery, R, plus lost interest, r. 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 values of the two sides of the swap equal.

Figure 3 shows quoted market prices from 2006 to 2009 for the four vintages of the AAA ABX.HE indices.[12] 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 June 30, 2009. The quoted prices for these AAA securities on June 30, 2009, are shown in Table 4. We are focusing on the AAA bonds because the primary mark-to-market losses in the balance sheets of the commercial banks, investment banks, and structured investment vehicles (SIVs) were related to AAA RMBS.

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

[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. Similar patterns exist for the lower rated securities (not shown).

Figure 3: Prices for the bonds with AAA credit ratings for the 2006 and 2007 Markit ABX.HE indices.

This Figure plots the Markit ABX.HE indices for the AAA ABX.HE-2006-1, AAA ABX.HE-2006-1, AAA ABX.HE-2007-1, and AAA ABX.HE–2007–1 Series from January 2006 to June 2009.

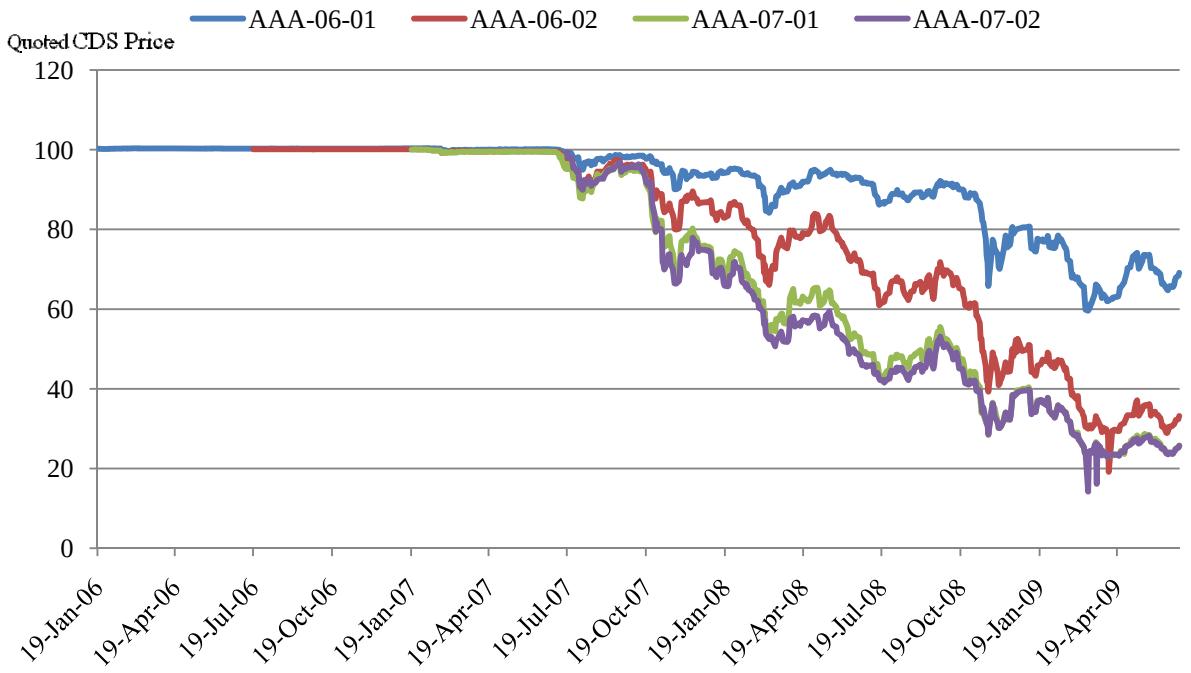


Table 4: Prices of ABX.HE AAA CDS, June 30, 2009

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

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, and compare these with what we observed during the worst financial crisis this century, the Great Depression.

4.1 A "back-of-the-envelope" valuation model

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 developing a formal model, we start with a 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.

