Jump and Cojump Risk in Subprime Home Equity Derivatives

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Abstract

I analyze the jump risk in the ABX index of subprime home equity credit default swaps and CME housing futures. Using estimators of the jump and cojump components of security prices, I document: (1) significant jumps in the ABX as early as September 2006, well before any problems in the mortgage market were discussed in the press or policy circles; (2) news explains up to 56% of the jump risk; (3) the return variation due to jumps in the housing futures is larger than the ABX; (4) 25 significant cojump episodes between the AAA ABX and the 12-month housing futures; (5) a predictive model that explains up to 85% of the jump risk; (6) a 20 point slope in the housing futures curve leads to an expected jump of -1.4% in the BBB- ABX; (7) jumps explain up to 50% of the value-at-risk exceedences which occur at almost three times the expected rate.

`Keywords`: asset backed credit default swaps; housing futures; subprime; jump risk; cojumps;

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1. Introduction

Asset backed securities in residential real estate are an innovative structured financial product that has helped to diversify credit risk among intermediaries. They have indirectly benefited the consumer through lower financing rates. This market includes both residential mortgage backed securities (RMBS) and home equity loans (HEL). The HEL segment, which includes both first and second lien mortgages, has grown to nearly \$600 billion by the end of 2007 and helped to raise U.S. home ownership rates to a 2005 peak of 69%.

In the spring of 2007, these instruments came into focus with a collapse in credit markets around the world. Particular attention was paid to the so-called *subprime market*, a subset of home borrowers who failed to meet conventional mortgage qualifying criteria. These borrowers constitute an important class of the residential real estate market, particularly in recent years. Schloemer, Li, Ernst, and Keist (2006) estimate that the subprime share of mortgage originations reached 23% in 2006, up from only 10% in 1998. First-lien sub-prime mortgage loans as well as second-lien home equity loans and home equity lines of credit (HELCOs) are all part of what is called the Home Equity ABS sector.[1]

As real estate prices began to fall, in some areas as early as 2005, these subprime borrowers came under particular stress. Delinquency rates began to rise. The Mortgage Bankers Association (MBA) survey for the second quarter of 2008 showed a delinquency rate of 6.41%, up from 5.12% one year prior. 2.75% of loans were in foreclosure, the highest level recorded in the MBA survey since its 1979 inception. While subprime adjustable rate mortgages represent only 6% of total loans outstanding, they represent 36% of all foreclosures.

Housing sector financial intermediaries have suffered major losses. New Century, a California based lender specializing in the subprime market, declared bankruptcy on April 1, 2007. Countrywide, the largest servicer of subprime mortgages, experienced a decline in shareholder equity of -78.7% in 2007 before being acquired by Bank of America in January 2008. Washington Mutual, the nation's largest thrift, was seized by the FDIC on September 25, 2008. There have been 19 banks seized as of November 2008. Major Wall Street firms have, as of June 2008, written down more than \$200 billion in assets, with the largest losses at UBS ($\$37bn$), Citigroup ($\$34.5bn$), and Merrill Lynch ($\$23.8bn$). The Bank of England estimates U.S. firm's mark-to-market losses in

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[1] Ashcraft and Scheurmann (2008) note that other non-conventional mortgages, including Alt-A and Jumbo loans, are classified into the Residential Mortgage Backed Securities (RMBS) sector.

subprime asset backed securities at $587 billion, as of October 2008.

This paper attempts to assess market risks associated with the ongoing subprime financial crisis. I analyze two derivative securities markets that are closely linked to changes in home prices and affordability. The first of these is the ABX.HE index, compiled by MarkIt, an independent provider of credit derivatives pricing. The ABX aggregates prices on the cost of credit default swaps on subprime mortgage backed securities.

The ABX index has been used to provide long and short exposure during the credit crisis and to price illiquid mortgage backed securities. The *Wall Street Journal* reported in December 14, 2007 that Goldman Sachs' structured products trading group earned more than $4*bn* in profits in 2007 from shorting subprime securities using the ABX. John Paulson's Credit Opportunities hedge fund returned 589.9% in 2007 betting on a decline in subprime mortgages. Paulson's funds shorted the ABX and bought the underlying credit default swaps, generating profits of $15*bn* and Paulson a personal gain of $3.7*bn*.

Motivated by the new accounting rule FASB 157, banks are being prompted to mark their securities to market prices rather than models. The ABX, according to Reuters, is being used to price up to $1 trillion dollars in subprime mortgage securities.

The second instrument which the paper analyzes is the Chicago Mercantile Exchange's residential real estate market futures. These contracts began trading in the Spring of 2006 and have provided a way to hedge the value of individual homes. The futures contracts track a repeat sales housing index originally constructed by Case and Shiller (1989).

Contracts trade at a variety of maturities, ranging from one month to several years. The term structure of prices is currently inverted, indicating that the market anticipates housing prices will fall further. At the end of October 2008, the composite index price for November 2008 was at 172.60, more than 13% above the 150.00 closing price for the November 2010 settlement.

I rely on the recent methods introduced by Barndorff-Nielsen and Shephard (2006) to extract the jump risk component from these derivative security prices. The procedure isolates the portion of security returns coming from discontinuous movements or *jumps* in the underlying stochastic process. I use Huang and Tauchen's (2005) estimator of relative jumps to assess statistical significance. In Mizrach (2009), I show that these methods, even at a daily frequency, can be useful in analyzing sudden market movements. This paper assesses their small sample properties using a Monte Carlo exercise and finds good power as long as the jump contribution to total variance is not too small.

I detect significant jump risk across all the credit quality tranches of the ABX. Most notable perhaps are the significant jumps in September 2006 long before the ABX index had shown any signs of weakness and was trading above par. The jump episodes correspond closely to economic news which I have collected from public and private sector reports on the subprime crisis. News dummies explain up to 56% of the variation in the jump risk.

Jumps in the housing futures explain more than 40% of the total return variation, and the 1- and 12-month contracts both experience significant jumps on nearly 2 out 3 days in the sample. These jumps are not, overall, related to news about the ABX, but I still find an important linkage between the levels and jumps of the housing futures and the subprime index.

I isolate common movements across the two markets using a measure of *cojump* risk introduced by Bollerslev, Law and Tauchen (2007). Beine, Lahaye, Laurent, Neely and Palm (2007) examine cojump risk in foreign exchange due to central bank intervention and Lahaye, Laurent and Neely (2007) analyze the effect of macroeconomic announcements on cojumps across stock, bond, foreign exchange and commodity markets.

There is, at the moment, no asymptotic theory for cojump processes, so I again undertake a Monte Carlo analysis. A studentized moving average of the daily return cross products shows good power for detecting cojumps. I find 25 or more significant cojumps between the futures and the ABX. Unlike the jump risk in the futures series, news dummies explain up to 42% of the cojump risk.

The cojump analysis is synthesized with estimates of a predictive model for jump risk. Current jump risk is fitted to lagged jump risk and lagged squared jump risk, the jump risk in the housing futures and the slope of the housing futures curve. The model explains up to 85% of the jumps. The slope of the housing futures curve matters for jumps in 3 of the 5 tranches. For the BBB- tranche, a slope of 20 points in the futures curve, a level reached during the peak of the housing bubble, implies an expected daily jump of -1.4%.

The final section of the paper analyzes the importance of jumps for bank capital requirements and risk management. Basel II (2006, p.163) requires that value-at-risk (VaR) capture "specific risk ....and *event* risk (where the price of an individual debt or equity security moves precipitously relative to the general market, e.g. on a takeover bid or some other shock event; such events would also include the risk of "default"). I form a hedged portfolio that is long the ABX and short the housing futures and calculate the VaR with static and dynamic hedging. I find that exceedences are nearly three times what the normal distribution would imply and that up to 50% of these large losses can be attributed to jumps.

Section 2 begins with details about the asset backed mortgage securities market which the ABX tracks. Section 3 develops the methodology for extracting jumps and assessing their statistical significance. Section 4 conducts Monte Carlo analysis of the daily jump estimator. Section 5 provides estimates for the jump risk across all the credit quality tranches of the ABX. Section 6 links the jump risk with the news flow in the markets about the subprime crisis. Section 7 describes the real estate futures market, and in Section 8, I analyze the jump risk in the CME futures prices. In Section 9, I analyze the cojump risk between the two housing derivatives markets, and I then use, in Section 10, a predictive model to summarize their interactions. Section 11 analyzes value-at-risk of a hedged ABX portfolio. I conclude with a limited set of policy implications and ideas for future research in Section 12.

2. Data: ABX

2.1 Asset backed securities

Asset backed securities (ABS) are structured fixed income instruments that distribute cash flows from a designated pool of loans. By pooling across households and regions, they mitigate the idiosyncratic risk of any individual borrower.

The corporate finance motivations behind asset securitization are related to capital market imperfections. In principal, securitizing should not effect the value of the firm. As Minton, Opler and Stanton (1999) note, the firm should be indifferent between issuing asset-backed and unsecured debt.

Lang, Poulsen and Stulz (1995) emphasize agency costs of managerial discretion as one motive. The firm may find it more efficient to create a *special purpose vehicle* (SPV) to monitor the cash flows. These SPVs are typically legally distinct entities that provide no explicit recourse to the sponsoring firm's assets, eliminating the credit exposure from the firm's balance sheet. The net impact of improved monitoring and credit risk insulation is that the SPV often achieves a higher credit rating than the originator.

Research on ABS indicates that the market assumes there is some *implicit recourse* from the sponsoring firm and the SPV. Gorton and Souleles (2006) find in a sample of over 400 SPVs that poorly rated sponsors had to promise more than 50 basis points of additional yield on average, regardless of the credit rating of the SPV.

On balance, Thomas (2001) shows, the securitization process is wealth creating for the firm that sells the assets. The benefits may be even larger for firms, like banks, whose capital base is closely regulated.

The securities bundle cash flows, transforming, as Jobst (2005) notes, an illiquid set of receivables into tradable claims or *tranches*. Wighton (2005) emphasizes that the division into distinct slices of risk and maturity make the securities attractive to a wide array of potential buyers.

The market has grown incredibly over the last decade. In 1996, there was a total of $404 billion in asset backed securities, with credit card receivables ($180.7 billion) and auto loans ($71.4 billion) the two largest categories.

[Insert Table 1 Here]

Between 1996 and 2007, the market grew by almost 18% per year to reach a total of $2,472.4 billion. I now turn to the home equity loans (HEL) securities that are the focus of this paper.

