



**Performance of Subprime Mortgage-backed Securities
Before and During the Subprime Crisis**

Xiaoqing Eleanor Xua^a

- a. Professor of Finance, Stillman School of Business, Seton Hall University,
South Orange, New Jersey, USA

ABSTRACT

As investors, policy makers and researchers searched through the wreckage of the subprime crisis, all were surprised by the size, complexity, risks of the Mortgage-backed Securities (MBS) market and the lack of understanding on subprime MBS. Since subprime mortgages are most often securitized as home equity Asset-backed Securities (HE ABS), a study of the performance on subprime MBS should directly examine the performance of HE ABS. Using ten years of monthly data from January 1999 to December 2008, this paper systematically examines the comparative performance between agency residential MBS and HE ABS and their performance drivers before and during the subprime crisis. Empirical evidence shows that the HE ABS market demonstrated similar return and risk characteristics as those of agency MBS during the pre-crisis period from 1999 to 2006, but much lower return and higher risk during the crisis period from 2007 to 2008. Further analysis on the drivers of excess returns on agency MBS and HE ABS illustrates the importance of the change in mortgage rates for agency MBS through the entire sample period, and for HE ABS during the pre-crisis period. It also reveals that the lag one-month change in the credit risk premium and change in the mortgage charge-off rate are significantly negative performance drivers for HE ABS during the crisis period, but not the pre-crisis period. These results suggest that the U.S. financial market underestimated the credit risk inherent in subprime MBS before the subprime crisis.

Keywords: Mortgage-backed Securities (MBS); Home Equity Asset-backed Securities (HE ABS); Subprime Crisis; Performance;

JEL: G11, G21

1. Introduction

During the period from 2007 to 2009, the U.S. financial markets went through the biggest meltdown since the Great Depression, led by declining housing prices and massive mortgage defaults, and followed by the crash in the subprime mortgage-backed securities (MBS) market and subsequent failures of many financial firms. As investors, policy makers and researchers searched through the wreckage of the subprime financial crisis, all are surprised by the size, complexity, risks of the MBS market and the lack of understanding on subprime MBS.

During the 10-year period from 1998 to 2007, the outstanding size of the U.S. MBS market grew dramatically from 2.96 trillions to 8.93 trillions, representing a 202% cumulative growth and a 19% annual growth. In the meantime, while agency MBS (i.e., MBS that are guaranteed by federal agencies such as Ginnie Mae, Fannie Mae or Freddie Mac) accounted for 87% of the MBS issuance in 1996-1998, this percentage dropped to 67% in 2005-2007.⁹ The growth in the non-agency MBS market has highlighted the increase in MBS credit risk, a risk that has been largely underestimated by mortgage underwriters and MBS market participants based on the assumption of continued robust housing price appreciation. However, housing prices started to decline in 2006 (see Chart 1), and subsequently mortgage delinquencies and foreclosures for subprime mortgages went up from 11.7% and 3.56% in the second quarter of 2006 to 20.0% and 12.55% in the third quarter of 2008. The impact of this housing market downturn on the subprime MBS market has been devastating, and many hedge funds and financial institutions with substantial exposure to the MBS market have failed as a result.

Even though the MBS market is the largest fixed income sector in the United States, research has provided little guidance on the subprime MBS market. Dunn and McConnell (1981), Schwartz and Torous (1989, 1992), and Stanton (1995) research the impact of prepayment risk on the valuation of MBS. Black, Garbade, and Silber (1981) and Kolari, Fraser, and Anari (1998) examine the impact of MBS issuance on the yield or interest rate of mortgage debt, demonstrating the relevance and contribution of MBS in the financial markets. Holmes (2003) and Chen and Deng (2004) model the default behavior of commercial mortgages and commercial

⁹ At the peak of the real estate bubble in 2005-2006, subprime mortgages accounted for about 20% of the new mortgage originations [see Krinsman (2007)].

MBS. Xu (2010) examine whether the mortgage REITs reflect the performance of the underlying MBS market. Little attention has been paid to the pricing of credit risk in residential MBS (RMBS) and the performance of subprime MBS.

In an important study of the MBS market performance, Xu and Fung (2005) examine the total return performance of the MBS market using monthly data on the Lehman MBS index from 1988 to 2001. The Lehman MBS index, however, only includes agency RMBS that are guaranteed by Ginnie Mae, Fannie Mae or Freddie Mac.¹⁰ Using the Lehman MBS index will certainly overestimate the return and underestimate the loss on subprime MBS due to its focus on agency RMBS that carries no explicit credit risk.

Hayre, Huang and Zimmerman (1993) provide the first analysis on the early home equity Asset-backed Securities (HE ABS) market with a focus on prepayment analysis. Chomsisengphet and Pennington-Cross (2006) describe the evolution of subprime mortgage market up to 2005. Although the subprime crisis has motivated several recent studies [see Zimmerman (2007), Crouchy, Jarrow, and Turnbull (2008), Hayre, Saraf, Young, and Chen (2008), Jacobs (2008), Mashayekh-Ahangarani (2009), Ashcraft et al. (2011), and Demyanyk and Hemert (2011)] to address mortgage defaults and mortgage spreads from a credit risk perspective, none is based on comprehensive market-wide data on the subprime mortgage-backed securities.

Since the vast majority of subprime mortgages (i.e., mortgage loans extended to less credit-worthy borrowers with low credit scores and/or no documentation) do not meet the underwriting standards of federal agencies, they are often pooled together and securitized as home equity Asset-backed Securities (HE ABS). As of December 2008, the outstanding HE ABS and agency RMBS amount to \$395.5 billion and \$5,075.2 billion, respectively. Chart 2 illustrates the annual agency RMBS and HE ABS market sizes from 1999 to 2008. Hayre, Huang and Zimmerman (1993) indicate that in the early years, the collaterals of HE ABS focus more on second-lien home equity loans rather than first-lien home equity loans. However, a home equity loan is defined by today's industry custom as a subprime first-lien mortgage [see Heike and

¹⁰ See Lehman Brothers (March 2008) and Barclays Capital (December 2008).

Mago (2005)]. Nomura (2004) estimated that more than 75% of the HE ABS collaterals are first-lien subprime mortgages while less than 25% are second-lien home equity loans (i.e., traditional home equity loans) or home equity line of credit.

Although subprime MBS may also include ABS CDOs, i.e., collateralized bond obligations that use the HE ABS or commercial MBS (CMBS) as collaterals to conduct re-securitization, it is much harder to track the return performance on ABS CDOs than that of the HE ABS directly.¹¹ A study of the subprime MBS should directly examine the performance on HE ABS. This is the first study that presents systematic empirical evidence on the performance and performance drivers of subprime MBS, using a comprehensive set of monthly HE ABS index data covering the periods before and during the subprime crisis.

Empirical evidence in this paper shows that the HE ABS market demonstrated similar return and risk characteristics as those of agency MBS during the pre-crisis period from 1999 to 2006, but much lower return and higher risk during the crisis period from 2007 to 2008. Further analysis on the drivers of excess returns on agency MBS and HE ABS illustrates the importance of the change in mortgage rate for agency MBS through the entire sample period, and for HE ABS during the pre-crisis period. It also reveals that the lag one-month change in credit risk premium and change in mortgage charge-off rate are significantly negative performance drivers for HE ABS during the crisis period, but not the pre-crisis period. These results suggest that the U.S. financial market underestimated the credit risk inherent in subprime MBS before the subprime crisis.¹²

2. Data

Performance data on the home equity ABS can be obtained from two major sources: (1) the BARCAP (rebranded from Lehman Brothers) fixed-rate HE ABS index (available since 1992) and variable-rate HE ABS index (available since May 2005);¹³ (2) the Markit ABX.HE indices

¹¹ Newman et. al. (2008) present empirical evidence on the upgrade and downgrade performance of CDOs due to the difficulty in obtaining pricing or return information on CDOs.

¹² Others, such as Bharati and Jia (2014), have studied pre-crisis risk taking behaviors in the banking sector.

¹³ On November 3, 2008, Barclays Capital (BARCAP) announced the rebranding of its unified family of indices under the “Barclays Capital Indices” name. This combines the existing Lehman Brothers and Barclays Capital indices into a single platform. See Barclays Capital (December 2008).

that are based on the credit default swaps (CDS) referencing a portfolio of 20 HE ABS (available since January 2006).

The BARCAP/Lehman fixed-rate ABS index was first launched in 1992. Due to a dramatic shift from fixed-rate to variable-rate in the ABS market, the variable-rate ABS index was introduced in May 2005 to capture this growing segment of the ABS market [see Lehman Brothers (2005)]. Both the fixed-rate and variable-rate ABS indices include separate indices on HE ABS. Appendix 1 presents the snapshots of the BARCAP/Lehman MBS indices as of January 1999, January 2007 and December 2008. As of January 2007 (beginning of the crisis period), the fixed-rate HE ABS index includes 291 issues of HE ABS with an outstanding amount of \$19 billion (up from 9 issues with \$1 billion outstanding in January 1999), while the variable-rate HE ABS index includes 1,273 issues of ABS with an outstanding amount of \$141 billion. By the end of 2008, the variable-rate HE MBS index has been substantially downsized, including only 653 issues and an outstanding total of \$47 billion. Due to the size limit (no less than \$500 million per deal and no less than \$25 million per tranche), ERISA-eligibility, and credit-rating restrictions (Aa or better), the BARCAP HE ABS indices may not fully represent the entire HE ABS universe and may be placing upward bias on the subprime MBS sector performance. Monthly data on home equity fixed-rate ABS index, home equity variable-rate ABS index, CMBS indices, and other fixed income indices were obtained from BARCAP from inception to December 2008.