Expressing all quantities per \$1 of current principal, let the subordination level on the AAA security be S,[13] and assume that a proportion H of the loans are of higher seniority than the AAA tranche,[14] so the AAA balance starts at

$$1 - H - S.$$

Now assume that a (known) fraction $Y < H$ of the underlying mortgages prepays immediately, lowering the total pool balance per initial dollar to $1 - Y$, and a fraction D of the remaining mortgages then defaults. We assume no further default or prepayment, and also ignore the periodic fixed payment made by the protection buyer. In this case, if the recovery rate on defaulted loans is R, the defaults reduce the total principal by $D(1 - R)(1 - Y)$,

[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.

[14] The AAA tranche underlying the ABX.HE CDS is the lowest seniority AAA tranche.

hence reducing the AAA principal by a fraction[15]

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

The fair lump-sum price (per \$1 of principal) for default insurance on the AAA tranches equals the loss, and the NPV of the security is thus

$$\text{NPV} = \min\left(1, \max\left\{\frac{D(1-R)(1-Y)-S}{1-H-S}, 0\right\}\right) - (1-P). \tag{3}$$

Focusing on the 2006-2 AAA security, we set $S = 0.38$ and $H = 0.45$ (the observed fractions of principal junior to and senior to the AAA tranches on June 30, 2009), $P =$ \$33.165, and $Y = 25\%$ (close to the historical average for the twenty underlying pools). Table 5 shows the NPV per dollar of principal for different assumptions about the recovery rate, R, and default rate, D, calculated using Equation (3). It can clearly be seen that,

Table 5: Back-of-the-envelope valuation results for the ABX 2006-2 AAA for June 30, 2009

The table shows the net present value per dollar of principal insured for the ABX 2006-2 AAA ABS.HE CDS as of June 30, 2009, given the closing price that day of \$0.33165 per dollar, and assuming a 25% prepayment rate (close to the historical average for the twenty underlying pools), and various default and recovery rates.

	Default Rates					
Recovery Rates	0.0%	20.0%	50.0%	70.0%	80.0%	100.0%
100.0%	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684
60.0%	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684
50.0%	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684
40.0%	-0.6684	-0.6684	-0.6684	-0.6684	-0.6684	-0.2566
20.0%	-0.6684	-0.6684	-0.6684	-0.4331	-0.0801	0.3317
0.0%	-0.6684	-0.6684	-0.6684	0.1846	0.3317	0.3317

except at very low recovery rates and very high default rates, the NPV of the security is always negative. To see this in more detail, note that a 100% default rate is implied when

[15]The max and min in this expression account for the possibility that either all or none of the AAA principal might be lost.

NPV $= 0$ and $D = 1$ in Equation (3), i.e., when the recovery rate is

$$R^* = 1 - \left(\frac{(1-P)(1-H-S)+S}{1-Y} \right).$$

With our parameter values, $R^* = 34.2\%$. If recovery rates exceed this value (extremely low by historical standards), even 100% default rates are not enough to support the quoted price. Similarly, a 0% recovery rate is implied when NPV $= 0$ and $R = 0$ in Equation (3), i.e., when the default rate is

$$D^* = \frac{(1-P)(1-H-S)+S}{1-Y}.$$

With our parameter values, $D^* = 65.8\%$. If the default rate is lower than this value, even a 0% recovery rate is not enough to support the quoted price.

To emphasize how extreme these numbers are, consider the Great Depression.[16] It is hard to find exactly comparable statistics on foreclosure and recovery rates during the Depression for several reasons. In particular, most loans then had no more than five years to maturity, and involved little or no payment of principal before the final balloon payment (see Wheelock (2008b)). The failure of thousands of banks and other financial institutions during the Depression meant that even many good borrowers could not refinance and therefore entered financial distress. In addition, foreclosure rates from that time are rather misleading, because Congress created the government-owned Home Owners' Loan Corporation (HOLC) in June 1933 to purchase and refinance underwater mortgages. Many lenders preferred to sell their loans to the HOLC (for relatively attractive terms — see Rose (2008)) rather than foreclosing. The HOLC then wrote down the principal to no more than 80% of the property's appraised value. Thus there were significant losses of principal, even if no foreclosure occurred.