2.2 Home equity loans

In 2004, as housing prices were reaching their peak and low interest rates were making refinancing a popular choice for homeowners, HEL securities surpassed credit card receivables as the largest category of asset backed securities, $454.0 versus $390.7 billion. From 1996 to 2007, they grew nearly 25% per year. In 2007 alone, the Securities Industry and Financial Markets Association (SIFMA) reported issuance of $222 billion in HEL.[2]

Thomas (2001) documents that the majority of HEL loans are cash out refinancing, with the cash flows used to consolidate debt, pay for education, or to make home improvements. For more than a decade, these loans have been made available to subprime borrowers. These high risk borrowers, according to Standard and Poor's,[3] have Fair Isaac & Co. (FICO) credit scores in the low 600s, high loan to value (LTV) ratios, and they may lack documentation of their income or

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[2] The data are from the Securities Industry and Financial Markets Assocation (SIFMA), "U.S. Market Outlook," January 2008. $1,700 billion of mortgage backed securities were issued in 2007. These securities are backed by primary mortgages though and are not incorporated into the ABX indices.

[3] Victoria Wagner, "Credit FAQ: Will Subprime Woes Spread To The Wider Mortgage Market?," March 13, 2007.

assets.

As the credit crunch unfolded in 2007, HEL securities faced growing credit spreads, deteriorating collateral, and the prospect of ratings downgrades from the credit rating agencies. According to SIFMA, “in excess of 95 percent of ABS downgrades in the 2005-2007 vintages sector were HEL.” So while HEL securities face systematic risk from changes in underlying real estate prices and/or changes in the ability of homeowners to repay their mortgages, different tranches are particularly vulnerable.

2.3 Credit default swaps

One mechanism for hedging this risk was a new instrument known as a *credit default swap.* Credit default swaps are derivative securities that pay security holders contingent upon a credit event. Typically, these are triggered by some failure to deliver the underlying cash flows promised to the security pool. There are now very liquid markets in credit default swaps on corporate and sovereign bonds.

Credit default swaps on ABS reference individual tranches from an SPV because they are likely to have a wide range of default probabilities. Other unique features of asset backed securities are: (1) the amortization of principal; (2) adjustment of security values in light of partial interest shortfalls or principal writedown.[4] Both considerations require a careful definition of default and settlement procedures. The market has, since 2006, begun to standardize though.

With home equity securities, credit default swaps provide a sequence of payments to the protection buyer. For this reason, the contracts are often referred to as *pay-as-you-go.* The protection seller will compensate for losses in principal and any interest shortfall. These differ from corporate credit default swaps which usually involve a single payment after a credit event. Because the maturity of the ABS contract is usually the same as the underlying mortgage securities, ABS credit default swaps can have long maturities. Corporate bond contracts typically last only 5 years.

2.4 The ABX indices

2.4.1 Entities

The ABX indices are aggregators of the performance of a variety of credit default swaps on asset backed securities. MarkIt Ltd., a London based source of credit derivatives information, collects

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[4] The principal can also be written back up in the event of catchup payments by the security pool.

information on individual credit default swaps and produces a series of indices that have become benchmarks for the industry. This paper studies the ABX.HE indices which track home equity loans.

MarkIt has eight criteria for including a security in the index: (a) deals from the largest 25 issuers (by sub-prime home equity issuance); (b) issued within the last six months (c) offering size of at least \$500M; (d) at least 90% 1st lien mortgages; (e) weighted average FICO credit score $<$ 660; (f) Deals must pay on the 25th of the month; (g) Referenced tranches must bear interest at a floating rate benchmark of one-month LIBOR; (h) at issuance, each deal must have tranches of the required ratings with a weighted average life greater than 4 years, except the AAA which must have an average life of longer than 5 years.

From a list of 54 reference obligations that met the MarkIt criteria, 20 distinct securities were chosen to form the ABX HE-061 index which was constituted on January 11, 2006. The index began trading on January 19, 2006. There have been subsequent indices formed every 6 months, with HE-062 pricing beginning on July 19, 2006, HE-071 on January 19, 2007, and HE-072 on July 19, 2007. There are 5 credit tranches to each of the underlying exposures, AAA, AA, A, BBB and BBB-. Ratings are determined by the lower of the Moody's or Standard & Poor's grades.

The 15 issuers that make up the ABX index are in the first column of Table 2.

[Insert Table 2 Here]

Nearly every major investment bank is represented including Barclays, Goldman Sachs, JP Morgan, Merrill Lynch, Morgan Stanley and UBS. Non-bank financial intermediaries include GMAC. There are also mortgage originators like Ameriquest, Countrywide, First Franklin, and New Century.

With the recent turmoil in the credit markets, particularly in home equity, MarkIt was unable to constitute an index for 2008. On December 19, 2007, they released a statement that they would postpone the launch of HE 08-1: "Under current index rules, only five deals qualified for inclusion in the MarkIt ABX.HE 08-1. MarkIt and the dealer community considered amending the index rules to include deals which failed to qualify initially but decided against this approach at this time." As of this writing, July 2008, there have been no new rolls of the ABX. On May 14, 2008, MarkIt introduced the "penultimate ABX," a new more senior slice of the AAA tranche for the 07-2 roll. It currently trades about 15% above the AAA.

The characteristics of the HE-061, HE-062 and HE-071 deals are summarized in Table 3.

[Insert Table 3 Here]

While the deals have progressively lower FICO scores, and less documentation, the loan to value ratio also falls slightly to offset these risks. The characteristics clearly indicate a very clean exposure to high risk borrowers. While liquidity has certainly fallen off recently, the ABX indices constitute the best available aggregate indicator of subprime borrowing and are now widely used to mark to market institutional portfolios.

2.4.2 Trades and prices

When the ABX indexes are released, they trade at or close to par. Coupon rates for the various releases and credit tranches are in Table 4.

[Insert Table 4 Here]

We will try to describe the cash flows when the index is selling at par. A purchaser of default protection will pay the coupon rate. To protect \$1 million in security value in the AAA tranche of the 06-1 index, you will pay \$1,800 per year, usually in monthly installments. For the riskier BBB- security from the first half of 2006, protection buyers must pay a 2.67% coupon, or \$26,700 per year. Note that for the high credit quality tranches, AAA and AA, coupon rates have actually fallen in the first half of 2007. For riskier BBB and BBB- securities, the coupon rates have risen to up to 389 basis points.

An important part of the recent credit market turmoil is that the ABX securities have fallen dramatically in price. The HE-061 AAA security has traded in a range of 100.32 and 79.97 during our sample, with 100 representing par. With the index trading at a discount, purchasing credit protection becomes much more costly.[5] The buyer must not only pay the coupon, but make payments up front based on the distance from par. With the index at 79.97, a protection buyers would pay

$$\$1mn \times (100 - 79.97)\% + \$1,800 = \$202,100.$$

The lower credit quality tranches have seen even larger declines. The ABX-061 BBB- tranche has traded in a range between 100.94 and 15.15. At the low for this index, a protection buyer would pay \$848,500 up front, plus \$3,420 per month for credit protection on \$1 million dollars

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[5] With the securities trading above par, it is possible that the protection buyer could be a net recipient of cash flows from the protection seller.

worth of securities.[6]

ABX prices are often quoted in terms of implied spreads. This is an unfortunate convention because it requires a duration estimate of a very complex security. Nonetheless, we use estimates from UBS Securities that are reported in Ashcraft and Scheurmann (2008) to compute implied spreads in Table 5.

[Insert Table 5 Here]

We use prices from October 31, 2007 for the ABX.HE-071 tranches. We compute the implied spread as

$$100 \times (100 - p_t)/Duration + coupon.$$

For the BBB- tranche, for example, we find a spread of

$$100 \times (100 - 18.94)/2.75 + 389 = 3,337.$$

These enormous spreads are reflective of the extreme risk in these instruments.

My objective here is to describe the day-to-day movements in the level and volatility of ABS protection, and link to the risk of correlated assets. I turn next to the modeling of discontinuous jumps in this index.

3. Jump Processes

Consider a stochastic volatility model with jumps,

$$dp_t = \mu_t dt + \sigma_t dw_{1,t} + J_t dq_t, \tag{1}$$

$$d\sigma_t^2 = \beta(\theta - \sigma_t^2)dt + \gamma\sqrt{\sigma_t^2}dw_{2,t}, \tag{2}$$

where p_t is the log price of the underlying asset, μ_t is its drift, σ_t is the local volatility, $w_{1,t}$ and $w_{2,t}$ are standard Brownian motions with correlation ρ, q_t is a Poisson process with intensity λ_t, and J_t is a normally distributed jump process with mean μ_J and and standard deviation σ_J. Define the within day return process,

$$r_{t,j} = p_{t-1+\frac{j}{M}} - p_{t-1+\frac{j-1}{M}},\ j = 1, 2, \ldots M. \tag{3}$$

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[6] According to the *Wall Street Journal* of December 17, 2007, Goldman Sachs had concentrated its short position in the ABX in the BBB- tranche.

The *quadratic variation* for the daily return process is then

$$[r,r]_t = \textstyle\int_{t-1}^{t} \sigma_s^2 ds + \sum_{t-1<s\leq t} J_s^2. \tag{4}$$

Estimation of the quadratic variation proceeds with discrete sampling from the log price process. The *realized volatility* is

$$RV_t = \textstyle\sum_{j=1}^{M} r_{t,j}^2. \tag{5}$$

In the standard stochastic volatility model, $J = 0$, researchers have employed realized volatility as an estimator of the integrated volatility, $\int_{t-1}^{t} \sigma_s^2 ds$.

In the case of discontinuous price paths, Barndorff-Nielsen and Shephard (2006) show that the realized volatility will also include the jump component, and that, in the limit, realized volatility will capture the entire quadratic variation,

$$\lim_{M\longrightarrow\infty} RV_t = [r,r]_t \tag{6}$$

To extract the integrated volatility from (6), Barndorff-Nielsen and Shephard have also introduced the *realized bi-power variation*,

$$BV_t = \mu_1^{-2} \textstyle\sum_{j=1}^{M} |r_{t,j}|\, |r_{t,j-1}| \tag{7}$$

where $\mu_1 = \sqrt{2/\pi}$. It is then possible to show

$$\lim_{M\longrightarrow\infty} BV_t = \textstyle\int_{t-1}^{t} \sigma_s^2 ds. \tag{8}$$

By comparing (6) and (8), we have the estimate of just the jump portion of the process,

$$\lim_{M\longrightarrow\infty} (RV_t - BV_t) = \textstyle\sum_{t-1<s\leq t} J_s^2. \tag{9}$$

3.1 Testing for jump risk

We follow Bollerslev, Law and Tauchen (2007) to analyze the statistical significance of the jump risk. Barndorff-Nielsen and Shephard (2006) show that the joint distribution of RV_t and BV_t is asymptotically normal,

$$M^{1/2}\left[\textstyle\int_{t-1}^{t} \sigma_s^4 ds\right]^{-1/2} \begin{pmatrix} RV_t - \int_{t-1}^{t} \sigma_s^2 ds \\ BV_t - \int_{t-1}^{t} \sigma_s^2 ds \end{pmatrix} \longrightarrow N\left(0, \begin{matrix} v_{qq} & v_{qb} \\ v_{qb} & v_{bb} \end{matrix}\right) \tag{10}$$

where $v_{qq} = 2$, $v_{qb} = 2$, and $v_{bb} = (\pi/2)^2 + \pi - 3$. Approximating this distribution requires an estimate of the *integrated quarticity* $\int_{t-1}^{t} \sigma_s^4 ds$. In computing our test statistics, we utilize a consistent estimator called the *tripower quarticity*,

$$TP_t = [2^{2/3}\frac{\Gamma(7/6)}{\Gamma(1/2)}]^{-3}\left(\frac{M}{M-2}\right) \textstyle\sum_{j=3}^{M} |r_{t,j}|^{4/3}\, |r_{t,j-1}|^{4/3}\, |r_{t,j-2}|^{4/3}. \tag{11}$$

Relying on the analysis of Huang and Tauchen (2005), we utilize their relative jump measure

$$RJ_t = \frac{RV_t - BV_t}{RV_t}, \tag{12}$$

and the test statistic,

$$z_t = \frac{RJ_t}{\left[(v_{bb} - v_{qq})\frac{1}{M}\max(1, \frac{TP_t}{BV_t^2})\right]}, \tag{13}$$

which has a standard normal distribution as $M \longrightarrow \infty$ if $J_t = 0$. Monte Carlo evidence in Huang and Tauchen shows that this statistic has good size and power properties.