The ABX.HE indices are created by the London-based Markit Group. Each ABX.HE index is based on CDS trading underlying a basket of 20 of the largest HE ABS deals from the six-month period preceding the roll. Different ABX.HE indices are based on different vintages and different credit ratings: AAA AA, A, BBB. For example, ABX.HE AAA 06-01 refers to the ABX.HE index that was launched in the first half of 2006 underlying 20 AAA-rated HE ABS. The ABX.HE indices have been used extensively by market participants as a barometer of subprime MBS performance since the start of the subprime crisis. From January 2006 to December 2008, the ABX.HE 06-01 AAA and ABX.HE 06-01 BBB indices declined 20% and 94% in value, respectively, reflecting sharp losses in subprime MBS. These results, however, should be interpreted with caution since the indices were based on subprime MBS that were

launched at the lowest point of the credit underwriting standards and based on CDS pricing of the HE ABS basket during a period of extreme liquidity crisis. Another challenge dealing with the ABX data is the short history (only three years) of its data series. Monthly data on the ABX.HE06-01 AAA index and ABX.HE 06-01 BAA index were obtained directly from the London-based Markit Group for this study. Appendix 2 presents the subprime MBS components underlying these two indices.

To examine potential performance drivers of subprime MBS, I have obtained data on various economic and financial factors. Monthly data on the 30-year mortgage rate, consumer confidence index, and median price on existing homes sold were downloaded from Bloomberg. Composite average loan to price ratio on real estate loans were obtained from the Federal Housing Finance Board. Monthly data on the Consumer Price Index, corporate bond yields, industrial production, personal disposable income, Treasury yields, unemployment rate, and quarterly data on the charge-off rate on real estate loans¹⁴ were obtained from the Federal Reserve Board website. Monthly data on the stock market excess return factor, small minus big (size factor), high minus low (book to market value factor), and momentum factor were downloaded from the French Data Library.

I use the ten years of monthly total return data (from January 1999 to December 2008) on the MBS indices and the financial & economic variables to perform the analysis. To examine the differences in the performance and performance drivers before and during the crisis, I further divide the sample into the pre-crisis period from 1999 to 2006, and the crisis period from 2007 to 2008.

3. Empirical Analysis

Due to the opaque and illiquid nature of subprime ABS trading, market participants and regulators are relying on home-equity ABS indices for performance tracking. However, the two BARCAP HE ABS indices and the Markit ABX.HE indices tend to present dramatically different pictures of the HE ABS market due to differences in index construction and pricing

¹⁴ Since the charge-off rate on real estate loans are only available on a quarterly basis, I use a smoothing technique to derive the monthly charge-off series.

methods. This paper fills a significant gap in both the academic literature and industry research on subprime MBS market research by examining (1) performance of home equity ABS, its relative performance and correlation to the agency RMBS and CMBS, and (2) the drivers of the home-equity ABS return performance before and during the crisis.

3a. Performance of Subprime MBS Before and During the Crisis

Table 1 presents the descriptive statistics of monthly total returns¹⁵ (Panel A) and yields (Panel B) on various BARCAP/Lehman MBS indices in comparison with other investment classes (Treasuries, corporate bonds, and stocks) from January 1999 to December 2008.¹⁶ Five MBS indices included in Table 1 are the agency RMBS index, the fixed-rate HE ABS index, the AAA fixed-rate HE ABS index, the investment-grade CMBS index, and the high-yield CMBS index. The well-known BARCAP/Lehman MBS index, by default, refers to the agency RMBS index which covers MBS that are issued or guaranteed by the three federal agencies (Ginnie Mae, Fannie Mae and Freddie Mac), and thus carry either implicit or explicit guarantees from the U.S. government. The home equity ABS tends to be more oriented toward subprime RMBS since they are the securitized products of non-agency residential mortgages. However, the BARCAP HE ABS index only includes AAA or AA-rated home equity ABS, which tends to overestimate the performance of subprime MBS. Majority of the CMBS are not guaranteed by federal agencies and thus have similar credit risk exposure as the subprime RMBS. The BARCAP CMBS indices include those that are investment-grade (BBB or above) and those that are high-yield (BB or below). I include the IG and HY CMBS indices since they could serve as relevant benchmarks for credit-sensitive MBS.

During the 10-year sample period from 1999 to 2008, the monthly average total return on agency RMBS, HE ABS, AAA HE ABS, IG CMBS, and HY CMBS are 0.5%, -0.02%, 0.04%, 0.29% and 0.21%, respectively. The agency RMBS was the best performing MBS class since its total return has higher mean and lower standard deviation relative to other MBS classes. The HE

¹⁵ Total return, which is also called the holding period return, measures what investors can earn from a security over a specified holding period, and it is the most commonly used measure of return for all securities (stocks, bonds, etc). Total return on mortgage-related securities is computed as the sum of price return, coupon return and prepayment return for each monthly period.

¹⁶ The Markit ABX.HE home equity ABS indices and the BARCAP variable-rate home equity ABS indices are not included in Table 1 since they do not have the complete 10-year history. They will appear in Table 2 where the analysis is focused on the three-year period since the Markit ABX.HE indices' initial availability in January 2006.

ABS, which mainly represents the subprime MBS, has the lowest mean total return. The investment-grade and high-yield CMBS indices have higher total return and also higher volatility relative to the HE ABS. When examining the 10-year average total return performance of all MBS classes together with non-MBS investment classes (such as Treasury, corporate bonds and stocks), Treasury and agency MBS were ranked the best, while the HE ABS and stocks were the worst. The high-yield CMBS market and the stock market exhibited the greatest return volatility, while the agency RMBS and the Treasury have the lowest return volatility. Clearly, during the past ten years, the agency RMBS and Treasury outperformed the other major fixed income classes and the stocks based on either total return or risk-adjusted return.

A decomposition of the sample into the pre-crisis period (January 1999 to December 2006) and the crisis period (January 2007 to December 2008) reveals the dramatic difference in performances before and during the subprime crisis. Before the crisis, the total return on the HE ABS index showed similar mean and standard deviation as that of the agency RMBS. However, during the crisis period, the HE ABS index has a mean total return of -2.13%, which is 2.76% below the mean return for agency RMBS, and a standard deviation that is over three times that of the agency RMBS. Even worse than the HE ABS, high-yield CMBS suffered an average monthly loss of 3.4% and reached a standard deviation that is close to nine times that of the agency RMBS.

Yield statistics presented in Panel B of Table 1 illustrate that the yield spread between HE ABS and agency RMBS were about -0.56% in the pre-crisis period, but sharply rose to an average of 4.56% (i.e., 10.02%-5.46%) during the crisis period. Even the AAA-rated HE ABS has reached a yield spread of 2.76% (i.e., 8.22%-5.46%) over the crisis period. High-yield CMBS have the highest yield before and during the crisis, reaching a yield spread of 13.45% (i.e., 18.91%-5.46%) during the crisis period. This suggests that investors might have been underestimated the credit risk inherent in home equity MBS and CMBS during the pre-crisis period.

Table 2 presents the descriptive statistics and correlations among all prime and subprime MBS indices from January 2006 (initial availability of the Markit ABX.HE indices) to December

2008. Chart 3 illustrates the monthly return time series on the HE ABS indices from 2006 to 2008. During this three-year window, all the HE ABS and CMBS indicators have shown negative mean total return. The well-known BARCAP MBS index, which covers only agency RMBS index, shows the highest mean return and the lowest standard deviation among all MBS indices. This is true for both the entire sample period and the 2007-2008 crisis period. The performances of the fixed-rate and variable-rate BARCAP HE ABS both trailed the performance of the agency RMBS.

Since the major focus of this paper is on subprime MBS, special attention must be paid to the HE ABS. The BARCAP AAA fixed-rate HE ABS, BARCAP AAA variable-rate HE ABS, and Markit ABX.HE AAA indices show similar return and risk characteristics as all of these indices cover the AAA rated HE ABS. From January 2006 to December 2008, the ABX.HE AAA and BBB indices lost 20% and 94.45% of their value, respectively. The home equity ABS index that shows the biggest loss was the ABX.HE BBB index, with a mean monthly return of -9.816% from 2006 to 2008 and -14.325% from 2007 to 2008.

The ABX.HE indices have attracted lots of attention from the market since its inception. Many investors and institutions that previously used the BARCAP/Lehman MBS indices as benchmarks have now switched to the ABX.HE indices as benchmarks. The contrast in the performances between Markit ABX.HE subprime MBS indices and BARCAP agency MBS index is so large, which has caused big swings and huge markdowns in the valuation of banks' MBS portfolios. Several factors, however, might have led to the ABX.HE indices' overestimation of losses in subprime MBS. First, the ABX.HE indices were initially launched in the first half of 2006 covering securitized subprime MBS issued in the second half of 2005, a period with loose credit risk checking and inflated credit rating. Second, many subprime MBS are held by investors who do not mark-to-market, resulting in a wide gap between reported write downs and estimated fair value of losses [see Fender and Hördahl (2008)]. Finally, the ABX.HE index is not based on pricing of subprime MBS directly, but rather on the CDS trading of a portfolio of 20 subprime MBS deals. The liquidity crisis coupled with the subprime meltdown has negatively affected the subprime MBS CDS market much more dramatically than the subprime MBS itself. On the other hand, the BARCAP HE ABS indices, like other

BARCAP/Lehman fixed income indices, are using matrix pricing rather than actual transaction prices. They also may not represent the same index components through time due to the downgrade of many HE ABS issues.

Panel B of Table 2 shows the correlations among all prime and subprime RMBS and CMBS indices. The agency RMBS index (prime) and other MBS indices (more subprime oriented) are negatively correlated during the past three years, indicating potential differences in the underlying determinants of the index return dynamics. Among the HE ABS indices, the fixed-rate HE ABS index has a 0.73 correlation with the variable-rate HE ABS index, and correlations of 0.65 and 0.60 with the ABX.HE AAA and BBB indices. With the exception of the agency RMBS, it appears that all other MBS indices are all showing strong positive correlations.