At the beginning of 1934, roughly half of all homes with an outstanding mortgage were in default; the average time of delinquency on these loans was 15–18 months (see Wheelock (2008b) and Bridewell (1938)). Many of these loans were sold to the HOLC, but to be con-

[16] Excellent discussions of mortgage performance during the Great Depression can be found in Bridewell (1938), Harriss (1951), Wheelock (2008a,b) and Rose (2008).

servative, we shall assume that all of these loans would otherwise have gone into foreclosure, and set the default rate in the model to 50%. From Table 5, even with an impossibly low recovery rate of 10%, a default rate of 50% is not high enough to be consistent with the observed market price.

4.2 A Monte Carlo valuation model

The analysis above shows that, under the simplifying assumptions given, current prices for the AAA ABX.HE 2006-2 CDS are inconsistent with any reasonable assumption about default and recovery rates.[17] To verify that this conclusion is not merely due to the simplicity of the model, and to account for the impact of prepayment and default over time, we here repeat the analysis with a more sophisticated valuation model, using Monte Carlo simulation to estimate the expectations in Equation (1). This involves

1. Simulating 12,000 paths for interest rates and property prices.
2. Calculating the cash flows along each path. These in turn depend on
    - The payout structure of each of the 20 subprime deals underlying the security.
    - Prepayment, default and recovery rates on the underlying loans.

Pool and loan characteristics Table 6 summarizes the characteristics of the twenty deals underlying the 2006-2 ABX.HE CDS. As shown, there is considerable heterogeneity in the structure of these deals, with the number of tranches, including the "credit enhancement" (CE) tranche, ranging from fourteen to eighteen. The pools have all experienced considerable reduction in principal through both prepayment and default, leaving the current outstanding balance on the loans ranging from about one third to one half of the initial balances. The average subordination level for the AAA bonds is 38% as of June 30, 2009, and the fixed payment on the ABX.HE 2006-2 is 11 basis points per month. For each of the twenty subprime pools, we calculate the monthly mortgage cash flows and the allocation to each

[17] Table 4 shows that prices for the 2007-1 and 2007-2 CDS are even more extreme.

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

The table summarizes the deal structure for the twenty pools that that make up the ABX.HE 2006-2. The table presents the contributor name, the deal name, the number of A1 and A2 bonds in the deal, the number of mezzanine, M, bonds, and the number of B bonds. The original overall pool principal and the outstanding pool principal as of June 30, 2009 are also reported.

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 Sec. 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 Mort. 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 Sec. Trust	MABS 2006-NC1	4	0	11	0	915	334
Merrill Lynch Mortgage Invest. 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 Mort. Prod. 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 Invest. 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

bond using the contingent payout structures defined in the prospectus for that pool. The mortgage cash flows are modeled by class of loan for the A1 and A2 principal pools.[18] We model two classes of mortgage (fixed and adjustable rate), and use weighted averages over the two types of loans for characteristics including amortization structure, coupon, weighted-average life, loan-to-value ratios, initial balances, and indexing (such as the maximum life-of-loan caps and the periodic interest rate caps). About 72% of the pool principal in these deals is composed of adjustable-rate loans, and there is considerable heterogeneity in the allocations of fixed- and adjustable-rate mortgage principal between the A1 and A2 pools across the deals. We model the cash flow of the A1 and A2 tranches separately for each pool, based upon their respective compositions of fixed- and adjustable-rate mortgages and the pool-specific rules for distributing A1 and A2 principal and interest to the bonds in the waterfall. In most of the deals, the A1 tranches contain more fixed-rate mortgages. Although the adjustable-rate mortgages include both option ARMs and standard adjustable-rate mortgage products, we make the simplifying assumption that all the ARMs share the same weighted-average contract characteristics. Allocation of defaulted and prepaid principal are assigned following the prospectus for each of the twenty pools in the 2006-2 ABX.HE. In our simulations, we make the simplifying assumption that the assumed default recovery rates are realized immediately.

Interest Rates We assume interest rates are described by the Hull and White (1990) model. In this extension of Vasicek (1977), the short-term riskless rate follows the risk-neutral process

$$dr = [\theta(t) - ar]\, dt + \sigma\, dZ,$$

[18] Referring back to Figure 1, the deals have two parallel sets of AAA tranches, labelled A1 and A2. The A1 tranches are structured for sale to the GSEs (Fannie Mae and Freddie Mac), and their collateral is therefore mostly fixed-rate loans with higher FICO scores. The AAA tranche underlying the ABX.HE CDS is from the A2 pool.

where the function $\theta(t)$ is picked so that the model matches the entire initial yield curve,

$$\theta(t) = F_t(0,t) + aF(0,t) + \frac{\sigma^2}{2a}\left(1 - e^{-2at}\right).$$

In addition to picking $\theta(t)$ to match the observed term structure of interest rates for June 30, 2009, the parameters a and σ were set to 0.0552 and 0.0107 respectively, to minimize the sum of squared pricing errors for at-the-money caplets on the same date.