3.2 Daily return analysis

Our ABX data are daily closing observations, and in this section, I adjust the estimators for the lower sampling frequency.

I set the sampling interval to be daily changes, $M = 1$, and compute n-day rolling sample estimates of realized volatility,

$$RV_t = \textstyle\sum_{k=0}^{n-1} r_{t-k}^2 \tag{14}$$

and bipower variation,

$$BV_t = (\pi/2)\textstyle\sum_{k=0}^{n-1} |r_{t-k}|\,|r_{t-k-1}|\,. \tag{15}$$

I adapt the tripower quarticity for daily changes,

$$TP_t = [2^{2/3}\frac{\Gamma(7/6)}{\Gamma(1/2)}]^{-3}\frac{n}{n-2}\textstyle\sum_{k=0}^{n-1} |r_{t-k}|^{4/3}\,|r_{t-k-1}|^{4/3}\,|r_{t-k-2}|^{4/3}\,, \tag{16}$$

and construct the statistic

$$z_t = \frac{RJ_t}{\left[((\pi/2)^2 + \pi - 5)\frac{1}{n}\max(1, \frac{TP_t}{BV_t^2})\right]}. \tag{17}$$

I constrain the jump risk to be positive,

$$J_t^2 = (\max[RV_t - BV_t, 0])/n, \tag{18}$$

and then compute what Andersen, Bollerslev and Diebold (2007) call the *significant jumps* using an α% confidence level,

$$J_{z,t}^2 = J_t^2 I(z_t > \Phi_\alpha^{-1}), \tag{19}$$

where Φ is the cumulative normal distribution.

I now begin the analysis with an examination of the finite sample properties of the rolling estimator.

4. Monte Carlo

I will establish in this section that the rolling daily estimator has good properties when jumps contribute the majority of the return variation. When jumps are not as important, the estimator is very conservative.

4.1 Sample design

Consider the process (1)-(2) with parameters to match those in Tauchen and Zhou (2007). The data are driftless, $\mu(t) = 0$ with volatility mean reversion $\beta = 0.10$, and volatility of volatility $\gamma = 0.05$. Jumps can occur at every tick with probability $\lambda dt = 0.05dt$. The average jump size is $\mu_J = 0.20$ with a standard deviation of $\sigma_J = 1.40$. The return and volatility shocks have a correlation of $\rho = -0.5$.

Tauchen and Zhou note that as you raise the long run mean of volatility θ, you lower the jump contribution to the total variance. At $\theta = 0.9$, the jump contributes only 10%, but at $\theta = 0.025$, the jump contribution rises to 76%. I also consider an intermediate case with $\theta = 0.2$ where the jump contributes 33%.

I use 400 days of simulated 1-minute data which are sampled at 5-minute and daily intervals. For the daily estimator, I set the moving average to $n = 50$. The tick frequency and sample length approximate those of the ABX sample.

4.2 Size and power

Econometricians, including Andersen, Bollerslev and Diebold (2007), have found that tests using just the jump component (9) typically bias upward the jump frequency. Huang and Tauchen (2005) have established that the relative jump statistic (12) has better size properties. I compare the size and power of this estimator using intra-daily and daily sampling.

For my sample design, the size of both tests, which are tabulated in the top panel of Table 6, is very conservative. In the absence of jumps, the 5-minute estimator rejects no more than 0.87% at the 5% significance level. The rolling estimator never rejects.

[Insert Table 6 Here]

Although both tests are quite conservative, they have good power, which I report in the lower panel of Table 6, against a process that jumps, on average, once every 20 days. The ability to detect the jumps, particularly for the daily estimator, depends very much on how much the jump process is contributing to the overall volatility.

When jumps represent 3/4 of the total return variation, $\theta = 0.025$, the daily and intra-daily estimators are essentially equal. Both reject approximately 85% of the time at the 5% significance level. As θ rises and the jump contribution diminishes, the power of the daily estimator falls off much more quickly. At $\theta = 0.2$, the intra-daily estimator rejects twice as often at the 5% significance level, 75.8% versus 36.8%. Once jumps represent just 10% of the total variance, the daily estimator falls off even more, rejecting only 7.3% of the time while the intra-daily estimate remains at 64.3%.

The conclusions to draw are fairly straightforward. If you have the intra-daily data, you definitely want to use it, but any jumps detected in the daily estimates should not be ignored.

5. Jump Risk Estimates for the ABX

This section reports estimates of model parameters and jump risk for the daily ABX data. I then turn to an exploratory graphical analysis of the 2006-1 roll.

5.1 Jump risk parameters

I report estimates of the jump contribution (12) for the 5 credit tranches of the four rolls of the ABX. I also assess the statistical significance of these jumps by looking at $J^2_{z,t}$ using the 95% confidence interval. I also sign the jump direction assuming that the jump is in the same direction as the daily return,

$$J^*_{t,z} = sign(r_t) \times \sqrt{J^2_t I(z_t > \Phi^{-1}_\alpha)}. \tag{20}$$

I then use these expressions to estimate the frequency of jumps in a sample of size T

$$\lambda^* = \# I(J^*_{t,z} > 0)/T = N^*/T. \tag{21}$$

The expected jump size is also obtained this way

$$\mu^*_J = \textstyle\sum_{t=1}^{T} J^*_{t,z}/N^*. \tag{22}$$

I report estimates in Table 7.

[Insert Table 7 Here]

The 2006-1 roll has the greatest number[7] of significant jumps, ranging from 11 in the BBB credit tranche to 91 in the AAA. Jumps contribute between 4.87% and 23.81% of the total return variation. Even for the BBB, where the overall jump contribution is the lowest, the contribution of jumps reaches a maximum of 38.23%. For the AAA series with the greatest discontinuities, the return contribution from jumps peaks at 81.17%.

Since the series jumps in both directions, the average jump μ_J^* is quite small, but they can be quite frequent. The AAA jumps about every 4 days, while the BBB jumps only once every 28 days. On average, across the 5 tranches, there is a jump every 7.01 days.

The 2006-2 roll has anywhere from 0 to 62 jumps. The jump frequency in the middle tranches is similar to the 2006-1, but the BBB- and the AAA jump far less frequently than the 2006-1 security. The contribution of jumps to total variation is just under 10%.

The number of jumps drops off substantially for the 2007-1 ABX. Jumps make up only slightly more than 10% of total variation for the most active AA and BBB tranches. The BBB jumps about once every 8 days, but the BBB- only jumps once in the sample.

The 2007-2 roll has no significant jumps in the lowest credit quality tranches. This is partly due to a very short history after using 50 days in forming the moving average. The AA jumps on 44% of the 25 sample days though.

5.2 Exploratory analysis

I will focus most of the empirical analysis on the 2006-1 roll which has the highest jump risk. I plot the ABX.HE index A rated tranches are in Figure 1 and the BBB tranches in Figure 2.

[Insert Figure 1 Here]

[Insert Figure 2 Here]

The ABX indices, regardless of credit quality, were all trading within 5% of par until February 2007. It is very interesting that there are small but significant jumps in several indices in November 2006 well before the BBB index loses par. I graph the statistically significant jumps in Figures 3 and 4.

[Insert Figure 3 Here]

[Insert Figure 4 Here]

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[7] As a robustness check, I also computed the number of significant jumps using the test procedure of Lee and Mykland (2007). I found results quite similar to those reported in Table 7.

The first sizable jump risk emerges in early February. On January 31, 2007, the jump risk in the BBB- tranche of reaches -0.17%. By the end of the month, the largest jumps take place. On February 27, 2007, the BBB- tranche spikes down -0.94%. A similar spike occurs a few days earlier, on February 23rd, in the A tranches.

The jump risk quiets down to zero by March, and remains insignificant until May 24-25, 2007. There is another large spike at that point in the BBB- of -0.37%. There are jumps in the AA and AAA indices later in the month of May.

The jump risk in the BBB- index again spikes in July 2007, reaching -0.64% on July 24, 2007. That is the last significant jump in the series despite continuing deterioration in the index.

The AAA tranche has jump risk increases in July as well with significant jumps from July 10 to July 17, 2007. Interestingly, July 10, 2007 is the first date that the AAA trades below par. The final significant jump for the AAA occurs on August 2, 2007. The latest jump in the sample is the -0.52% jump on October 26, 2007 in the AA tranche.

It is tempting to begin matching these risks to particular news events, but I will propose in the next section a more formal approach.

6. Events

Despite mentions from prominent observers like Edward Gramlich[8] of the Federal Reserve, the subprime lending market was not on policy makers' or Wall Street's radar screen. *The Wall Street Journal* noted in January 8, 2008, there were only 75 mentions in the *Journal* of the word subprime in the second half of 2006. In the second half of 2007, there were $1,561$. The question before us here is whether jump risk did any better anticipating it.

6.1 Measuring news flow

To try to provide an objective measure of the effect of news on the jump risk, I utilized three time lines that have been published since the subprime crisis hit. The first of these was from the British Broadcasting Company (BBC). Britain, apart from the US, has been the country most strongly impacted. The second timeline was from the U.S. Senate Joint Economic Committee. The

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[8] In testimonry before the House Committee on Banking and Financial Services on May 24, 2000, Gramlich wrote: "Most predatory lending seems to occur in the subprime mortgage market, a market that has grown recently. In this market, the premiums paid by borrowers typically range from about 1 percentage point to about 6 percentage points over the rate charged for prime mortgage loans, depending on the credit risk involved."

committee chair, Senator Charles Schumer of New York, has been a leading proponent of relief for subprime borrowers. The third timeline was from the largest U.S. bond mutual fund, Pacific Investment Management, PIMCO.