3b. Performance Drivers of Subprime MBS

In this second part of the empirical analysis, I examine the potential financial and economic factors that drive the return on subprime MBS. According to the cash flow and risk characteristics of MBS, I have identified the following financial and economic variables as potential drivers of prime and subprime MBS: change in 30-year mortgage rate (MRC), change in Treasury term structure spread (TSC), change in credit spread between Baa and Aaa corporate bonds (CSC), inflation rate (annual % change in Consumer Price Index, CPIYG), annual % change in the median price of existing homes sold (EHPYG), change in composite average loan to price ratio (LTPC), change in charge-off rate on real estate loans (CORC), annual % change in personal disposable income (DPYG), % change in Industrial Production (IPG), % change in consumer confidence (CONG), change in unemployment rate (UEC), Fama-French Factor 1 (Stock Market Excess Return, $R_m - R_f$), Fama-French Factor 2 (Small minus Big Size Factor, SMB), Fama-French Factor 3 (High minus Low Book to Market Value Factor, HML), and Fama-French Factor 4 (Momentum, Mom). The changes in mortgage rate, term structure spread, inflation rate are expected to be negative drivers due to the interest rate risk exposure of all fixed income securities, including MBS. The changes in consumer confidence, industrial production, personal disposable income, and unemployment rate are potential drivers due to their relationship with both economic growth and credit risk premium. The Fama and French factors

are included to see if the major equity market systematic factors are also relevant to the MBS market. The changes in the median price of existing homes sold, composite average loan to price ratio, and charge-off rate on real estate loans are real estate market specific factors that could be key drivers of MBS, especially subprime MBS performance. The change in the credit spread (Baa to Aaa corporate bond yield spread) should be negatively related to the performance on subprime MBS since they expose investors to substantial credit risk.

Table 3 presents the concurrent and lag one month correlations between excess returns¹⁷ on MBS indices (agency RMBS, fixed-rate HE MBS index, ABX.HE AAA index, ABX.HE BBB index, IG CMBS index, and HY CMBS index) and the above fifteen potential MBS performance drivers for both the periods before the crisis (Panel A) and during the crisis (Panel B).¹⁸ Before the crisis, the agency RMBS, the HE ABS index, and the CMBS indices showed strong negative correlations with the changes in mortgage rate, term structure spread, inflation rate, indicating that interest rate risk was an important pricing factor in both prime and subprime MBS. During the crisis, the agency RMBS continue to be negatively driven by these three factors, but the HE ABS and CMBS indices have weaker and inconsistent correlation with these factors. Before the crisis, the change in credit spread (CSC) did not have significant concurrent or lag impact on the either the prime or subprime MBS return indices. During the crisis, this CSC factor became an important driver of the performance on all non-agency MBS indices. The correlations with the lag one month CSC during the crisis were strong and negative for the HE MBS and CMBS indices, but small and insignificant for the agency MBS.

Before or during the crisis, the change in composite average loan to price ratio (LTPC) does not appear to be a good indicator of the credit worthiness of mortgage loans.¹⁹ Correlation statistics indicate that the home price appreciation factor (EHPYG) does not have consistent relationship with the non-agency MBS return indices, either before or during the crisis. The change in the charge-off rate on real estate loans (CORC) appears to be a strong negative driver of the return performance during the crisis period for all non-agency MBS. During the pre-crisis

¹⁷ The excess return is calculated as total return minus the three-month risk free return.

¹⁸ ABX.HE AAA and BBB indices are not included in either Panel A of Table 3 or Table 4 since their data history only went back to January 2006.

¹⁹ I thank David Roderer from FHFB for pointing out that the limitation of this indicator was due to its small survey sample size and lack of coverage on subprime mortgage loans.

period, the agency MBS and non-agency MBS indices tend to have similar signs in their correlations with the major economic factors (such as CONG, UEC, DPYG and IPG) and the Fama-French stock market factors, but opposite signs during the crisis.

Although a structural vector autoregressive (VAR) framework [see Xu and Fung (2005) and Xu (2007)] could provide a richer characterization of the performance drivers of MBS, it does not allow for a meaningful comparison before and during the crisis due to the limited number of observations (96 monthly observations before the crisis and 24 monthly observations during the crisis). Based on the initial correlation screening from Table 3, I include the three most relevant factors (change in mortgage rate, lag one month change in credit spread, and change in mortgage charge-off rate) in the regression model to examine the key performance drivers of prime and subprime MBS (including agency MBS, fixed-rate home equity MBS, IG CMBS, and HY CMBS). Panel A and Panel B of Table 4 present the regression estimates for the excess returns on these four MBS indices before the crisis and during the crisis.

Panel A shows that the intercept and the change in mortgage rate (MRC) are both highly significant for the excess returns on all four MBS indices prior to the crisis. The intercepts are positive while the MRC coefficients are negative for all four regressions. Since increases in prevailing mortgage rates lead to lower valuation of MBS, this result is consistent with the discount rate effect. Due to credit risk exposure, the non-agency MBS (such as home equity ABS and CMBS) should also be driven by changes in the market credit risk premium and/or charge-off rate on real estate loans. However, the lag one month change in credit spread (CSC1) coefficients are insignificant for the excess returns on agency MBS, home equity MBS, and investment-grade CMBS indices. The change in mortgage charge-off rate (CORC) coefficients are insignificant across the four agency and non-agency MBS indices. The testing results on the CSC1 and CORC coefficients imply that the non-agency MBS market, especially the home equity ABS and investment-grade CMBS sectors, ignored the credit risk inherent in those securities before the subprime crisis.

During the crisis period (see Panel B), the performance of agency and non-agency MBS reacted quite differently to the three factors. The agency MBS continued to be negatively driven

by the changes in mortgage rate, but also showed a significantly positive relationship with the lag credit spread. The positive CRC1 coefficient is consistent with the “flight to quality” during the credit crisis. The coefficients of MRC are still negative for the excess returns on non-agency MBS, but their statistical significances are much weaker. The negative and significant CRC1 coefficients for the non-agency MBS indicate that the lag credit spread became a dominant driver for the excess return performance on home equity ABS investment-grade CMBS, and high-yield CMBS. In addition, the change in mortgage charge-off rate shows significant negative impact on the excess return on home equity ABS.

4. Conclusion

This study presents systematic empirical evidence on the performance and performance drivers of subprime MBS, using a complete set of home equity ABS total return data from various sources, including the BARCAP/Lehman fixed-rate (from 1999) and variable-rate (from 2005) HE ABS indices and the Markit ABX.HE subprime MBS indices (from 2006) before and during the subprime crisis.

During the 10-year sample period from 1999 to 2008, the monthly average return on BARCAP agency RMBS, fixed-rate HE ABS, IG CMBS, and HY CMBS are 0.5%, -0.02%, 0.29% and 0.21%, respectively. A decomposition of the sample into the pre-crisis period (January 1999 to December 2006) and the crisis period (January 2007 to December 2008) reveals the dramatic difference in performances before and during the subprime crisis. During the pre-crisis period, the total return on the HE ABS index delivered similar mean and standard deviation as that of the agency RMBS. However, during the crisis period, the HE ABS index has a mean total return of -2.13%, which is 2.76% below the mean return for agency RMBS. The standard deviation of the HE ABS index, however, is over three times that of the agency RMBS.

From January 2006 (the initial availability of the ABX.HE indices) to December 2008, the ABX.HE AAA and BBB indices lost 20% and 94.45% of their value, respectively. The home equity ABS index that shows the biggest loss was the ABX.HE BBB index, with a mean monthly return of -9.816% from 2006 to 2008 and -14.325% from 2007 to 2008. During this three-year window, all the HE ABS and CMBS indicators have shown negative mean total return. The well-

known BARCAP MBS index, which covers only agency RMBS index, shows the highest mean return and the lowest standard deviation among all MBS indices. The contrast in the performances between Markit ABX.HE subprime MBS indices and BARCAP agency MBS index is so large, which has caused big swings and huge markdowns in the valuation of banks' subprime MBS portfolios.

I further use the ten-year monthly data from January 1999 to December 2008 on BARCAP MBS total return indices (including agency RMBS, home equity ABS, investment-grade CMBS, and high-yield CMBS) and fifteen financial & economic variables to examine the potential performance drivers of subprime MBS. Correlation analysis was performed on all fifteen potential factors while the regression analysis was focused on three most critical potential performance drivers (*change in mortgage rate, lag one month change in credit spread, and change in mortgage charge-off rate*) based on the initial correlation screening. Regression analysis from the MBS excess returns shows that the non-agency MBS market did not properly evaluate the credit risk exposure of home equity ABS and invest-grade CMBS prior to the subprime crisis. Similar to the agency MBS, the key performance driver of the non-agency MBS before the crisis was the *change in mortgage rate* factor. During the subprime crisis, the *lag change in credit spread* became the most important negative performance driver for all the non-agency MBS sectors, and a positive performance driver for the agency MBS. The *change in charge-off rate on real estate loans* is also an important negative performance driver for the home equity ABS during the crisis. In summary, empirical evidence suggests that the U.S. financial market underestimated the credit risk inherent in subprime MBS during the pre-crisis period, but not the crisis period.

Acknowledgments: The author thanks Hung-Gay Fung, Sherwood Kuo of Barclays Capital, Edward Lipes of Markit Group, and David L. Roderer of Federal Housing Finance Board for generous data support, Michael Carhill, Stuart Gabriel, Crocker Liu, Tony Loviscek, Joseph Nichols, seminar participants at the 2009 AsRES-AREUEA joint conference at UCLA and 2010 Financial Management Association Annual Meetings in New York for valuable comments and suggestions, and the Institute for International Business at Seton Hall University for generous financial support.