Prepayment rates Based on the results of fitting an empirical hazard model for prepayment to the individual loans underlying the 20 pools, we assume a constant monthly prepayment rate of 2% per month.[19]

Results Given the model for interest rates above, and various assumptions about default and recovery rates, we simulate 12,000 paths for interest rates, using antithetic variates to reduce standard errors (see Glasserman (2004)). Along each path, we use the prepayment/default assumptions, together with the payout details for each pool from the prospectus, to determine the cash flows each month. We then discount back to the present using the simulated path of the risk-free rate, and average across all paths to obtain a Monte Carlo estimate of the expectations in Equation (1). Table 7 shows the net present value of the AAA CDS security for various assumptions about default and recovery rates, defined as the calculated value minus the observed market price of \$33.165. The results are mostly similar to those from the back-of-the envelope model above. In particular, with an annual default rate of 50%, the NPV of the CDS is only positive when recovery rates are below 40%. This seems at first sight less extreme than the back-of-the-envelope numbers above (where, at a default rate of 50%, there was *no* possible recovery rate at which the NPV of

[19]We also estimated prepayment and default hazard rates as functions of interest rates and house prices, using loan level data for all four vintages of the ABX.HE. We then valued the 2006-2 CDS by simulating both interest rates and house prices, estimating the hazards and the expected cash flow for the mortgages and pools. The pricing results obtained were similar to those obtained assuming constant per period probabilities of default and prepayment for the assumed recovery rates.

the CDS was positive). It is important to note, however, that a 50% default rate in this model is much more extreme than a 50% default rate in the back-of-the-envelope model. In the earlier model this meant a single default event of magnitude 50%; in this model the loans are defaulting at a rate of 50% *per year*. Thus, 75% of nonprepaid loans will have defaulted after two years, and this fraction rises to 87.5% after three years. These much larger total default rates mean that the CDS is much more likely to pay out, in turn leading to NPV numbers higher than those shown in Table 5.

Table 7: Valuation results for the ABX 2006-2 AAA for June 30, 2009

The table shows the net present value per dollar of principal insured for the ABX 2006-2 AAA ABS.HE CDS as of June 30, 2009, given the closing price that day of $0.33165 per dollar, and assuming a 2.0% constant monthly prepayment rate (the historical average for the twenty pools), and various constant default and recovery rates.

Recovery	Annual Default Rates					
Rates	0.0%	20.0%	50.0%	70.0%	80.0%	100.0%
100.0%	-0.7125	-0.6936	-0.6818	-0.6774	-0.6755	-0.6695
60.0%	-0.7125	-0.6906	-0.5345	-0.4549	-0.4089	-0.2645
50.0%	-0.7125	-0.6509	-0.3794	-0.2166	-0.1134	0.0617
40.0%	-0.7125	-0.5923	-0.1252	0.0545	0.1125	0.2438
20.0%	-0.7125	-0.4120	0.2072	0.2908	0.3056	0.3296
0.0%	-0.7125	-0.1196	0.2968	0.3127	0.3181	0.3296

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?

5.1 Empirical specification and data description

To explore the determinants of ABX.HE price changes, we regress daily percentage changes in the quoted price of the respective AAA ABX.HE index for 2006-1, 2006-2, 2007-1, and 2007-2, on a selection of potential explanatory variables. The regression specification is:

$$\Delta ABX_{it}^{AAA} = \beta_0^{AAA} + \beta_1^{AAA}\Delta ABX_{i,t-1} + + \sum \beta_l^{AAA}\Delta X_{i,Credit_{lt}} + \sum \beta_l^{AAA}\Delta X_{i,Short_{lt}} + \sum \beta_l^{AAA}\Delta X_{i,Control_{lt}} + \varepsilon_{it}^{AAA}, \quad (4)$$

where Δ indicates percentage changes, and the right hand side variables control for the credit performance of the underlying mortgages, the short-sales ratio of firms in mortgage-related industries, repo rates, and various controls. We now discuss the variables and the data used in more detail.