I gathered news stories from the three timelines about (1) Federal Reserve actions; (2) Materials news from subprime lenders like Countrywide and investment banks like Merrill Lynch; (3) I excluded macroeconomic news unless it appeared on at least 2 of 3 timelines. The stories caught by these filters are listed in Table 8.

[Insert Table 8 Here]

I consider two measures of news. The first is simply the message count which I denote $\#M_t$. This variable counts stories that appeared in any of the three timelines on a given event day. For example, on August 9, 2007, there was; (1) a coordinated intervention by ECB, Fed and Bank of Japan; (2) the French bank BNP Paribas suspended redemption in three hedge funds; and (3) AIG warned that defaults were spreading beyond subprime. This would set the count variable to 3. There are several other days with three stories including June 14, 2007 and August 13, 2007.

My second measure was one of intensity. If any story appeared in all three timelines, this variable, which I denote $\#nM_t$, would be set to 3. For example, the Bear Stearns' announcement on August 18, 2007 that it would be returning little or nothing to investors in two of its' mortgage backed hedge funds appears in the BBC, JEC and PIMCO timelines, so $\#nM_t = 3$. If there are multiple stories for a given day, the story that appears the most determines the counter for this variable.

6.2 News flow regressions

To smooth over possible difficulties in timing with stories being released in Europe and the U.S. and the possibility that action might take effect with some lag, I construct a 5-day sum of both variables,

$$D_{1,t} = \sum_{j=1}^{5} \#M_{t+1-j},\ D_{2,t} = \sum_{j=1}^{5} \#nM_{t+1-j} \tag{23}$$

I then regress the statistically significant jumps at time t on the lagged values of the two moving sums,

$$J^*_{t,z} = b_0 + b_1 D_{i,t-1},\ i = 1, 2. \tag{24}$$

Regressions results for all 5 credit quality tranches for the 2006-1 roll are in Table 9.

[Insert Table 9 Here]

By confining the focus to statistically significant jumps, I highlight the days in which certain tranches make their most extreme moves. News explains the jumps best in the AAA and BBB- tranches. The best fit is with the D_2 variable for the AAA, where news explains 56% of the jump risk. For the BBB-, the same variable explains nearly 53%.

In the middle tranches, the fits are respectable to poor. For the A and AA, news explains between 9% and 23% of the jumps. The BBB tranche, which has only 11 jumps, is uncorrelated with the news flow.

I now turn to the index that in some respects is the underlying for the ABX, the value of single family residences.

7. Data: CME

In the late 1980s, economists Karl Case and Robert Shiller (1989) began to study housing in a modern portfolio theory context. Both were concerned that the dramatic declines in the stock market that took place in 1987 might also extend to real estate. They noted that, unlike the stock market, there was no low transaction cost method to short real estate prices. This was surprising given the size of the sector ($23.2 trillion in the third quarter 2007 Federal Reserve flow of funds accounts), and apparent frequency of boom and bust cycles in real estate.

Case, Shiller and Allan Weiss (1993) proposed the creation of futures and options markets in real estate to “allow diversification and hedging.” The first step in creating such a market though was the production of real estate indices for the U.S. and important geographical markets. Case, Shiller and Weiss founded a firm in 1991 to produce the indices which was sold to the publicly traded information provider Fiserv in 2002. Standard and Poor’s began “co-branding” the indices in March 2006.

The key method to the Case-Shiller indices (CSI) is the use of repeat sale methodology. The index computes a three-month moving average of the repeat sales of single family houses in 20 metropolitan areas. The use of repeat sales is preferable to using a hedonic index to compensate for changes in quality, but obviously does not avoid it due to home improvements (or lack thereof). The method produces a cap-weighted index for residential real estate in a particular region. A national composite in then produced from the regional indices using census weights..

In May 2006, the Chicago Mercantile exchange began trading futures on the CSI indices for

10 metropolitan areas: Boston; Chicago; Denver; Las Vegas; Los Angeles; Miami; New York; San Diego; San Francisco; and Washington, D.C. There are also options on the futures.

The contracts trade at \$250 per index point and are cash settled. For example on July 23, 2008, the August 25, 2008 expiry of the composite index closed at 175.80. The November 2010 expiry was trading at 151.40. If the August 2008 contract were to fall to the November 2010 level, an investor who was long the contract would lose $\$250 \times (151.40 - 175.80) = -\$6,100$. The contracts trade in ticks of 0.20.

I have the full history of the indices from inception and will analyze the sample that coincides with the ABX index.

8. Jump Risk Modeling of Housing Futures

In the first section, I extract the jump risk component from the returns on the CME futures using the Barndorff-Nielsen and Shephard approach. I then try to explain movements in the jump risk using the news timelines.

8.1 Jump risk estimates

I report estimates of the jump contribution to total variation and the number of statistically significant jumps in Table 10. I examine the 1-month and 12-month contracts, f^1 and f^{12}. Jumps are, on average small, but they contribute 40.7% of the total return variation in the 1-month futures and 46.2% in the 12-month. Both series jump over 200 times, with the probability of a jump occurring around 2/3.

[Insert Table 10 Here]

To get a visual sense of the jump risk in this data series, I plot $J^*_{t,z}$ for the near month, f^1, and one-year ahead, f^{12}, housing futures composite index in Figure 5.

[Insert Figure 5 Here]

Because jumps are so frequent, the non-jump episodes are the main story. The f^1 has some small jumps in August 2006, and then enters a quiet period from September to November 2006. From the end of November to the middle of February 2007, it has jumps nearly every day. After a quiet end of February, there are jumps every day through the early part of May. From May 30, 2007 to the end of sample, November 2, 2007, there are again nearly daily jumps except for the middle of August.

The f^{12} has no jumps until November 15, 2006. It then jumps nearly continuously until May 2007. After a quiet end to that month, it again jumps almost continuously through to the end of the sample. Between November 15, 2006 and November 2, 2007, it jumps 221 out of 242 days.

8.2 The impact of news

I repeat the exercise with the news regressions for the two futures contracts. Results are reported in Table 11.

[Insert Table 11 Here]

The news about subprime mortgages does not explain much of the variation in the housing futures jump risk. While news is significant for the f^1 contract, the R^2 is less than 3%. The news variables are even less successful for the 12-month contract.

The link of the jump risk, if any, between these markets requires further exploration.

9. Cojumps

9.1 Theory

Bollerslev, Law and Tauchen (BLT, 2007) have proposed a measure of the cross correlation of markets to look at jumps occurring simultaneously in more than one market, called *cojumps*. I restrict the analysis here to the contemporaneous daily correlation,

$$cp_t = \textstyle\sum_{k=0}^{n-1} r_{1,t-k} r_{2,t-k}, \tag{25}$$

where $r_{1,t}$ and $r_{2,t}$ are the returns in markets 1 and 2. There is, as of this writing, no formal asymptotic theory for cojumps, so I follow BLT and use the studentized statistic,

$$z_{cp,t} = \frac{cp_t - \overline{cp}}{s_{cp}}, \tag{26}$$

where

$$\overline{cp} = \frac{1}{T} \textstyle\sum_{t=1}^{T} cp_t, \tag{27}$$

and

$$s_{cp} = \left[\frac{1}{T-1} \textstyle\sum_{t=1}^{T} (cp_t - \overline{cp})^2\right]^{1/2}. \tag{28}$$

I will designate the significant cojumps as

$$cp^*_{t,z} = sign(r_{1,t} r_{2,t}) \times cp_t I(|z_t| > \Phi^{-1}_{\alpha}). \tag{29}$$

I use the absolute value in (29) because the cojump test is two-sided. I explore the finite sample performance in the next section.

9.2 Monte Carlo

To explore the size and power of the cojump statistic, I utilize a bivariate jump diffusion like (1) and (2). I set the correlation between the w_i to zero, but I assume the jumps, which I designate $J_{1,t}$ and $J_{2,t}$ are correlated. Let $q_{1,t}$ and $q_{2,t}$ be the count processes for the two jumps. I then set

$$\Pr[(q_{1,t} = 1 | q_{2,t} = 1] = \rho_J \tag{30}$$

As the correlation increases, the cojumps increase.

I use the identical parameters from Section 4.1 and set the long run volatility mean to either $\theta = 0.1$ or $\theta = 0.5$. I report rejections of the null of no cojumps on days where cojumps occur. Results are in Table 12.

[Insert Table 12 Here]

In the first power exercise, I set $\rho_J = 0.5$. The test is quite powerful and seems unaffected by the jump contribution to the variance. We reject between 90 and 92.5% at the 5% significance level. As we increase the number of cojumps by setting $\rho_J = 0.75$, the detection rate falls off just a little, to 87.7% at the 5% level for the case $\theta = 0.5$.

It appears that I can reliably utilize the studentized cojump statistic (26).

9.3 Cojump estimates

I set market 1 to be the ABX index and set market 2 to be the 12 month futures. I compute the cojump estimates $cp^*_{t,z}$ for our two markets using a two-sided 5% test. For brevity, I only analyze the AAA and BBB- tranches. I graph the cojump risk in Figure 6.

[Insert Figure 6 Here]

There are 25 significant cojumps in the AAA tranche/12-month futures pair. All of these episodes occur in the summer of 2007 once the subprime crisis was well under way. There is a significant negative period in August 2007 followed by a shorter positive episode in mid-to-late

October.

I identify 27 significant cojumps in the BBB- pairing. There is a strong positive spike on February 27, 2007 which is the day that jump risk spikes in the BBB- ABX tranche. There are some positive moves in the ABX index in late May and early June 2007. Cojump risk is negative again in the first part of August. The BBB- remains insignificant for the rest of the sample after August 13.

The next logical step is to see if news is driving these cojump episodes. I regress the significant cojumps on the two news dummies.

$$cp^*_{t,z} = b_0 + b_1 D_{i,t-1},\ i = 1, 2. \tag{31}$$

Results are in Table 13.

[Insert Table 13 Here]

News does appear to explain much of the cojumps risk for the AAA tranche. Both news dummies are highly significant and the $\overline{R}^2$ reaches 0.43. The story is less clear with the BBB- where only the D_2 dummy is significant and news explains, at most, 15% of the risk.

In the final section, I now turn to the question of not just explaining jump risk, but predicting it.

10. A Predictive Model of Jump Risk

The significant cojumps and their relation to the subprime news flow suggest that common factors are driving the jump risk in the ABX. I begin with some empirical modeling of the their interactions to provide the building blocks for a future structural model.

Jump risk, like a lot of other volatility measures, is clearly persistent. Figures 3 and 4 indicate that jump risk may be autoregressive, so I will include lagged jumps $J^*_{1,t-1,z}$ in the empirical model. On the other hand, extreme events are quite rare and seem to stand out in the figures. To model these large jumps, I include a lagged squared value of the ABX jumps, $J^{2*}_{1,t-1,z}$.