References

- Ashcraft, A., P. Goldsmith-Pinkham, P. Hull, and J. Vickery. 2011. Credit Ratings and Security Prices in the Subprime MBS Market. *American Economic Review* 101: 115-119.
- Barclays Capital. December 2008. *The Benchmark in Fixed Income: Barclays Capital Indices. Rebranding the Unified Barclays Capital Indices.*
- Black, D.G., K.D. Garbade, and W.L. Silber. 1981. The Impact of GNMA Passthrough Program on FHA Mortgage Costs. *Journal of Finance* 36: 457-469.
- Bharati, R., and J. Jia. 2014. CEO Compensation and Risk Taking: Evidence from the Pre-Crisis Banking Industry. *International Review of Accounting, Banking and Finance* 6(1).
- Chen, J., and Y. Deng. 2004. Commercial Mortgage Workout Strategy and Conditional Default Probability: Evidence from Special Serviced CMBS Loans. *Real Estate Research Institute (RERI) Working Paper.*
- Chomsisengphet, S., and A. Pennington-Cross, 2006, The Evolution of the Subprime Mortgage Market. *Federal Reserve Bank of St. Louis Review* 88(1): 31-56.
- Crouchy, M.G., R.A. Jarrow, and S.M. Turnbull. Fall 2008. The Subprime Credit Crisis of 2007. *Journal of Derivatives*: 81-110.
- Demyanyk Y., and O. V. Hemert. 2011. Understanding the Subprime Mortgage Crisis. *Review of Financial Studies* 24(6): 1848-1880.
- Dunn, K.B., and J.J. McConnell. 1981. Valuation of GNMA Mortgage-Backed Securities. *Journal of Finance* 36(3): 599-616.
- Fender, I., and P. Hördahl. June 2008. Estimating valuation losses on subprime MBS with the ABX HE index — some potential pitfalls. *BIS Quarterly Review*: 5-6.
- Hayre, L.S., Manish Saraf, Robert Young, and Jiakai (David) Chen. Spring 2008. Modeling of Mortgage Defaults. *Journal of Fixed Income*: 6-30.
- Hayre, L.S., C. Huang, and T. Zimmerman. December 1993. Analysis of Home-Equity Loan Securities. *Journal of Fixed Income*. 7-13.
- Heike, D., and A. Mago. June 2005. The ABCs of HELs. *Journal of Fixed Income*: 5-27.
- Holmes, C. 2003. Commercial Mortgage Delinquency, Foreclosure and Reinstatement. *Real Estate Research Institute (RERI) Working Paper.*
- Jacobs, B. I. 2009. Tumbling Tower of Babel: Subprime Securitization and the Credit Crisis. *Financial Analysts Journal* 65(2): 17-30.

- Lehman Brother Fixed Income Research. *The Lehman Brothers U.S. ABS Floating-rate Index* April 2005.
- Lehman Brothers Fixed Income Research. March 2008. *A Guide to the Lehman Brothers Global Family of Indices*.
- Krinsman, A. N. 2007. Subprime Mortgage Meltdown: How Did It Happen and How Will It End? *Journal of Structured Finance* 13(2):13-29.
- Kolari, J.W., D.R. Fraser, and A. Anari. 1998. The Effect of Securitization on Mortgage Market Yields: A Cointegration Analysis. *Real Estate Economics* 26(4): 677-693.
- Mashayekh-Ahangarani, P. Winter 2009. The Structural Change in Mortgage-Treasury Spreads during the Credit Crunch. *Journal of Fixed Income*: 47-51.
- Newman D., F.J. Fabozzi, D. J. Lucas, and L.S. Goodman. Fall 2008. Empirical Evidence on CDO Performance. *Journal of Fixed Income* 18(2): 32-41.
- Nomura Fixed Income Research. Home Equity ABS Basics. November 2004.
- Schwartz, E.S., and W.N. Torous. 1989. Prepayment and the Valuation of Mortgage-Backed Securities. *Journal of Finance* 44(2): 375-392.
- Schwartz, E.S., and W.N. Torous. 1992. Prepayment, Default, and the Valuation of Mortgage Pass-Through Securities. *Journal of Business* 65(2): 221-239.
- Stanton, R. 1995. Rational Prepayment and the Valuation of Mortgage-Backed Securities. *Review of Financial Studies* 8(3): 677-708.
- Xu, X.E. 2007. What Drives the Return on CMBS? *Journal of Portfolio Management* Special Issue: 145-157.
- Xu, X.E. 2010. Do Mortgage REITs Reflect the Underlying MBS Market Performance? *International Review of Accounting, Banking and Finance* 2(4): 60-78.
- Xu, X. E., and H.G. Fung. 2005. What Moves the Mortgage-Backed Securities Market? *Real Estate Economics* 33(2): 397-426.
- Zimmerman, T. Fall 2007. The Great Subprime Meltdown of 2007. *Journal of Structured Finance*: 7-20.

Table 1. Performance of Mortgage-backed Securities Before and During the Subprime Crisis
Panel A. Descriptive Statistics of Monthly Returns (in %) on MBS and Other Investment Classes

| Period | ALL | Returns on Mortgage-related Securities | | | | | Returns on other Investment Classes for Comparison | | | | |
|---------------------------|-----------|--|--------|------------|----------------|-----------------|--|---------------------|----------------------|---------|--------------|
| | | Agency RMBS | HE ABS | AAA HE ABS | Inv-grade CMBS | High-yield CMBS | Treasury | Inv-grade Corporate | High-yield Corporate | S&P 500 | Russell 3000 |
| Entire Sample (1999-2008) | Mean | 0.50 | -0.02 | 0.04 | 0.29 | 0.21 | 0.52 | 0.39 | 0.22 | -0.02 | 0.03 |
| | Median | 0.58 | 0.38 | 0.35 | 0.44 | 0.89 | 0.55 | 0.61 | 0.69 | 0.66 | 0.90 |
| | Maximum | 4.17 | 1.91 | 1.91 | 16.45 | 13.25 | 5.31 | 6.80 | 7.68 | 9.78 | 8.17 |
| | Minimum | -1.87 | -14.76 | -11.33 | -18.80 | -37.22 | -4.39 | -7.77 | -15.91 | -16.79 | -17.74 |
| | Std. Dev. | 0.86 | 1.95 | 1.66 | 2.89 | 4.94 | 1.40 | 1.73 | 2.91 | 4.36 | 4.45 |
| Before Crisis (1999-2006) | Mean | 0.46 | 0.51 | 0.50 | 0.54 | 1.11 | 0.42 | 0.48 | 0.55 | 0.36 | 0.44 |
| | Median | 0.58 | 0.49 | 0.49 | 0.62 | 1.14 | 0.52 | 0.64 | 0.97 | 0.74 | 0.99 |
| | Maximum | 2.14 | 1.91 | 1.91 | 3.44 | 5.82 | 3.02 | 3.58 | 7.49 | 9.78 | 8.17 |
| | Minimum | -1.87 | -1.70 | -1.65 | -4.46 | -4.79 | -4.39 | -4.34 | -7.37 | -10.87 | -10.51 |
| | Std. Dev. | 0.78 | 0.69 | 0.68 | 1.39 | 1.89 | 1.35 | 1.35 | 2.19 | 4.10 | 4.15 |
| During Crisis (2007-2008) | Mean | 0.63 | -2.13 | -1.80 | -0.71 | -3.40 | 0.91 | 0.01 | -1.07 | -1.56 | -1.58 |
| | Median | 0.55 | -1.25 | -0.68 | 0.08 | -0.98 | 0.65 | 0.19 | 0.20 | -0.56 | -0.60 |
| | Maximum | 4.17 | 1.20 | 1.04 | 16.45 | 13.25 | 5.31 | 6.80 | 7.68 | 4.87 | 5.00 |
| | Minimum | -1.43 | -14.76 | -11.33 | -18.80 | -37.22 | -1.72 | -7.77 | -15.91 | -16.79 | -17.74 |
| | Std. Dev. | 1.13 | 3.44 | 2.80 | 5.82 | 9.72 | 1.54 | 2.80 | 4.67 | 5.07 | 5.31 |

Notes: Barcap RMBS Index (agency residential MBS index); Barcap HE ABS Index (fixed rate, home equity Asset-backed Securities index); Barcap AAA-rated HE ABS Index; Barcap Investment-grade Commercial MBS Index; Barcap high-yield commercial MBS Index; Barcap Treasury Index; Barcap Investment-grade Corporate Bond Index; Barcap high-yield Corporate Bond Index; S&P 500 Stock Index; Russell 3000 Stock Index.