ABX.HE prices: The ABX.HE CDS prices, ABX_{it}, used in our empirical analysis are as reported to the market by Markit Group Ltd., who report daily trading prices.

Mortgage credit and prepayment 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. The performance data were obtained from Bloomberg and from the two major securitization trustees, Wells Fargo Bank and LaSalle Trustee. We track the monthly rates of delinquency, foreclosure, Real Estate Owned,[20] and prepayment. We report the time-series average credit and performance levels by pool in Table 8. As shown in the table, the average credit performance across the twenty pools tracked by each index is quite similar, though the periods

[20]This is the dollar value of housing collateral held by the trust after the foreclosure auction.

over which we observe data are different. The average 30-, 60-, and 90-day delinquency rates are about 5%, 3%, and 5% respectively; the average foreclosure rate is about 12% through June 2009; and the REO rate is about 6%. As is clear from the standard deviations and the minimum and maximum values of all the performance characteristics, there is considerable variability in the credit experience across the twenty deals in each AAA ABX.HE vintage. The maximum foreclosure rate reaches about 31% for some pools. The average annualized monthly prepayment rate is about 22%. The prepayment rate is also quite heterogeneous, particularly in the 2006 vintages pools, which experienced very significant decreases in interest rates followed by large decreases in house prices.

Table 8: Summary statistics for the credit and prepayment performance of the ABX.HE 2006-1, ABX.HE 2006-2, ABX.HE 2007-1, ABX.HE 2007-2 pools

The table presents the summary statistics for the percentage of the overall outstanding mortgage collateral that was 30-days delinquent, 60-days delinquent, 90-days delinquent, in foreclosure, or held as Real Estate Owned, and the annualized thirty-day prepayment rate for the Markit ABX.HE 2006-1, ABX.HE 2006-2, ABX.HE 2007-1, ABX.HE 2007-2 pools. We report the summary statistics for the period July 20, 2007 through July 30, 2009 which is the same period that is tracked in the panel regressions.

	Mean	Standard Deviation	Minimum	Maximum
30 Day Delinquency Rate	0.0557	0.0125	0.0141	0.1315
60 Day Delinquency Rate	0.0335	0.0109	0.0023	0.0917
90 Day Delinquency Rate	0.0629	0.0493	0.0	0.3487
Foreclosure Rate	0.1368	0.0573	0.0	0.3355
REO Rate	0.0714	0.0415	0.0	0.2153
Annualized Prepayment Rate	0.2185	0.0949	0.0	0.7330

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, a candidate explanation for the pricing anomalies described above 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. We follow prior authors (see Lamont and Stein (2004), Fishman, Hong, and Kubik (2007), and Jones and Lamont (2002)) in the use of 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 began to rise. A higher short-interest ratio is usually viewed by market participants as a bearish signal about a specific stock, and higher ratios have been found to be associated with other measures of demand pressure for shorting, such as high premia paid to borrow the stock.[21] We obtain monthly data for the short-interest ratio from Shortsqueeze.com from January 2006 to June 2009, and then use splines to estimate a daily series for each of four publicly traded types of firms with exposure to the subprime mortgage market: banks, investment banks, public builders, and the GSEs.[22] From our daily series, we construct a measure of the daily percentage changes in the daily interpolated short-interest ratios for commercial banks, investment banks, builders, Fannie Mae and Freddie Mac.

Repo market conditions: Gorton and Metrick (2009) argue that most of the financial

[21] See, for example, Lamont and Stein (2004), Jones and Lamont (2002), and Dechow, Hutton, Muelbroek, and Sloan (2001)

[22] 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.

problems observed during 2007–2008 were caused by failure of the repo market. We therefore include in our regression the percentage change in the overnight repo rate and in the spread between three-month LIBOR and the overnight index swap (OIS) rate, downloaded from Bloomberg. Gorton and Metrick (2009) argue that the LIBOR-OIS spread is a measure of counterparty risk in the interbank lending system.[23] A higher value of this spread is an indication of a decreased willingness to lend by major banks, while a lower spread indicates lower concerns about counterparty risk. Historically, this spread has been around 10 basis points. However, on October 10, 2008, the spread spiked to all-time high of 366 basis points.