The jump risk from the housing market $J^*_{2,t-1,z}$ should be impacting the mortgage securities in the ABX index, so I include the lagged jump risk from the housing futures in our specification as well. Finally, there may be risks to the ABX index from changes in home prices in the near future. I include the slope of the housing futures curve $(f^{12}_{t-1} - f^{1}_{t-1})$ as the final explanatory variable.

I specify the predictive model as

$$J^*_{1,t,z} = b_0 + b_1 J^*_{1,t-1,z} + b_2 J^{2*}_{1,t-1,z} + b_3 J^*_{2,t-1,z} + b_4 (f^{12}_{t-1} - f^{1}_{t-1}), \tag{32}$$

and estimate it for the 5 ABX credit tranches in Table 14.

[Insert Table 14 Here]

The model fits the data quite well, explaining 31% to 85% of the jumps. b_1, the coefficient on lagged jumps, is statistically insignificant in each specification, but the lagged squared jump risk, b_2, is significant for the AA and A tranches. The extreme jumps appear to be climatic for the market and lower the jump risk the next day, $b_2 < 0$.

Jump risk from the housing futures appears to matter only for the highest and lowest rated tranches, and it tends to increase the jump size, $b_3 > 0$.

The slope of the housing futures yield curve matters for jumps in 3 of the 5 tranches. A steeply sloping yield curve like we had in the housing bubble contributes to negative jumps, $b_4 < 0$. To get some idea of magnitudes, consider than on May 19, 2006, the 1-month composite futures price was at 235.20 and the 12-month ahead price was 255.80. This spread of 20.60 leads to an expected jump of -1.42% in the BBB- tranche.

A possibly hopeful sign is that the inversion of the futures curve since June 19, 2006 makes jumps *up* more likely.

11. Risk Management and VaR

Basel II (2006) requires that banks set aside capital to hedge against *event risk*, but it relies on the value-at-risk (VaR) methodology to estimate potential losses. In this section, I find that a subprime mortgage portfolio hedged with a short position in the housing futures still experiences large daily negative returns that are more frequent than implied by the VaR. Jumps appear to be responsible for up to half the underestimate of losses.

Consider a portfolio consisting of a long position in the ABX and a short position ω_2 in the composite housing futures

$$\Pi_t = p_{1,t} - \omega_2 p_{2,t} \tag{33}$$

The expression above is often called the *basis risk* of the hedged portfolio. The optimal hedge ratio is the variance minimizing weight, e.g. Hull (2006),

$$\omega_2^* = \rho \frac{\sigma_1}{\sigma_2}, \tag{34}$$

where ρ is the correlation between the ABX and housing futures return.

I first report VaR estimates in Table 15 using the unconditional sample moments for two portfolios, the first a long position in the AAA and a short position in the 1-month housing futures, the second a long position in the BBB- with a short position in the 12-month housing futures.[9] The daily value-at-risk at the 95% confidence interval,

$$\% VaR^{0.05} = -1.645 \sigma_{\Pi}, \tag{35}$$

is -0.3529% for the AAA portfolio and -2.6520% for the BBB-.

[Insert Table 15 Here]

The hedge parameter (34) is static, and it may be the case that the correlation structure the two assets may be changing over time. I next consider a dynamic hedge ratio based on the realized covariance and realized volatility,

$$\omega_{2,t}^* = \textstyle\sum_{k=0}^{n-1} r_{1,t-k} r_{2,t-k} / \sum_{k=0}^{n-1} r_{2,t-k}^2. \tag{36}$$

This hedge parameter moves around considerably compared to the static hedge, and produces a much broader range of portfolio variances,

$$\sigma_{\Pi,t}^2 = [\textstyle\sum_{k=0}^{n-1} r_{1,t-k}^2 + \omega_{2,t}^{2*} \sum_{k=0}^{n-1} r_{2,t-k}^2 - 2\omega_{2,t}^* \sum_{k=0}^{n-1} r_{1,t-k} r_{2,t-k}]/n. \tag{37}$$

I then compute and plot $\% VaR^{0.05}$ in Figure 7 using $\sigma_{\Pi,t}$.

[Insert Figure 7 Here]

The VaR for both portfolios in the early part of the sample is considerably below the VaR using the portfolio's unconditional variance in (35). By the end of the sample, the VaR is nearly double.

There are 26 exceedences of the 95% confidence interval in the AAA portfolio in a sample of 314 daily returns. Exactly half of those exceedences occur on days of significant jumps in the ABX. There are 45 exceedences for the BBB- portfolio, and 10 of those occur on days of significant jumps. VaR is heavily biased downward, even when we allow volatility to vary with a dynamic hedge. Across credit quality tranches, the exceedences due to jumps is consistent with our earlier

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[9] I chose the futures maturity that had the highest correlation with the ABX tranche.

findings of the percentage contribution of jumps to total variance.

12. Conclusion

This is the first paper to show a linkage between discontinuous movements in two housing derivatives markets, the ABX.HE index and the CME housing futures. Detecting this link in daily returns suggests that nonparametric jump estimators provide useful, conservative inferences, even in the absence of high frequency data.

The jump risk in the ABX is largely driven by news, but our predictive model indicates that some of the changes in risk profile can be anticipated. These results may help regulators diagnose potential problems before they reach crisis levels. This may be especially important because VaR, in the presence of event risk, appears to underestimate potential losses.

The literature awaits a formal asymptotic theory for multivariate jump risks. A structural framework that incorporates the term structure of housing futures prices and the impact of interest rates on housing affordability is the most important step on the modeling side. It may also be possible to compute analytically the value-at-risk of the hedge portfolio in a manner similar to Duffie and Pan (2001). In the interim, economists and policy makers can apply nonparametric models of jump risks to interpret the signals in derivatives prices.

References

Andersen, T.G., Bollerslev, T. and Diebold, F.X. (2007),“Roughing It Up: Including Jump Components in the Measurement, Modeling and Forecasting of Return Volatility,” *Review of Economics and Statistics* 89, 701-20.

Barndorff-Nielsen. O. and N. Shephard (2006), “Econometrics of Testing for Jumps in Financial Economics using Bipower Variation,” *Journal of Financial Econometrics* 4, 1-30.

Basel Committee on Banking Supervision (2006), “International Convergence of Capital Measurement and Capital Standards: A Revised Framework,” Bank for International Settlements.

Beine, M., J. Lahaye, S. Laurent, and C. Neely (2007), “Central Bank Intervention and Exchange rate Volatility, Its Continuous and Jump Components,” *International Journal of Finance and Economics* 12, 201-23.

Bollerslev, T., T. Law and G. Tauchen (2007), “Risk, Jumps, and Diversification,” Working Paper, Duke University.

Case, K. and R. Shiller (1989), “The Efficiency of the Market for Single Family Homes,” *American Economic Review* 79, 125-37.

Case, K., R. Shiller, and A. Weiss (1993), “Index-Based Futures and Options Trading in Real Estate,” *Journal of Portfolio Management* Winter, 83-92.

Duffie, D. and J. Pan (2001), “Analytical Value-at-Risk with Jumps and Credit Risk,” *Finance and Stochastics* 5, 155-180,

Gorton, G. and N. Souleles (2006), “Special Purpose Vehicles and Securitization,” in *The Risks of Financial Institutions,* R. Stulz and Mark Carey (eds.), Chicago: University of Chicago Press.

Haas, M., S. Mittnik, and B. Mizrach, “Assessing Central Bank Credibility During the EMS Crises: Comparing Option and Spot Market-Based Forecasts,” *Journal of Financial Stability* 2, 2006, 28-54.

Huang, X. and G. Tauchen (2005), “The Relative Contribution of Jumps to Total Price Variance,” *Journal of Financial Econometrics* 3, 456-499.

Hull, J. (2006), *Options, Futures and Other Derivatives Securities*, 6th ed., Englewood Cliffs: Prentice Hall.

Jobst, A. (2005), “Asset Securitisation as a Risk Management and Funding Tool: What Does It Hold In Store For SMEs,” Working Paper, FDIC.

Karatzas, I. and S. Shreve (1991). *Brownian Motion and Stochastic Calculus*, 2nd ed. New York: Springer-Verlag,

Kiff, J. and P. Mills (2007), “Money for Nothing and Checks for Free: Recent Developments in U.S. Subprime Mortgage Markets,” IMF Working Paper 07/188.

Lahaye, J., S. Laurent, and C. Neely (2007), “Jumps, Cojumps and Macro Announcements,” Working Paper #2007-032A, Federal Reserve Bank of St. Louis.

Lang, L. H. P., Poulsen, A. and R. Stulz (1995), “Asset Sales, Firm Performance and the

Agency Costs of Managerial Discretion," *Journal of Financial Economics* 37, 3-38.

Lee, S. and P. Mykland (2007), "Jumps in Financial Markets: A New Nonparametric Test and Jump Dynamics," *Review of Financial Studies*, forthcoming.

Minton, B., T. Opler and S. Stanton, (1997), "Asset Securitization among Industrial Firms," Working Paper, Ohio State University.

Merton, R. (1976), "Option Pricing when Underlying Stock returns are Discontinuous," *Journal of Financial Economics*, 3, 124-44.

Mizrach, B. (2006), "The Enron Bankruptcy: When Did The Options Market Lose Its Smirk," *Review of Quantitative Finance and Accounting* 27, 2006, 365-82.

Mizrach, B. (2009), "Estimating Implied Probabilities From Option Prices and the Underlying," in. C.F. Lee and A.C. Lee (eds), *The Handbook of Quantitative Finance*, New York: Springer-Verlag, forthcoming.

Schloemer, E., W. Li, K. Ernst, and K. Keist (2006), "Losing Ground: Foreclosures in the Subprime Market and Their Cost to Homeowners." Working Paper, Center for Responsible Lending.

Tauchen, G. and H. Zhou (2007), "Realized Jumps on Financial Markets and Predicting Credit Spreads," Working Paper, Federal Reserve Board.

Thomas, H. (2001), "Effects of Asset Securitization on Seller Claimants," *Journal of Financial Intermediation* 10, 306–330.

Table 1
Asset Backed Securities Outstanding ($bn)

	Automobile Loans	**Credit Card Receivables**	**Home Equity Loans**	**Student Loans**	**Other**	**Total**
1996	71.4	180.7	51.6	10.1	90.6	404.4
1997	77.0	214.5	90.2	18.3	135.8	535.8
1998	86.9	236.7	124.2	25.0	258.7	731.5
1999	114.1	257.9	141.9	36.4	350.5	900.8
2000	133.1	306.3	151.5	41.1	439.8	1,071.8
2001	187.9	361.9	185.1	60.2	486.1	1,281.2
2002	221.7	397.9	286.5	74.4	562.7	1,543.2
2003	234.5	401.9	346.0	99.2	612.1	1,693.7
2004	232.1	390.7	454.0	115.2	635.8	1,827.8
2005	219.7	356.7	551.1	153.2	674.5	1,955.2
2006	202.4	339.9	581.2	183.6	823.3	2,130.4
2007	198.5	347.8	585.6	243.9	1,023.5	2,472.4
2008:1	196.6	358.2	587.6	248.9	1,018.0	2,480.3

The data were compiled by SIFMA, the Securities Industry and Financial Markets Association. The 2008 numbers are for the first quarter.