Table 1 (cont.)
Panel B. Descriptive Statistics of Yields (in %) on MBS and other Investment Classes

| Period | ALL | Yields on Mortgage-related Securities | | | | | Yields on other Investment Classes for Comparison | | |
|---------------------------|-----------|---------------------------------------|--------|------------|----------------|-----------------|---|---------------------|----------------------|
| | | Agency RMBS | HE ABS | AAA HE ABS | Inv-grade CMBS | High-yield CMBS | Treasury | Inv-grade Corporate | High-yield Corporate |
| Entire Sample (1999-2008) | Mean | 5.80 | 6.26 | 5.87 | 5.82 | 13.59 | 4.32 | 6.00 | 10.34 |
| | Median | 5.60 | 5.67 | 5.64 | 5.63 | 12.63 | 4.32 | 5.89 | 10.11 |
| | Maximum | 7.88 | 19.29 | 12.13 | 15.44 | 49.86 | 6.67 | 9.09 | 21.83 |
| | Minimum | 3.63 | 2.82 | 2.75 | 3.45 | 9.84 | 1.55 | 4.04 | 6.76 |
| | Std. Dev. | 0.93 | 2.95 | 1.98 | 1.65 | 5.42 | 1.13 | 1.12 | 2.70 |
| Before Crisis (1999-2006) | Mean | 5.88 | 5.32 | 5.29 | 5.56 | 12.26 | 4.49 | 5.93 | 10.22 |
| | Median | 5.66 | 5.30 | 5.28 | 5.34 | 12.03 | 4.42 | 5.84 | 10.52 |
| | Maximum | 7.88 | 8.20 | 8.20 | 8.10 | 14.44 | 6.67 | 8.27 | 14.58 |
| | Minimum | 3.72 | 2.82 | 2.75 | 3.45 | 9.84 | 2.59 | 4.04 | 6.76 |
| | Std. Dev. | 1.00 | 1.42 | 1.45 | 1.26 | 1.26 | 1.10 | 1.15 | 2.32 |
| During Crisis (2007-2008) | Mean | 5.46 | 10.02 | 8.22 | 6.89 | 18.91 | 3.64 | 6.28 | 10.82 |
| | Median | 5.58 | 8.61 | 8.46 | 5.87 | 15.02 | 3.49 | 5.90 | 9.83 |
| | Maximum | 6.02 | 19.29 | 12.13 | 15.44 | 49.86 | 4.99 | 9.09 | 21.83 |
| | Minimum | 3.63 | 5.59 | 5.58 | 5.29 | 11.33 | 1.55 | 5.48 | 7.45 |
| | Std. Dev. | 0.49 | 4.28 | 2.13 | 2.46 | 10.43 | 0.98 | 0.97 | 3.90 |

Notes: Barcap RMBS Index (agency residential MBS index); Barcap HE ABS Index (fixed rate, home equity Asset-backed Securities index); Barcap AAA-rated HE ABS Index; Barcap Investment-grade Commercial MBS Index; Barcap high-yield commercial MBS Index; Barcap Treasury Index; Barcap Investment-grade Corporate Bond Index; Barcap high-yield Corporate Bond Index.

Table 2. Performance of All Prime and Subprime MBS Indicators (2006-2008)**Panel A. Descriptive Statistics on Monthly Total Returns**

| Indices | Agency RMBS | (Fixed-rate) HE ABS | (Fixed-rate) AAA HE ABS | Variable-rate HE ABS | Variable-rate AAA HE ABS | ABX.HE AAA | ABX.HE BBB | Inv-grade CMBS | High-yield CMBS |
|---|----------------|------------------------|----------------------------|-------------------------|-----------------------------|---------------|---------------|-------------------|--------------------|
| January 2006-December 2008 (Since the initial availability of ABX.HE index) | | | | | | | | | |
| Mean | 0.569 | -1.323 | -1.098 | -0.827 | -0.802 | -0.694 | -9.816 | -0.352 | -1.962 |
| Median | 0.498 | 0.031 | -0.017 | 0.414 | 0.402 | -0.010 | -0.539 | 0.121 | 0.258 |
| Maximum | 4.173 | 1.199 | 1.174 | 2.889 | 1.502 | 5.601 | 4.550 | 16.447 | 13.252 |
| Minimum | -1.435 | -14.763 | -11.330 | -9.058 | -12.920 | -16.196 | -68.036 | -18.802 | -37.220 |
| Std. Dev. | 1.018 | 3.086 | 2.549 | 2.569 | 2.848 | 3.289 | 17.784 | 4.837 | 8.298 |
| January 2007-December 2008 (Crisis Period) | | | | | | | | | |
| Mean | 0.629 | -2.133 | -1.804 | -1.414 | -1.373 | -1.017 | -14.325 | -0.715 | -3.399 |
| Median | 0.554 | -1.252 | -0.681 | -0.249 | 0.077 | -0.398 | -4.826 | 0.079 | -0.979 |
| Maximum | 4.173 | 1.199 | 1.038 | 2.889 | 1.502 | 5.601 | 4.550 | 16.447 | 13.252 |
| Minimum | -1.435 | -14.763 | -11.330 | -9.058 | -12.920 | -16.196 | -68.036 | -18.802 | -37.220 |
| Std. Dev. | 1.132 | 3.436 | 2.803 | 2.935 | 3.303 | 3.955 | 19.999 | 5.819 | 9.716 |

Notes: Barcap RMBS Index (agency residential MBS index); Barcap HE ABS Index (fixed rate, home equity Asset-backed Securities index); Barcap AAA-rated HE ABS Index; Barcap variable-rate HE ABS Index; Barcap variable-rate AAA-rated HE ABS Index; Markit ABX.HE AAA 06-01 Index; Markit ABX.HE BBB 06-01 Index; Barcap Investment-grade Commercial MBS Index; Barcap high-yield commercial MBS Index.

Table 2 (cont.)
Panel B. Return Correlation

| | Agency RMBS | (Fixed-rate) HE ABS | (Fixed-rate) AAA HE ABS | Variable-rate HE ABS | Variable-rate AAA HE ABS | ABX.HE AAA | ABX.HE BBB | Inv-grade CMBS | High-yield CMBS |
|---|-------------|---------------------|-------------------------|----------------------|--------------------------|------------|------------|----------------|-----------------|
| January 2006-December 2008 (Entire sample period, since the initial availability of ABX.HE index) | | | | | | | | | |
| Agency RMBS | 1.000 | -0.491 | -0.454 | -0.338 | -0.407 | -0.386 | -0.374 | -0.127 | -0.330 |
| (Fixed-rate) HE ABS | -0.491 | 1.000 | 0.970 | 0.730 | 0.828 | 0.652 | 0.603 | 0.576 | 0.683 |
| (Fixed-rate) AAA HE ABS | -0.454 | 0.970 | 1.000 | 0.741 | 0.804 | 0.691 | 0.632 | 0.578 | 0.678 |
| Variable-rate HE ABS | -0.338 | 0.730 | 0.741 | 1.000 | 0.916 | 0.672 | 0.663 | 0.505 | 0.730 |
| Variable-rate AAA HE ABS | -0.407 | 0.828 | 0.804 | 0.916 | 1.000 | 0.800 | 0.635 | 0.687 | 0.868 |
| ABX.HE AAA | -0.386 | 0.652 | 0.691 | 0.672 | 0.800 | 1.000 | 0.700 | 0.765 | 0.852 |
| ABX.HE BBB | -0.374 | 0.603 | 0.632 | 0.663 | 0.635 | 0.700 | 1.000 | 0.439 | 0.494 |
| Inv-grade CMBS | -0.127 | 0.576 | 0.578 | 0.505 | 0.687 | 0.765 | 0.439 | 1.000 | 0.763 |
| High-yield CMBS | -0.330 | 0.683 | 0.678 | 0.730 | 0.868 | 0.852 | 0.494 | 0.763 | 1.000 |
| January 2007-December 2008 (Crisis Period only) | | | | | | | | | |
| 2007-2008 | Agency RMBS | (Fixed-rate) HE ABS | (Fixed-rate) AAA HE ABS | Variable-rate HE ABS | Variable-rate AAA HE ABS | ABX.HE AAA | ABX.HE BBB | Inv-grade CMBS | High-yield CMBS |
| Agency RMBS | 1.000 | -0.580 | -0.550 | -0.358 | -0.437 | -0.413 | -0.404 | -0.168 | -0.378 |
| (Fixed-rate) HE ABS | -0.580 | 1.000 | 0.964 | 0.691 | 0.812 | 0.656 | 0.535 | 0.579 | 0.652 |
| (Fixed-rate) AAA HE ABS | -0.550 | 0.964 | 1.000 | 0.705 | 0.787 | 0.704 | 0.567 | 0.584 | 0.647 |
| Variable-rate HE ABS | -0.358 | 0.691 | 0.705 | 1.000 | 0.907 | 0.669 | 0.613 | 0.502 | 0.708 |
| Variable-rate AAA HE ABS | -0.437 | 0.812 | 0.787 | 0.907 | 1.000 | 0.801 | 0.591 | 0.692 | 0.859 |
| ABX.HE AAA | -0.413 | 0.656 | 0.704 | 0.669 | 0.801 | 1.000 | 0.704 | 0.765 | 0.854 |
| ABX.HE BBB | -0.404 | 0.535 | 0.567 | 0.613 | 0.591 | 0.704 | 1.000 | 0.433 | 0.444 |
| Inv-grade CMBS | -0.168 | 0.579 | 0.584 | 0.502 | 0.692 | 0.765 | 0.433 | 1.000 | 0.763 |
| High-yield CMBS | -0.378 | 0.652 | 0.647 | 0.708 | 0.859 | 0.854 | 0.444 | 0.763 | 1.000 |

Table 3. Correlations between Excess Returns on MBS and Various Financial and Economic Factors**Panel A1. Descriptive Statistics for the Period before Crisis (1999-2006)**

| Name | Label | Mean | Median | Max | Min | Stdev |
|--|-------|--------|--------|--------|---------|-------|
| Excess Return on Agency RMBS | ER_AR | 0.256 | 0.331 | 1.743 | -1.943 | 0.769 |
| Excess Return on Fixed-rate home equity ABS | ER_HA | 0.254 | 0.225 | 1.518 | -1.782 | 0.665 |
| Excess Return on Investment-grade CMBS | ER_IC | 0.379 | 0.477 | 3.363 | -4.534 | 1.383 |
| Excess Return on High-yield CMBS | ER_HC | 0.924 | 0.897 | 5.736 | -4.858 | 1.857 |
| Change in 30-year mortgage rate | MRC | -0.022 | -0.080 | 0.900 | -0.520 | 0.226 |
| Change in Treasury term structure spread | TSC | -0.016 | -0.070 | 0.820 | -0.420 | 0.274 |
| Chg. in credit spread between Baa & Aaa corp. bonds | CSC | 0.003 | 0.000 | 0.440 | -0.160 | 0.078 |
| Inflation rate (Annual % change in CPI) | CPIYG | 2.764 | 2.900 | 4.700 | 1.100 | 0.857 |
| Annual % chg. in median price of existing homes sold | EHPYG | 7.196 | 7.750 | 16.600 | -4.300 | 4.037 |
| Change in composite average Loan to Price Ratio | LTPC | -0.015 | -0.100 | 2.000 | -2.900 | 0.740 |
| Change in Charge-off rate on real estate loans | CORC | 0.000 | 0.000 | 0.160 | -0.120 | 0.039 |
| Annual % change in personal disposable income | DPYG | 5.361 | 5.400 | 9.600 | 1.600 | 1.643 |
| % change in Industrial Production | IPG | 1.430 | 2.100 | 5.700 | -5.700 | 2.765 |
| % change in consumer confidence | CONG | -0.041 | -0.726 | 12.132 | -13.692 | 5.023 |
| Change in unemployment rate | UEC | 0.005 | 0.000 | 0.300 | -0.200 | 0.127 |
| Fama-French Factor 1 (Stock Market Excess Return) | Rm-Rf | 0.034 | 0.845 | 8.180 | -10.760 | 4.360 |
| Fama-French Factor 2 (Small minus Big, SMB) | SMB | 0.590 | 0.445 | 21.960 | -16.790 | 4.546 |
| Fama-French Factor 3 (High minus Low, HML) | HML | 1.148 | 1.130 | 13.850 | -12.400 | 3.973 |
| Fama-French Factor 4 (Momentum, Mom) | Mom | 0.407 | 0.710 | 18.390 | -25.060 | 6.295 |