House price performance: House prices are an important factor influencing future default rates. We collect the same data that are available to market participants: quarterly repeat-sales house price indices by state, available from the Office of Housing Enterprise Oversight (OFHEO).[24] We then interpolate the quarterly series to a monthly series using splines, and use this interpolated series to estimate the monthly changes in house prices for each state. We then compute a weighted-average house price series for each pool, where the weights are the percentage of the pool principal from each state. Obviously, this is an imperfect measure of the actual house price dynamics for each pool. However, these house price indexes are the only information that market participants are likely to have available for valuation purposes.

Additional market control variables: We also consider the following market controls:

- Daily percentage changes in the S&P volatility index, *vix*, downloaded from finance.yahoo.com. *vix* is calculated from market prices of CBOE-traded options on the S&P 500 Index, and is often referred to as the market's "fear gauge" (see Whaley, 2000).

[23]The OIS is a fixed-to-floating interest rate swap where the periodic floating rate of the swap is tied to the geometric average of an overnight index, such as the federal funds rate, over every day of the contractual loan payment period. The fixed leg of the swap is the expected average of the overnight federal funds rate over the term of the contract. Since principal does not change hands with these swaps, OIS contracts do not have significant credit risk exposure.

[24]An alternative important source of information on house prices is the Case/Shiller index, but it only tracks twenty cities and was not available through June of 2009

- Daily percentage changes in the ten-year constant-maturity Treasury rate, *CMT10*, obtained from the Federal Reserve web site.
- Daily percentage changes in the slope of the constant-maturity yield curve, *slope*. The slope is calculated as the difference between the ten-year and three-month yields, obtained from the Federal Reserve web site.
- Daily S&P 500 returns, to control for the market, downloaded from finance.yahoo.com.

5.2 Results

Table 9 reports the results of various regression specifications. Two specifications use all of the individual regressors described above, while in two we replace the individual credit variables with a single variable equal to their sum, and we replace the individual short-interest ratio variables with a single variable equal to their sum. We use data from July 2007 to June 2009, the period for which we have data on all four pools.

The most surprising result is that the credit variables have very little impact on ABX.HE prices. None of them appears significantly in any of the four specifications. By contrast, the investment bank short-interest ratio (and the sum of all short-interest ratios) has a statistically significant negative relation with price changes in all four specifications, hence a positive relation with the cost of insurance. The other short-sales ratios also have negative coefficients, but are not significant. This result suggests that, similar to the findings of Froot (2001) in the catastrophe insurance market, the price of ABS insurance moves with supply and demand imbalances related to short selling the stocks of investment banks, commercial banks, builders, and the GSEs. Since buying AAA ABX.HE CDS is roughly equivalent to shorting the mortgage market or firms with RMBS exposure, it appears that the supply and demand imbalances in the market for shorting the stocks of firms with RMBS risk positively "spilled over" into the AAA ABX.HE market. The spill-over effect drove up the cost of insuring AAA RMBS, or alternatively, the cost of building up short positions against key mortgage market participants.

The change in the ten-year constant-maturity Treasury rate also has a positive and statistically significant coefficient. This probably reflects the flight-to-quality that occurred during this period, which lowered Treasury rates, but increased the cost of insurance products such as AAA ABX.HE. Percentage changes in the house price indices have little effect. They are statistically significant at the .10 level in one of the four regressions, and otherwise insignificant. While somewhat surprising, this result is likely to be the result of limitations with the available indices for measuring house price fluctuations, rather than an indication that shocks to housing prices did not affect the costs of insuring AAA RMBS bonds through the AAA ABX.HE CDS.

Consistent with Gorton and Metrick (2009), the percentage change in the repo rate and in the LIBOR-OIS spread are both negatively associated with changes in AAA ABX.HE quoted prices. Positive shocks to both measures thus increase the cost of insuring a dollar of AAA principal. The LIBOR–OIS spread is only significant at the .10 level and the repo rate is significant at the .05 level.[25]

Overall, these results suggest that the short-interest imbalance channel is a more important correlate with ABX.HE returns than are credit events on the mortgages. Other important channels in the price dynamics of the AAA ABX.HE include the flight to quality to the long Treasury bond and counterparty risk in the sale and repurchase markets.