Table 2
Issuers and Entities in the ABX Index

	Issuer	**Entities**
1	ACE Securities Corp. (DeutscheBank)	2005-HE7
2	Ameriquest Mortgage Securities	2005-R11
3	Argent Securities Inc.	2005-W2
4	Bear Stearns Asset Backed Securities, Inc.	2005-HE11
5	Countrywide Asset-backed Certificates	2005-BC5
6	First Franklin MTG Loan Asset Backed	2005-FF12
7	GSAMP Trust (GoldmanSachs)	2005-HE4
8	Home Equity Asset Trust (CSFB)	2005-8
9	JP Morgan Mortgage Acquisition Corp.	2005-OPT1
10	Long Beach Mortgage Loan Trust	2005-WL2
11	MASTR Asset Backed Securities Trust (UBS)	2005-NC2
12	Merrill Lynch Mortgage Investors Trust	2005-AR1
13	Morgan Stanley ABS Capital	2005-HE5
14	New Century Home Equity Loan Trust	2005-4
15	Residential Asset Mortgage Product Series (RFC/GMAC)	2005-EFC4
16	Residential Asset Securities Corp. (RFC/GMAC)	2005-KS11
17	Securitized Asset Backed Receivables (Barclays)	2005-HE1
18	Soundview Home Equity Loan Trust (Greenwich)	2005-4
19	Structured Asset Investment Loan Trust (Lehman)	2005-HE3
20	Structured Asset Securities Corp. (Lehman)	2005-WF4

The data are from MarkIt and the securities represent the constituents of the ABX.HE 06-1 index. Ownership of the securities was confirmed from the 8-K filings of the registrants.

Table 3
Weighted Average Deal Characteristics

ABX	60+	FICO	LTV	ARM	IO	Full Doc
2006-01	11.94	634	80.36	81.75	32.13	58.71
2006-02	11.94	627	77.76	80.78	22.52	56.90
2007-01	5.48	626	79.21	76.84	15.64	57.57

The data were compiled by Nomura Fixed Income Research in April 18, 2007. All numbers are percentages based on a weighted average of deals in the ABX indices. 60+ Delq. is the percentage of mortgage holders who are 60 days or more delinquent. FICO is their credit score, CLTV is the loan to value ratio, ARM is the percentage of floating rate mortgages, IO is interest only mortgages, Full Doc refers to the whether full income documentation was provided by the borrower.

Table 4
Coupon Rates on ABX Indices

Index	**AAA**	**AA**	**A**	**BBB**	**BBB-**
ABX.HE-061	18	32	54	154	267
ABX.HE-062	11	17	44	133	242
ABX.HE-071	9	15	64	224	389

The figures are in basis points. For example, a buyer of an ABX AAA security from the first half of 2006, HE-061, will pay protection of 18 basis points per annum, or $1,800 per year on $1 million dollars of bonds.

Table 5
Implied Spread Computation

Tranche	Coupon (bp)	Price	Duration	Implied Spread (bp)
AAA	9	82.72	5.07	350
AA	15	49.57	3.70	1,378
A	64	28.94	3.44	2,130
BBB	224	19.86	3.02	2,878
BBB-	389	18.94	2.75	3,337

The prices are from October 31, 2007 and are daily closes of the ABX.HE-071 roll with 100 representing par. Coupons are from Table 4. Duration estimates are from UBS and were first reported in Ashcraft and Scheurmann (2008). The implied spread is computed in basis points as $100 \times (100 - p_t)/Duration + coupon$.

Table 6
Monte Carlo Experiments

Size

		5-min		Daily	
θ	RJ	5%	1%	5%	1%
0.9	0.00	0.292%	0.058%	0.000%	0.000%
		(0.51)%	(0.23)%	(0.00)%	(0.00)%
0.2	0.00	0.870%	0.200%	0.000%	0.000%
		(0.97)%	(0.43)%	(0.00)%	(0.00)%
0.025	0.00	0.328%	0.052%	0.000%	0.000%
		(0.57)%	(0.23)%	(0.00)%	(0.00)%

Power

			5-min				Daily			
θ	$E[J^2]$	$E[RJ]$	J^2	RJ	5%	1%	J^2	RJ	5%	1%
0.9	0.1	0.10	0.086	0.087	64.311%	53.414%	0.054	0.053	7.285%	2.726%
			(0.03)	(0.03)	(13.61)%	(12.34)%	(0.03)	(0.03)	(10.13)%	(6.13)%
0.2	0.1	0.33	0.085	0.284	75.814%	69.932%	0.053	0.169	36.817%	25.420%
			(0.04)	(0.08)	(11.27)%	(10.12)%	(0.03)	(0.08)	(19.47)%	(18.21)%
0.025	0.1	0.76	0.092	0.746	84.427%	82.400%	0.078	0.598	84.662%	79.917%
			(0.04)	(0.08)	(9.10)%	(8.97)%	(0.04)	(0.10)	(12.16)%	(14.37)%

The table reports size and power comparisons of the intra-daily and daily estimators of jumps. The data generating process is (1)-(2) at a tick interval of 1-minute. I set $\mu = 0$, $\rho = -0.5$, $\beta = 0.10$, $\gamma = 0.05$, $\mu_J = 0.20$, and $\sigma_J = 1.40$. In the size test, I set the jump frequency λ to zero. In the power exercise, I set $\lambda = 0.05dt$ which implies one jump every 20 days. In the size and power exercises, I vary the long run mean of volatility between $\theta = 0.025$ and $\theta = 0.9$. This lowers the percentage contribution of the jump to total variance RJ_t from 76% to 10%. Standard errors are the standard deviations across 500 Monte Carlo trials.

Table 7
Jump Risk Parameter Estimates

	RJ						*RJ*				
ABX-061	Avg.	Max	μ_J^*	N^*	λ^*	**ABX-062**	Avg.	Max	μ_J^*	N^*	λ^*
AAA	0.2381	0.8117	-0.0000	91	0.2880	AAA	0.0882	0.8061	-0.0004	14	0.0509
AA	0.0991	0.5561	-0.0018	38	0.1203	AA	0.1658	0.9315	-0.0005	30	0.1091
A	0.0910	0.6725	-0.0001	59	0.1867	A	0.1137	0.7554	-0.0003	62	0.2255
BBB	0.0487	0.3823	-0.0001	11	0.0348	BBB	0.0744	0.3429	0.0005	49	0.1782
BBB-	0.0852	0.4303	-0.0012	26	0.0823	BBB-	0.0171	0.2619	0.0000	0	0.0000
ABX-071						**ABX-072**					
AAA	0.0878	0.6922	-0.0004	3	0.0200	AAA	0.0433	0.2625	-0.0037	1	0.0400
AA	0.1014	0.7684	-0.0001	12	0.0800	AA	0.2372	0.3962	-0.0020	11	0.4400
A	0.0363	0.4538	-0.0024	4	0.0267	A	0.0000	0.0000	0.0000	0	0.0000
BBB	0.1055	0.2808	-0.0022	19	0.1267	BBB	0.0000	0.0000	0.0000	0	0.0000
BBB-	0.0382	0.2660	-0.0093	1	0.0067	BBB-	0.0433	0.2062	0.0000	0	0.0000

RJ is the portion of the variance attributable to jumps. μ_J^* is an estimate of the mean jump size based on the N^* significant jumps in (21). The empirical jump frequency λ^* is obtained by dividing N^* by the sample size.

Table 8(a)
Subprime News Flow: Dec. 2006-August 2007

Date	News	BBC	JEC	PIMCO
20061228	OwnIt Mortgage Solutions files for bankruptcy		X	
20070207	Senate has hearings on subprime lending		X	
20070212	ResMae Mortgage files for bankruptcy		X	
20070220	Nova Star has surprise loss		X	
20070222	HSBC fires head of US mortgage business after $10.5bn loss	X		
20070302	Fed announces draft regulations for subprime		X	
20070308	DR Horton warns of huge losses	X		
20070308	New Century stops making loans		X	X
20070312	New Century shares halted	X		
20070316	Accredited Home Lenders sells $2.7bn in loans	X		
20070320	People's Choice files for bankruptcy		X	
20070327	Bernanke "likely to be contained"		X	X
20070402	New Century files for bankruptcy	X	X	X
20070406	American Home Mortgage writes down risky mortgages		X	
20070418	Freddie announces plans to refinance $20bn in subprime		X	
20070424	Sales of existing homes fall 8.4%, sharpest in 18 years		X	X
20070503	GMAC loses heavily in subprime	X		
20070503	UBS closes subprime lending arm	X		
20070509	Fed does not change rates		X	
20070517	Fed does not see broader economic impact		X	
20070612	Foreclosure filings surge 90% year over year.		X	X
20070614	Frank says Fed could lose mortgage regulatory authority	X		
20070614	News emerges about large liquidations at Bear			X
20070614	Goldman reports flat profit		X	
20070622	Bear Stearns $3.2bn hedge fund bail out	X	X	X
20070629	Bear fires head of asset management	X		
20070710	S&P and Moody's negative ratings $12bn in subprime		X	X
20070713	GE decides to sell WMC subprime business	X		
20070718	Bear : investors will get little money back	X	X	X
20070719	Fed comments shake global shares	X	X	
20070720	Bernanke warns subprime crisis could cost up to $100bn	X		
20070724	Rising default hit profits at CFC	X		
20070726	Bear Stearns seizes assets. Shares fall 4.2%, largest in five year.	X		
20070727	Worries about subprime hammer global stock markets	X		
20070730	Germany's IKB bailed out		X	
20070731	Bear Stearns stops withdrawls from third fund	X	X	
20070731	Home prices show 18th consecutive decline in growth rate		X	
20070803	Shares fall heavily on fears of credit crunch	X		
20070806	American Home Mortgage files for bankruptcy	X	X	
20070807	Fed leaves rates at %5.25		X	

BBC is the British Broadcasting Company, JEC is the Joint Economic Committee of U.S. House of Representatives, and PIMCO is from the Pacific Investment Management Co.