Panel A2. Correlations for the Period before Crisis (1999-2006)

| | Concurrent Correlation | | | | Lag 1 Correlation | | | |
|-------|------------------------|-------|-------|-------|-------------------|-------|-------|-------|
| | ER_AR | ER_HA | ER_IC | ER_HC | ER_AR | ER_HA | ER_IC | ER_HC |
| ER_AR | 1.00 | 0.87 | 0.91 | 0.77 | 0.04 | 0.09 | 0.07 | 0.03 |
| ER_HA | 0.87 | 1.00 | 0.91 | 0.71 | 0.08 | 0.10 | 0.09 | 0.04 |
| ER_IC | 0.91 | 0.91 | 1.00 | 0.84 | -0.02 | 0.02 | 0.01 | -0.01 |
| ER_HC | 0.77 | 0.71 | 0.84 | 1.00 | 0.02 | 0.01 | 0.05 | 0.05 |
| MRC | -0.76 | -0.73 | -0.83 | -0.68 | 0.10 | 0.01 | 0.06 | 0.09 |
| TSC | -0.39 | -0.29 | -0.47 | -0.59 | 0.13 | 0.14 | 0.13 | 0.06 |
| CSC | 0.01 | -0.03 | 0.00 | 0.07 | 0.03 | -0.05 | -0.03 | -0.12 |
| CPIYG | -0.10 | -0.13 | -0.14 | -0.08 | -0.04 | -0.04 | -0.05 | 0.01 |
| EHPYG | -0.13 | -0.12 | -0.12 | -0.09 | -0.11 | -0.10 | -0.07 | -0.05 |
| LTPC | -0.08 | -0.13 | -0.17 | -0.13 | 0.08 | 0.05 | 0.06 | 0.03 |
| CORC | 0.14 | 0.16 | 0.16 | 0.10 | 0.17 | 0.22 | 0.15 | 0.05 |
| DPYG | 0.02 | -0.06 | -0.08 | -0.04 | 0.17 | 0.08 | 0.09 | 0.10 |
| IPG | -0.08 | -0.14 | -0.07 | 0.05 | -0.03 | -0.12 | -0.04 | 0.09 |
| CONG | -0.14 | -0.15 | -0.11 | -0.03 | 0.18 | 0.15 | 0.15 | 0.07 |
| UEC | 0.15 | 0.24 | 0.16 | 0.12 | -0.11 | -0.06 | -0.10 | -0.17 |
| Rm-Rf | -0.16 | -0.30 | -0.25 | -0.21 | -0.12 | -0.08 | -0.08 | -0.12 |
| SMB | -0.03 | -0.03 | -0.05 | -0.01 | 0.05 | 0.05 | 0.03 | 0.01 |
| HML | 0.02 | 0.09 | 0.08 | 0.07 | 0.10 | 0.12 | 0.07 | 0.00 |
| Mom | 0.22 | 0.21 | 0.23 | 0.29 | 0.07 | -0.01 | -0.02 | -0.02 |

Panel B1. Descriptive Statistics during the Crisis (January 2007 to December 2008)

| Name | Label | Mean | Median | Max | Min | Stdev |
|--|-------|---------|--------|--------|---------|--------|
| Excess Return on Agency RMBS | ER_AR | 0.371 | 0.167 | 4.153 | -1.515 | 1.166 |
| Excess Return on Fixed-rate home equity ABS | ER_HA | -2.391 | -1.522 | 1.049 | -14.783 | 3.360 |
| Excess Return on ABX.HE AAA Index | ER_XA | -1.276 | -0.798 | 5.431 | -16.216 | 3.919 |
| Excess Return on ABX.HE BBB Index | ER_XB | -14.583 | -5.096 | 4.400 | -68.056 | 19.959 |
| Excess Return on Investment-grade CMBS | ER_IC | -0.973 | -0.310 | 16.357 | -18.822 | 5.784 |
| Excess Return on High-yield CMBS | ER_HC | -3.657 | -1.289 | 13.082 | -37.240 | 9.654 |
| Change in 30-year mortgage rate | MRC | -0.043 | -0.015 | 0.560 | -0.830 | 0.315 |
| Change in Treasury term structure spread | TSC | 0.117 | 0.160 | 0.660 | -0.950 | 0.351 |
| Chg. in credit spread between Baa & Aaa corp. bonds | CSC | 0.103 | 0.040 | 0.940 | -0.060 | 0.217 |
| Inflation rate (Annual % change in CPI) | CPIYG | 3.333 | 3.650 | 5.400 | -0.100 | 1.365 |
| Annual % chg. in median price of existing homes sold | EHPYG | -5.704 | -5.750 | 0.200 | -15.300 | 4.226 |
| Change in composite average Loan to Price Ratio | LTPC | -0.121 | 0.050 | 1.400 | -2.100 | 0.913 |
| Change in Charge-off rate on real estate loans | CORC | 0.198 | 0.200 | 0.450 | 0.020 | 0.142 |
| Annual % change in personal disposable income | DPYG | 5.079 | 5.400 | 9.800 | 2.000 | 1.534 |
| % change in Industrial Production | IPG | -0.050 | 1.400 | 2.500 | -8.200 | 3.022 |
| % change in consumer confidence | CONG | -1.516 | -2.417 | 11.587 | -18.065 | 6.829 |
| Change in unemployment rate | UEC | 0.117 | 0.100 | 0.500 | -0.100 | 0.181 |
| Fama-French Factor 1 (Stock Market Excess Return) | Rm-Rf | -1.808 | -0.960 | 4.940 | -18.550 | 5.448 |
| Fama-French Factor 2 (Small minus Big, SMB) | SMB | -0.028 | -0.070 | 4.040 | -3.460 | 2.103 |
| Fama-French Factor 3 (High minus Low, HML) | HML | -0.405 | -0.265 | 4.370 | -5.090 | 2.139 |
| Fama-French Factor 4 (Momentum, Mom) | Mom | 1.682 | 0.665 | 12.450 | -7.890 | 4.663 |

Panel B2. Correlations during the Crisis (January 2007 to December 2008)

| | Concurrent Correlation | | | | | | Lag 1 Correlation | | | | | |
|-------|------------------------|-----------|-----------|-----------|-----------|-----------|-------------------|-----------|-----------|-----------|-----------|-----------|
| | ER_A R | ER_H A | ER_X A | ER_X B | ER_I C | ER_H C | ER_A R | ER_H A | ER_X A | ER_X B | ER_I C | ER_H C |
| ER_AR | 1.00 | -0.63 | -0.43 | -0.43 | -0.19 | -0.42 | -0.01 | 0.04 | 0.46 | 0.33 | 0.58 | 0.30 |
| ER_HA | -0.63 | 1.00 | 0.65 | 0.53 | 0.57 | 0.64 | -0.17 | 0.20 | -0.15 | -0.05 | -0.46 | -0.02 |
| ER_XA | -0.43 | 0.65 | 1.00 | 0.70 | 0.76 | 0.85 | -0.44 | 0.14 | -0.20 | -0.25 | -0.55 | 0.00 |
| ER_XB | -0.43 | 0.53 | 0.70 | 1.00 | 0.43 | 0.44 | -0.18 | 0.17 | -0.13 | -0.07 | -0.52 | -0.12 |
| ER_IC | -0.19 | 0.57 | 0.76 | 0.43 | 1.00 | 0.76 | -0.45 | 0.38 | 0.19 | 0.08 | -0.16 | 0.41 |
| ER_HC | -0.42 | 0.64 | 0.85 | 0.44 | 0.76 | 1.00 | -0.57 | 0.40 | 0.00 | -0.11 | -0.22 | 0.26 |
| MRC | -0.75 | 0.22 | -0.03 | 0.05 | -0.27 | 0.10 | 0.16 | 0.02 | -0.43 | -0.31 | -0.29 | -0.33 |
| TSC | -0.26 | -0.27 | -0.30 | 0.00 | -0.56 | -0.33 | 0.15 | -0.27 | -0.15 | -0.18 | -0.11 | -0.24 |
| CSC | 0.08 | -0.49 | -0.36 | -0.05 | -0.44 | -0.64 | 0.72 | -0.73 | -0.54 | -0.39 | -0.32 | -0.62 |
| CPIYG | -0.30 | 0.11 | 0.12 | 0.06 | -0.18 | 0.10 | -0.07 | -0.30 | -0.17 | -0.07 | -0.48 | -0.31 |
| EHPY | | | | | | | | | | | | |
| G | -0.39 | 0.53 | 0.18 | 0.21 | 0.09 | 0.40 | -0.32 | 0.46 | 0.05 | 0.22 | 0.01 | 0.25 |
| LTPC | -0.14 | 0.08 | -0.14 | 0.10 | -0.17 | -0.10 | -0.02 | 0.14 | 0.37 | 0.33 | 0.11 | 0.38 |
| CORC | 0.17 | -0.60 | -0.28 | -0.37 | -0.34 | -0.37 | 0.16 | -0.43 | -0.13 | -0.26 | -0.02 | -0.25 |
| DPYG | -0.46 | 0.49 | 0.06 | -0.16 | 0.07 | 0.43 | -0.26 | 0.33 | -0.02 | 0.12 | -0.04 | 0.13 |
| IPG | -0.34 | 0.37 | 0.12 | 0.00 | 0.11 | 0.41 | -0.24 | 0.32 | 0.20 | 0.02 | 0.17 | 0.50 |
| CONG | 0.22 | 0.27 | 0.23 | 0.24 | 0.34 | 0.15 | -0.36 | 0.34 | 0.41 | 0.41 | 0.07 | 0.16 |
| UEC | -0.06 | 0.05 | -0.10 | -0.13 | 0.06 | -0.25 | 0.48 | -0.44 | -0.11 | -0.14 | -0.23 | -0.20 |
| Rm-Rf | -0.10 | 0.44 | 0.40 | 0.20 | 0.60 | 0.62 | -0.45 | 0.64 | 0.58 | 0.17 | 0.39 | 0.75 |
| SMB | -0.18 | 0.44 | 0.35 | 0.22 | 0.52 | 0.28 | -0.11 | 0.14 | 0.17 | 0.22 | -0.19 | 0.04 |
| HML | -0.18 | 0.33 | 0.49 | 0.45 | 0.24 | 0.39 | -0.48 | 0.12 | 0.08 | 0.18 | -0.35 | -0.08 |
| Mom | -0.16 | -0.35 | -0.48 | -0.42 | -0.45 | -0.36 | 0.36 | -0.16 | -0.17 | -0.08 | 0.10 | -0.14 |