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 assumptions 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

[25]These results are unchanged if we include one of the LIBOR-OIS spread or the repo rate in the regressions.

Table 9: Regressions for daily percentage changes in the quoted prices of the 2006 and 2007 Vintage AAA ABX.HE Indices, using data from June 19, 2007 to June 30, 2009.

	(1)	(2)	(3)	(4)
Constant	-0.00226*	-0.00237*	-0.00223**	-0.00226**
	(-1.80)	(-1.88)	(-2.23)	(-2.24)
Lag 1 Δ ABX.HE Quoted Price	0.141***	0.140***	0.143***	0.141***
	(6.20)	(6.14)	(6.31)	(6.23)
Credit and Prepayment Performance				
Δ 30 Day Delinquency	-0.0102	-0.00862		
	(-0.60)	(-0.50)		
Δ 60 Day Delinquency	-0.00357	-0.00424		
	(-0.39)	(-0.46)		
Δ 90 Day Delinquency	-0.00525	-0.00721		
	(-0.37)	(-0.50)		
Δ REO Rate	0.00629	0.00330		
	(0.80)	(0.40)		
Δ Foreclosure Rate	0.00495	0.00412		
	(0.28)	(0.23)		
Δ Prepayment Rate	-0.00210	-0.00343	-0.00184	-0.00338
	(-0.36)	(-0.58)	(-0.33)	(-0.60)
Δ Sum of credit variables			0.000754	-0.00114
			(0.30)	(-0.41)
Short-Interest Ratios				
Δ Bank Ratio	-0.0681	-0.0623		
	(-0.76)	(-0.69)		
Δ Builder Ratio	-0.0538	-0.0426		
	(-0.52)	(-0.41)		
Δ GSE Ratio	-0.0385	-0.0374		
	(-1.26)	(-1.22)		
Δ IV Bank Ratio	-0.00949***	-0.00943***		
	(-2.68)	(-2.66)		
Δ Sum of short interest ratios			-0.0100***	-0.00985***
			(-2.85)	(-2.80)
Repo market conditions				
Δ LIBOR-OIS spread	-0.0125*	-0.0125*	-0.0127*	-0.0125*
	(-1.74)	(-1.73)	(-1.78)	(-1.74)
Δ Repo Rate	-0.00389**	-0.00387**	-0.00374**	-0.00372**
	(-2.45)	(-2.43)	(-2.36)	(-2.35)
Other Controls				
Δ S&P	0.0703	0.0715	0.0720	0.0739
	(1.18)	(1.20)	(1.21)	(1.25)
Δ 10-year Treasury	0.0685**	0.0688**	0.0682**	0.0691**
	(2.19)	(2.20)	(2.20)	(2.23)
Δ Slope (10-year CMT minus 3-month Rate)	-0.00222	-0.00219	-0.00245	-0.00235
	(-0.77)	(-0.76)	(-0.85)	(-0.81)
Δ VIX Rate	0.00574	0.00621	0.00590	0.00664
	(0.32)	(0.35)	(0.34)	(0.38)
Δ House Price Index	-0.00807*	-0.00633	-0.00648	-0.00423
	(-1.73)	(-1.21)	(-1.45)	(-0.86)
Observations	1897	1897	1897	1897
R^2	0.0372	0.0356	0.0355	0.0344
Fixed Effects?	N	Y	N	Y

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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. This casts serious doubt on the current practice of using these securities to mark portfolios of subprime mortgages to market.

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. Other evidence for the existence of these limits include Gabaix, Krishnamurthy, and Vigneron (2007), who find that the idiosyncratic risk of homeowner prepayment (which must net to zero in aggregate) is priced in the mortgage-backed securities (MBS) market. They attribute this to limits of arbitrage in the MBS market, caused by the marginal investor being a specialized arbitrageur with limited capital, rather than a diversified representative investor. Froot (2001) finds similar evidence in the market for catastrophe insurance. In this market, 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,[26] 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.

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

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