Table 8(b)
Subprime News Flow: Aug.-November 2007

Date	News	BBC	JEC	PIMCO
20070809	Coordinated intervention by ECB, Fed and Bank of Japan	X	X	
20070809	AIG warns defaults spreading beyond subprime			X
20070809	BNP Paribas suspends 3 funds	X	X	
20070810	ECB provides extra 61bn in Euros. Fed pledges overnight money	X		
20070810	Global markets pressure. Worst day on FTSE in 4 years	X		
20070813	ECB pumps 47.7bn in Euros into money markets	X		
20070813	Goldman provides $3bn support for hedge fund	X		
20070813	Aegis Mortgage files for bankruptcy		X	
20070816	CFC draws entire 11.5bn credit line	X	X	X
20070817	Fed cuts discount rate by 50 basis points	X	X	X
20070820	CFC cuts jobs	X		
20070823	CFC get $2bn cash infusion from BAC	X		
20070828	German Sachsen Landesbank sold under threat of collapse	X		
20070831	Bernanke at Jackson Hole says US will act as needed		X	
20070903	German IKB records $1bn loss	X		
20070904	Bank of China reveals $9bn in subprime losses	X		
20070904	Overnight bank lending dries up	X		
20070906	ECB injects fresh cash into market	X		
20070911	Trichet says EU economy sound	X		
20070914	Northern Rock shares plummet after BofE rescue plan announced.	X		
20070914	Merrill signals mortgages will hurt 3Q earnings		X	
20070917	NovaStar eliminates its REIT			
20070917	Merill Lynch job cuts at First Franklin		X	
20070918	Fed cuts interest rates to 4.75%	X		X
20070918	Impac Mortgages closes			
20070920	Bernanke says subprime losses higher than expected	X		
20070920	Goldman makes profits betting MBS will fall	X		
20070921	HSBC closes Decision One		X	
20071001	UBS reveals $3.4bn loss	X	X	
20071001	Greenspan says housing crisis far from over			
20071005	Merrill reveals $5.6bn subprime loss	X		
20071010	Bush administration Hope Now		X	
20071015	Citi writes down additional $5.9bn	X		X
20071016	Bernake: subprime crisis and housing slump will be drag	X	X	
20071018	S&P cuts grades on 23.3bn of loans		X	
20071024	Merrill Lynch announces $7.9bn writedown		X	X
20071030	Merrill O'Neal resigns	X		
20071031	Deutsche Bank reveals $3bn writedown	X		
20071031	Fed delivers second rate cut	X	X	X
20071101	CFSB writes down $1bn	X		

BBC is the British Broadcasting Company, JEC is the Joint Economic Committee of U.S. House of Representatives, and PIMCO is from the Pacific Investment Management Co.

Table 9
ABX Index News Regressions

Tranche	$D_{1,t-1}$	$D_{2,t-1}$	Stat.
AAA	-0.0002	-0.0003	Coeff
	(-8.99)	(-10.74)	(t-stat)
	0.4727	0.5622	$\overline{R}^2$
AA	-0.0032	-0.0036	Coeff
	(3.11)	(2.15)	(t-stat)
	0.1897	0.0896	$\overline{R}^2$
A	-0.0005	-0.0012	Coeff
	-4.2087	-4.3029	(t-stat)
	0.2237	0.2319	$\overline{R}^2$
BBB	0.0000	0.0000	Coeff
	0.0000	0.0000	(t-stat)
	0.0000	0.0000	$\overline{R}^2$
BBB-	-0.0013	-0.0026	Coeff
	3.9656	4.0664	(t-stat)
	0.5250	0.5260	$\overline{R}^2$

These are estimates of the effect of news on ABX index jump risk using the specification (24) in the text. $D_{1,t}$ is a 5-day moving sum of the number of news stories in the BBC, JEC, and PIMCO timelines in Table 8. $D_{2,t}$ is the number of news timelines that carried a particular story on that day. I estimate the model on days when jump risk is statistically significant.

Table 10
CME Housing Futures Jump Risk Parameter Estimates

	RJ				
Contract	Avg.	Max	μ_J^*	N^*	λ^*
f^1	0.4071	1.0000	0.0013	212	0.6709
f^{12}	0.4617	1.0000	0.0012	221	0.6994

f^1 is the 1-month ahead contract, and f^{12} is the 12-month. RJ is the portion of the variance attributable to jumps. μ_J^* is an estimate of the mean jump size based on the N^* significant jumps in (21). The empirical jump frequency λ^* is obtained by dividing N^* by the sample size.

Table 11
CME Housing Futures News Regressions

Contract	$D_{1,t-1}$	$D_{2,t-1}$	**Stat.**
f^1	1.5669	1.3200	Coeff
	(-2.57)	(-2.07)	(t-stat)
	0.0259	0.0153	$\overline{R}^2$
f^{12}	0.2271	-0.1547	Coeff
	(-0.36)	(-0.27)	(t-stat)
	-0.0040	-0.0042	$\overline{R}^2$

These are estimates the effect of news on housing futures jump risk using the specification (24) in the text. f^1 is the 1-month ahead contract, and f^{12} is the 12-month. Coefficient estimates are $\times 10^4$. $D_{1,t}$ is a 5-day moving sum of the number of news stories in the BBC, JEC, and PIMCO timelines in Table 8. $D_{2,t}$ is the number of news timelines that carried a particular story on that day. I estimate the model on days when jump risk is statistically significant.

Table 12
Monte Carlo Analysis of Cojumps

	$\theta = 0.1$		$\theta = 0.5$	
ρ_J	5%	1%	5%	1%
0.50	92.532%	90.442%	90.103%	88.502%
	(19.68)%	(23.25)%	(22.73)%	(25.13)%
0.75	88.810%	87.088%	87.710%	86.118%
	(17.99)%	(19.54)%	(20.15)%	(21.24)%

The table reports rejection frequencies for the daily cojump statistic (26). The data generating process is a bivariate version of (1)-(2) at a tick interval of 1-minute. I set $\mu = 0$, $\rho = -0.5$, $\beta = 0.10$, $\gamma = 0.05$, $\lambda = 0.05dt$, $\mu_J = 0.20$, and $\sigma_J = 1.40$. I vary the long run mean of volatility between $\theta = 0.1$ and $\theta = 0.5$ and the correlation of jump occurrence from 0.5 to 0.75. Standard errors are the standard deviations across 500 Monte Carlo trials.

Table 13
Cojump News Regressions

Tranche	$D_{1,t-1}$	$D_{2,t-1}$	**Stat.**
AAA	-4.0632	-3.1544	Coeff
	-(4.42)	-(3.99)	(t-stat)
	0.4263	0.3736	$\overline{R}^2$
BBB-	-0.4364	-0.3558	Coeff
	-(1.55)	-(2.33)	(t-stat)
	0.0549	0.1553	$\overline{R}^2$

These are estimates the effect of news on cojump risk for the ABX-061 tranches paired with the 12-month CSI composite futures using the specification (31) in the text. Coefficient estimates are $\times 10^6$. $D_{1,t}$ is a 5-day moving sum of the number of news stories in the BBC, JEC, and PIMCO timelines in Table 8. $D_{2,t}$ is the number of news timelines that carried a particular story on that day. I estimate the model on days when cojump risk is statistically significant.

Table 14
Empirical Model of ABX Jump Risk

Tranche	Constant	$J^*_{1,z,t-1}$	$J^{2*}_{1,z,t-1}$	$J^*_{2,z,t-1}$	$(f^{12}_{t-1} - f^1_{t-1})$	$\overline{R}^2$
AAA	-0.2446	0.1112	-441.6708	0.0508	-0.0199	0.0756
	-(2.41)	(0.34)	-(0.54)	(2.13)	-(2.29)	
AA	-0.2476	0.6340	-468.7428	-0.0142	-0.0214	0.8483
	-(1.28)	(1.52)	-(13.40)	-(0.20)	-(1.27)	
A	-0.8450	-0.2187	-1,156.9378	0.0363	-0.0670	0.5884
	-(2.99)	-(0.95)	-(4.87)	(0.61)	-(3.14)	
BBB	-1.1830	-0.0927	-1,595.0460	-0.0267	-0.1030	0.3103
	-(0.94)	-(0.16)	-(0.88)	-(0.15)	-(1.20)	
BBB-	-9.9029	-0.1508	57.5454	1.0907	-0.6873	0.8393
	-(9.91)	-(0.56)	(1.21)	(4.27)	-(9.42)	

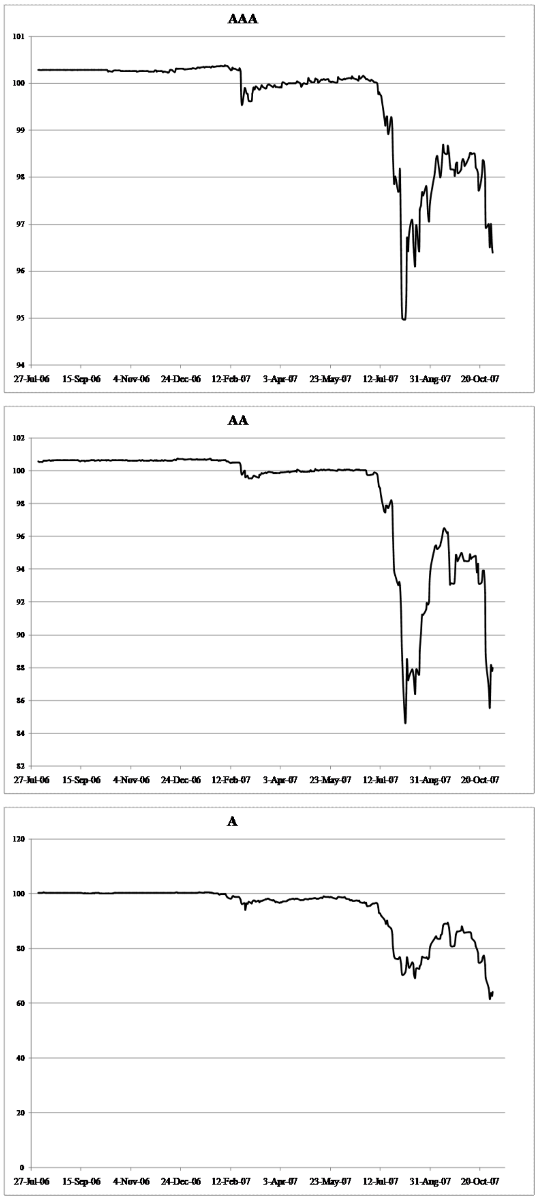
The table contains estimates of the predictive ABX jump risk model (32). $J^*_{1,z,t-1}$ is the lagged ABX jump risk, $J^{2*}_{1,z,t-1}$ is the lagged squared ABX jump risk, $J^*_{2,z,t-1}$ is the lagged jump risk from the CME housing futures, and $(f^{12}_{t-1} - f^1_{t-1})$ is the slope of the housing futures curve out one year. Coefficient estimates on the futures curve are $\times 10^4$. t-ratios are in parentheses. The sample period is August 2006 to November 2007.