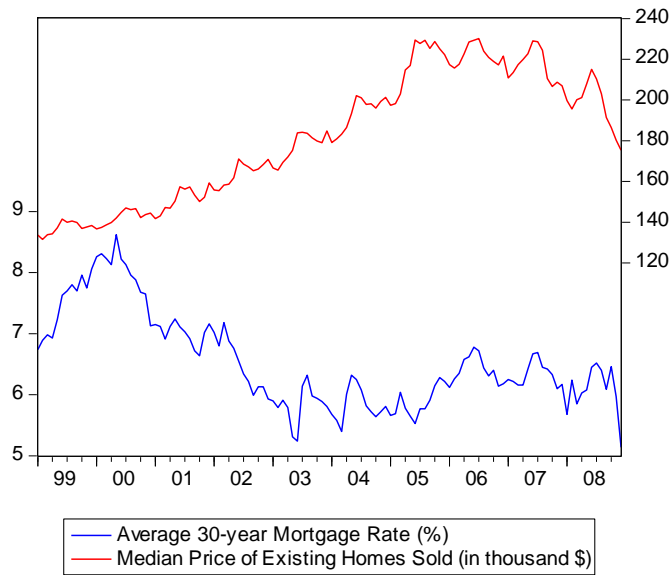
Table 4. Regression Analysis for the MBS Excess Returns on Three Major Factors (with a comparison before and during crisis)

| Panel A. Before the Crisis (January 1999 to December 2006) | | | | | | | | |
|---|--------------|-----------------|--------------|----------------|--------------|-----------------|--------------|-----------------|
| Independent\Dependent Variables | ER_MF | | ER_HA | | ER_CMI | | ER_CMH | |
| Intercept | 0.19 | (3.50) | 0.24 | (4.53) | 0.26 | (3.16) | 0.85 | (5.89) |
| Change in 30-year mortgage rate (MRC) | -2.53 | (-10.83) | -1.87 | (-7.15) | -4.90 | (-15.69) | -5.32 | (-10.29) |
| Lag one month change in credit spread (CSC1) | 0.54 | (0.98) | -0.70 | (-1.24) | -0.55 | (-0.57) | -3.76 | (-1.97) |
| Change in charge-off rate on real estate loans (CORC) | 0.36 | (0.26) | 1.23 | (0.75) | 1.08 | (0.50) | -0.08 | (-0.02) |
| R-squared | 56.3% | | 42.8% | | 66.8% | | 44.0% | |
| Adj. R-squared | 54.8% | | 40.9% | | 65.7% | | 42.1% | |
| F-statistic | 38.62 | | 22.47 | | 60.41 | | 23.58 | |
| Panel B. During the Crisis (January 2007 to December 2008) | | | | | | | | |
| Independent\Dependent Variables | ER_MF | | ER_HA | | ER_CMI | | ER_CMH | |
| Intercept | 0.20 | (1.03) | -0.19 | (-0.35) | 0.59 | (0.72) | -0.81 | (-0.42) |
| Change in 30-year mortgage rate (MRC) | -1.79 | (-2.66) | -1.62 | (-0.82) | -10.96 | (-1.89) | -10.01 | (-1.46) |
| Lag one month change in credit spread (CSC1) | 2.76 | (2.48) | -10.70 | (-2.98) | -16.54 | (-1.65) | -35.77 | (-3.05) |
| Change in charge-off rate on real estate loans (CORC) | -0.80 | (-0.80) | -6.46 | (-1.93) | -2.57 | (-0.42) | 0.14 | (0.01) |
| R-squared | 71.1% | | 62.8% | | 37.8% | | 45.6% | |
| Adjusted R-squared | 66.7% | | 57.2% | | 28.4% | | 37.5% | |
| F-statistic | 16.38 | | 11.25 | | 4.05 | | 5.59 | |

Note: ER_MF: Excess Return on the agency RMBS Index; ER_HA: Excess Return on the fixed rate, home equity ABS index; ER_CMI: Excess Return on the Investment-grade CMBS Index; ER_CMH: Excess Return on the High-yield CMBS Index.

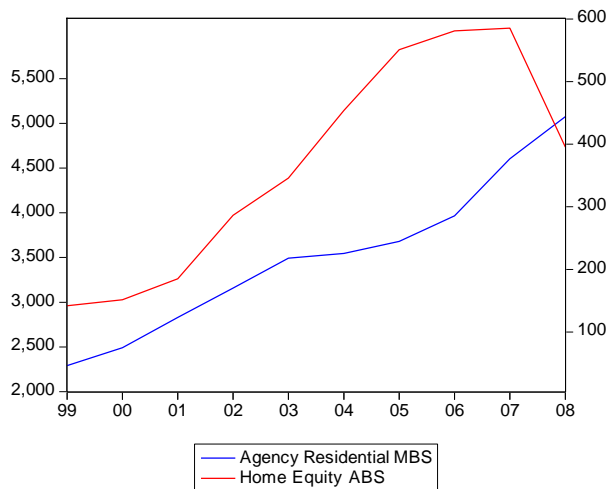
The t-statistics in parentheses are computed using White's heteroskedasticity-consistent variance-covariance estimator. **Bold** -- Significant at 5%; **Bold and Italic** -- Significant at 10%

Chart 1. Monthly Chart on Mortgage Rate and Housing Price (Jan. 1999 to Dec. 2008)



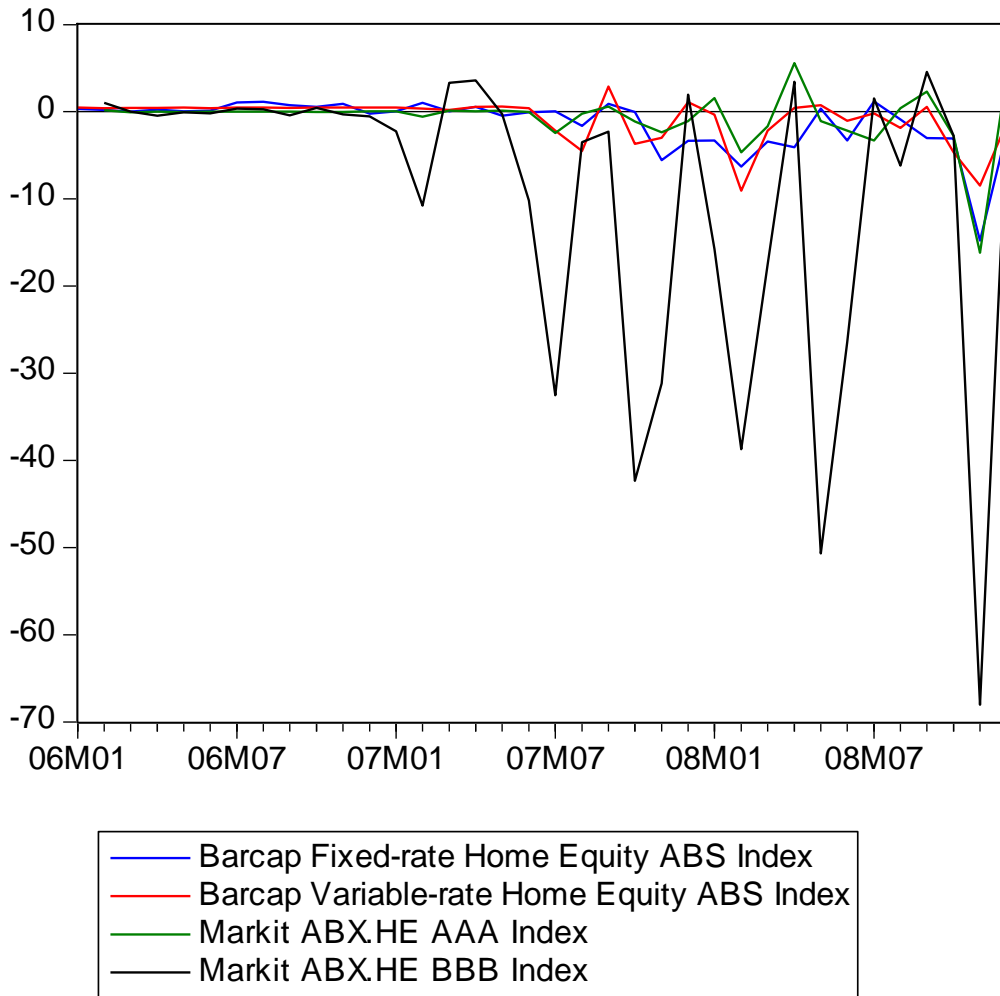
Source: Bloomberg.

Chart 2. Agency Residential MBS and Home Equity ABS: Annual Outstanding Amount from 1999 to 2008 (in Billions US\$)



Source: SIFMA.

Chart 3. Monthly Return (in %) on Home Equity Asset-backed Securities (Jan. 2006-Dec. 2008)



Source: BARCAP; Markit.

Appendix 1: Snapshots of the Barcap/Lehman Fixed Income Indices at the Beginning and End of the Sample Periods

| Barcap/Lehman US Fixed Income Index | Coupon | Duration | Yield to Worst | OAS | Amount Outstanding (Millions) | Market Value (Millions) | # of Issues |
|--|--------|----------|----------------|-------|-------------------------------|-------------------------|-------------|
| Panel A. Index snapshot at the start of the sample period: January 1999 | | | | | | | |
| Agency Residential MBS | 6.98 | 1.86 | 6.23 | 0.74 | 1,667,293 | 1,711,972 | 544 |
| (Fixed-rate) ABS Home Equity | 6.41 | 2.20 | 6.17 | 1.51 | 1,163 | 1,175 | 9 |
| (Fixed-rate) ABS Home Equity AAA | 6.41 | 2.20 | 6.17 | 1.51 | 1,163 | 1,175 | 9 |
| Investment Grade Commercial MBS | 6.68 | 5.95 | 6.08 | n/a | 65,356 | 68,058 | 411 |
| High Yield Commercial MBS | 6.65 | 6.79 | 13.37 | n/a | 8,154 | 4,753 | 337 |
| Treasury | 6.86 | 5.61 | 4.86 | 0.00 | 1,810,354 | 2,051,098 | 158 |
| Investment-Grade Corporate | 7.15 | 6.06 | 6.06 | 1.11 | 1,145,084 | 1,217,171 | 4,630 |
| High-Yield Corporate | 8.00 | 4.63 | 10.24 | 5.15 | 371,689 | 334,246 | 1,709 |
| Panel B. Index snapshot at the start of the crisis period: January 2007 | | | | | | | |
| Agency Residential MBS | 5.43 | 3.85 | 5.73 | 0.47 | 3,152,604 | 3,116,390 | 387 |
| (Fixed-rate) ABS Home Equity | 5.40 | 2.96 | 5.79 | 0.91 | 19,421 | 19,171 | 291 |
| (Fixed-rate) ABS Home Equity AAA | 5.41 | 3.02 | 5.77 | 0.90 | 18,400 | 18,167 | 266 |
| (Floating-rate) ABS Home Equity | 5.59 | 0.06 | 5.55 | 0.57 | 140,731 | 141,162 | 1,273 |
| (Floating-rate) ABS Home Equity AAA | 5.53 | 0.06 | 5.51 | 0.53 | 107,949 | 108,213 | 651 |
| Investment Grade Commercial MBS | 5.45 | 4.91 | 5.53 | 0.68 | 522,858 | 519,783 | 4,503 |
| High Yield Commercial MBS | 5.58 | 5.29 | 11.63 | 6.76 | 26,753 | 17,203 | 2,615 |
| Treasury | 5.00 | 4.85 | 4.90 | 0.00 | 2,091,158 | 2,192,193 | 136 |
| Investment-Grade Corporate | 5.97 | 6.07 | 5.75 | 0.86 | 1,659,841 | 1,712,211 | 2,765 |
| High-Yield Corporate | 7.93 | 4.43 | 7.61 | 2.58 | 647,763 | 662,241 | 1,624 |
| Panel C. Index snapshot at the end of the sample period: December 2008 | | | | | | | |
| Agency Residential MBS | 5.52 | 1.36 | 3.63 | 1.37 | 4,045,692 | 4,186,916 | 412 |
| (Fixed-rate) ABS Home Equity | 5.44 | 3.40 | 18.61 | 17.02 | 17,122 | 9,139 | 257 |
| (Fixed-rate) ABS Home Equity AAA | 5.12 | 3.49 | 12.01 | 10.45 | 7,933 | 5,509 | 153 |
| (Floating-rate) ABS Home Equity | 0.85 | -1.15 | 16.55 | 16.90 | 46,811 | 29,755 | 653 |
| (Floating-rate) ABS Home Equity AAA | 0.73 | -1.04 | 13.53 | 13.99 | 20,118 | 13,862 | 245 |
| Investment Grade Commercial MBS | 5.45 | 4.03 | 12.13 | 10.67 | 612,425 | 434,969 | 4,889 |
| High Yield Commercial MBS | 5.40 | 2.12 | 49.86 | 48.59 | 30,158 | 5,184 | 2,846 |
| Treasury | 4.31 | 5.53 | 1.55 | 0.00 | 2,446,536 | 2,865,149 | 141 |
| Investment-Grade Corporate | 6.14 | 6.15 | 7.50 | 5.55 | 2,148,061 | 2,019,827 | 3,144 |
| High-Yield Corporate | 8.10 | 4.09 | 19.43 | 16.62 | 651,081 | 411,151 | 1,442 |

Source: BARCAP.

Appendix 2: Components of the Markit ABX.HE Index**Panel A. Markit ABX.HE 06-01 AAA Index**

| Rating | Order | Reference Obligation | CUSIP | Weight |
|--------|-------|----------------------|-----------|--------|
| AAA | 1 | ACE 2005-HE7 A2D | 004421UB7 | 5% |
| AAA | 2 | AMSI 2005-R11 A2D | 03072SU86 | 5% |
| AAA | 3 | ARSI 2005-W2 A2C | 040104NC1 | 5% |
| AAA | 4 | BSABS 2005-HE11 A3 | 0738793M8 | 5% |
| AAA | 5 | CWL 2005-BC5 3A3 | 126670ND6 | 5% |
| AAA | 6 | FFML 2005-FF12 A2C | 32027NXV8 | 5% |
| AAA | 7 | GSAMP 2005-HE4 A2C | 362341KB4 | 5% |
| AAA | 8 | HEAT 2005-8 2A4 | 437084PW0 | 5% |
| AAA | 9 | JPMAC 2005-OPT1 A4 | 46626LAD2 | 5% |
| AAA | 10 | LBMLT 2005-WL2 3A4 | 542514NA8 | 5% |
| AAA | 11 | MABS 2005- NC2 A4 | 57643LMP8 | 5% |
| AAA | 12 | MLMI 2005-AR1 A3A4 | 59020UH24 | 5% |
| AAA | 13 | MSAC 2005-HE5 A2C | 61744CUR5 | 5% |
| AAA | 14 | NCHET 2005-4 A2C | 64352VMT5 | 5% |
| AAA | 15 | RAMP 2005-EFC4 A3 | 76112BD64 | 5% |
| AAA | 16 | RASC 2005-KS11 A14 | 76110W7B6 | 5% |
| AAA | 17 | SABR 2005-HE1 A3C | 81375WGE0 | 5% |
| AAA | 18 | SAIL 2005-HE3 A5 | 86358EWW2 | 5% |
| AAA | 19 | SASC 2005-WF4 A4 | 863576DE1 | 5% |
| AAA | 20 | SVHE 2005-4 2A4 | 83611MKC1 | 5% |

Panel B. Markit ABX.HE 06-01 BBB Index

| Rating | Order | Reference Obligation | CUSIP | Weight |
|--------|-------|----------------------|-----------|--------|
| BBB | 1 | ACE 2005-HE7 M8 | 004421UK7 | 5% |
| BBB | 2 | AMSI 2005-R11 M8 | 03072SV85 | 5% |
| BBB | 3 | ARSI 2005-W2 M8 | 040104NL1 | 5% |
| BBB | 4 | BSABS 2005-HE11 M7 | 0738793U0 | 5% |
| BBB | 5 | CWL 2005-BC5 M5 | 126670NJ3 | 5% |
| BBB | 6 | FFML 2005-FF12 M2 | 32027NXX4 | 5% |
| BBB | 7 | GSAMP 2005-HE4 M2 | 362341KD0 | 5% |
| BBB | 8 | HEAT 2005-8 M5 | 437084QD1 | 5% |
| BBB | 9 | JPMAC 2005-OPT1 M8 | 46626LAM2 | 5% |
| BBB | 10 | LBMLT 2005-WL2 M8 | 542514NJ9 | 5% |
| BBB | 11 | MABS 2005- NC2 M8 | 57643LMX1 | 5% |
| BBB | 12 | MLMI 2005-AR1 M1 | 59020UG90 | 5% |
| BBB | 13 | MSAC 2005-HE5 M2 | 61744CUT1 | 5% |
| BBB | 14 | NCHET 2005-4 M8 | 64352VNB3 | 5% |
| BBB | 15 | RAMP 2005-EFC4 M8 | 76112BD31 | 5% |
| BBB | 16 | RASC 2005-KS11 M8 | 76110W7L4 | 5% |
| BBB | 17 | SABR 2005-HE1 M1 | 81375WGF7 | 5% |
| BBB | 18 | SAIL 2005-HE3 M8 | 86358EXE1 | 5% |
| BBB | 19 | SASC 2005-WF4 M8 | 863576DN1 | 5% |
| BBB | 20 | SVHE 2005-4 M8 | 83611MKM9 | 5% |

Source: Markit.