Table 15
VaR Estimates

Tranche	ω_2^*	$\omega_{2,t}^*$	$\#r_\Pi < VaR^{0.05}$	$\#r_\Pi < VaR^{0.05}$ $\#J_{1,z}^2 > 0$
AAA	-0.3529%	0.1112	26	13
BBB-	-2.5650%	0.6340	45	10

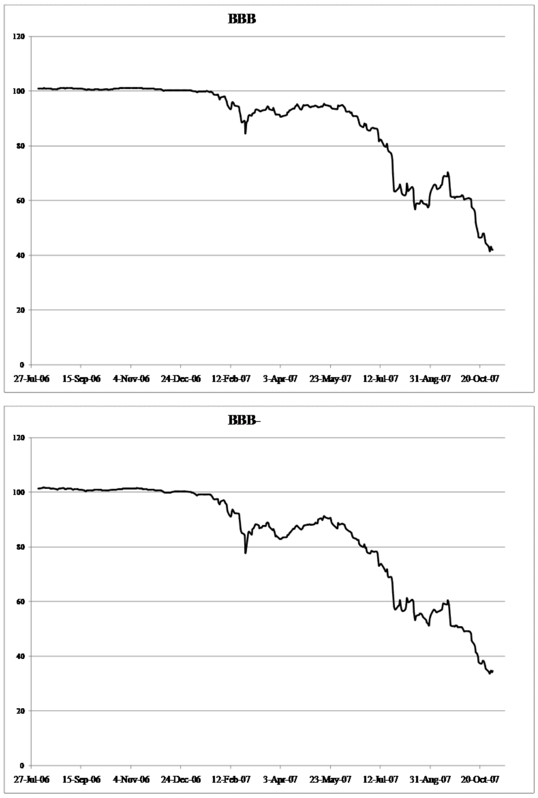
The table reports daily 95% confidence level VaR for an ABX and futures portfolio. The static hedge ratio is given by (34) and the dynamic hedge ratio by (36). The third column reports the number of exceedences of $VaR^{0.05}$ in the data, and the fourth column reports the number of times these exceedences occur on days with significant jumps in the ABX.

Figure 1
Prices on A Rated Tranches of ABX.HE 2006-1
May 2006-November 2007



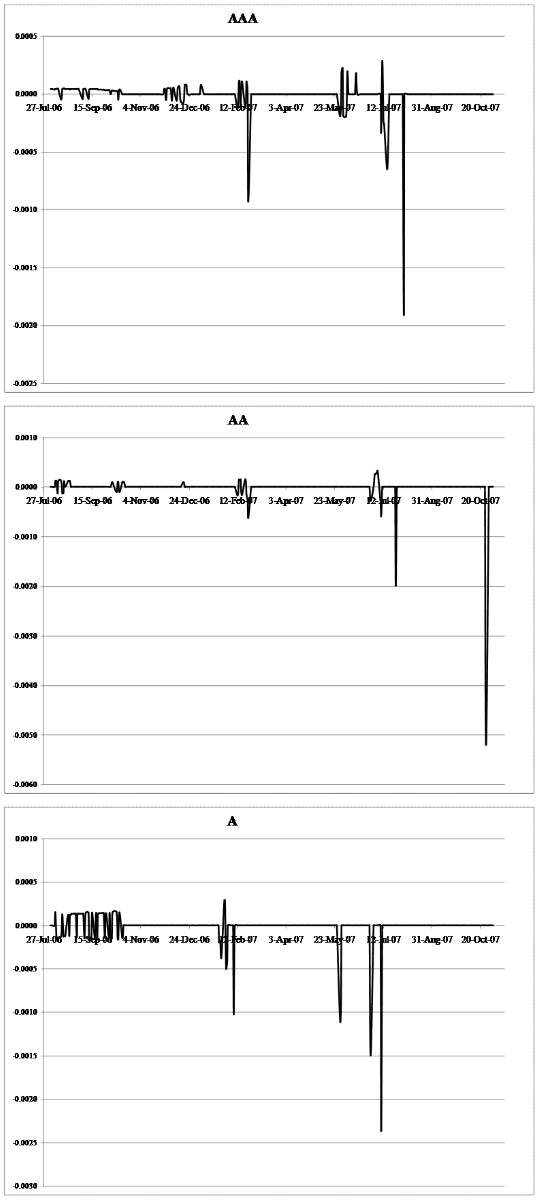
The data are daily closing prices on the ABX.HE indices for the first half roll of 2006.

Figure 2
Prices on B Rated Tranches of ABX.HE 2006-1
May 2006-November 2007



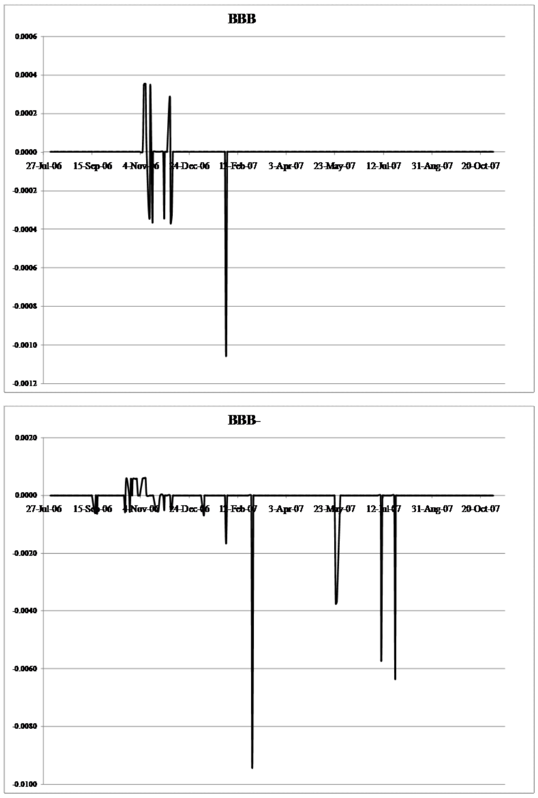
The data are daily closing prices on the ABX.HE indices for the first half roll of 2006.

Figure 3
Significant Jumps in A Rated Tranches of ABX.HE 2006-1
August 2006-November 2007



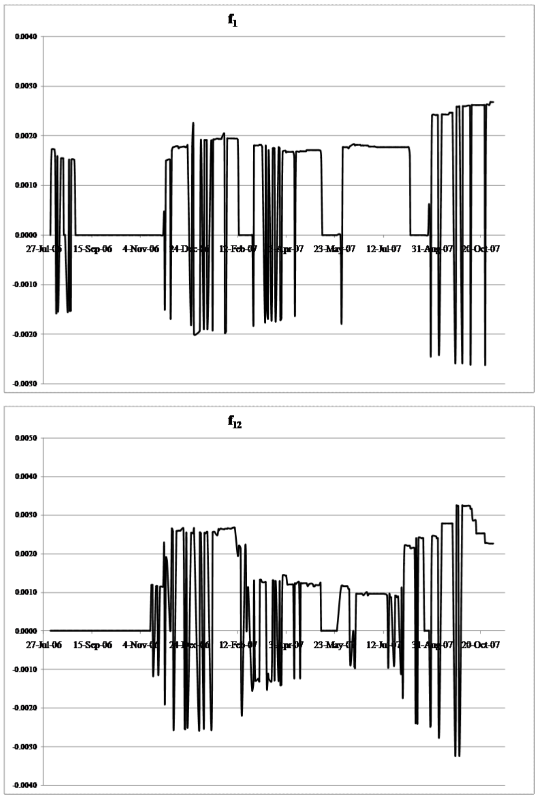
The data are statistically significant estimates of jump risk for the ABX.HE indices from the first half roll of 2006 using the 5% significance level in (20).

Figure 4
Significant Jumps in BBB Rated Tranches of ABX.HE 2006-1
August 2006-November 2007



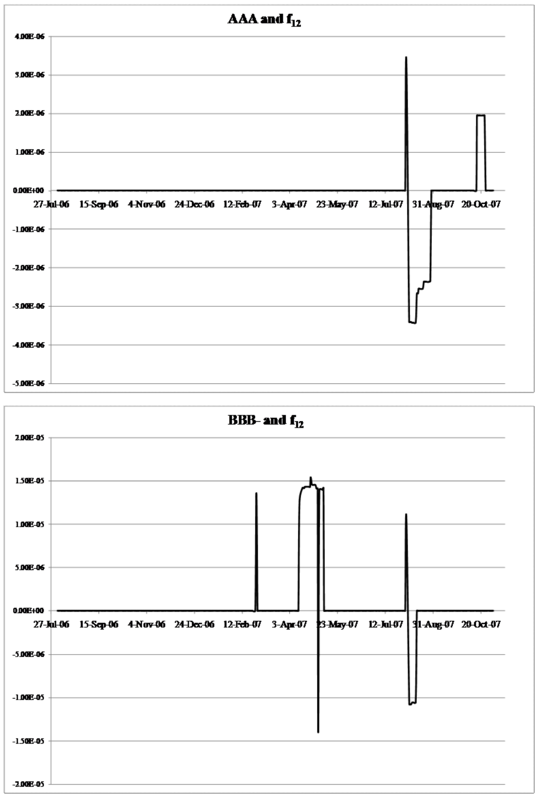
The data are statistically significant estimates of jump risk for the ABX.HE indices from the first half roll of 2006 using the 5% significance level in (20).

Figure 5
Jump Risk Of CME Composite CSI Housing Futures
August 2006-November 2007



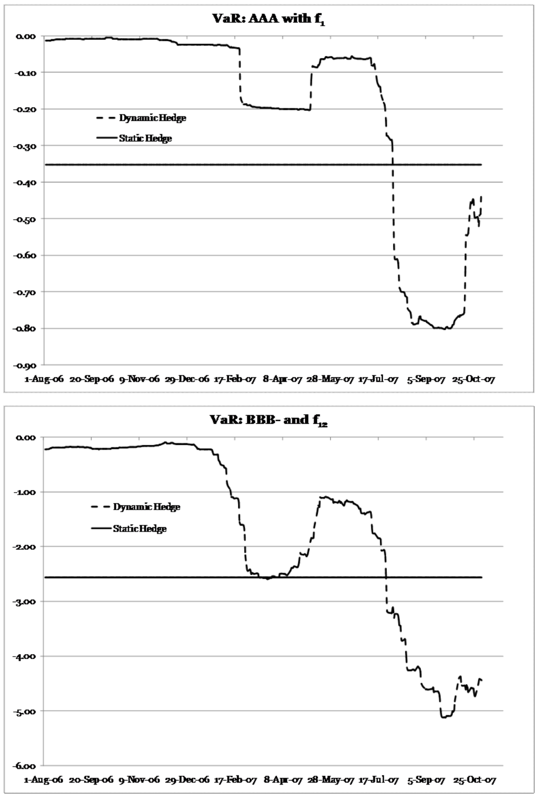
The data are estimates of jump risk (18) for the CME CSI composite housing futures for the near month f_1 and one year f_{12} expirations,

Figure 6
Cojump Risk Of ABX Housing Futures
August 2006-November 2007



The figures plot significant cojump risk (29) for the ABX.HE 06-1 and the 12-month ahead CME CSI composite housing futures.

Figure 7
VaR Estimates of Hedged ABX and Futures Portfolio
August 2006-November 2007



The figures plot the value-at-risk for static (35) and dynamically hedged (37) portfolios in the ABX.HE 06-1 and the CME CSI composite housing futures.