An Empirical Investigation of MBS Liquidity Risk

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This article investigates the liquidity risk of U.S. mortgage-backed securities (MBS) in comparison with that of government and agency securities. An empirical evaluation of liquidity risk is performed by negative tails from the historical changes of daily total transactions. A set of bond market risk factors is applied to control the pure market effects on transaction changes. Once market effects are controlled, negative tails are evaluated from the underlying distributions for residual transaction changes. During the recent five years, liquidity-driven MBS transaction changes show fat tails, as well as high sample volatility. This suggests that a sudden, large drop from the normal level of transactions is more likely for MBS than for government and agency bonds, in the case that there is negative liquidity shock.

Over the past several years, MBS have drawn a great deal of interest from major investors who invest in U.S. fixed-income securities. These investors, including foreign central banks and sovereign funds that maintain dollar reserves, typically hold large bond portfolios and place the highest priority on stable portfolio values. Hence, a large portion of these portfolios comprise highly liquid assets, especially Treasury bonds, so that holdings can be liquidated easily and without substantial losses, when necessary.

In this regard, agency MBS are considered an alternative to Treasury bonds, offering similar liquidity and yield enhancement. Exhibit 1 shows a picture of the recent popularity of MBS in the marketplace, using the value of daily total transactions from the Federal Reserve Bank of New York's primary dealer statistics. From 2004 to 2007 daily total transactions increased by 54.9% for agency MBS, whereas those of government and agency bonds increased, on average, by 13.5% and 11.3%, respectively. Further, between 2006 and 2007, average transactions for MBS increased by 26.8%, while increases were 8.0% and 11.0% for government and agency bonds, respectively. These results are summarized in Exhibit 2.

However, financial markets have fallen into turmoil since the middle of 2007, and investors are becoming increasingly concerned about liquidity and showing strong inclinations toward Treasury bonds, resulting in so-called "flight-to-liquidity." Because the U.S. housing market and subprime mortgage sectors are considered to have triggered the recent financial crisis, and because of concerns about the financial stability of U.S. government agencies, the liquidity risk surrounding MBS has become an increasingly important issue for further investigation.

This article investigates the liquidity risk of U.S. MBS from an empirical viewpoint. Market professionals and researchers use the bid–ask spread, the difference between the price available for an immediate sale and purchase, as a measure of liquidity. While this

EXHIBIT 1
Average Daily Total Transactions

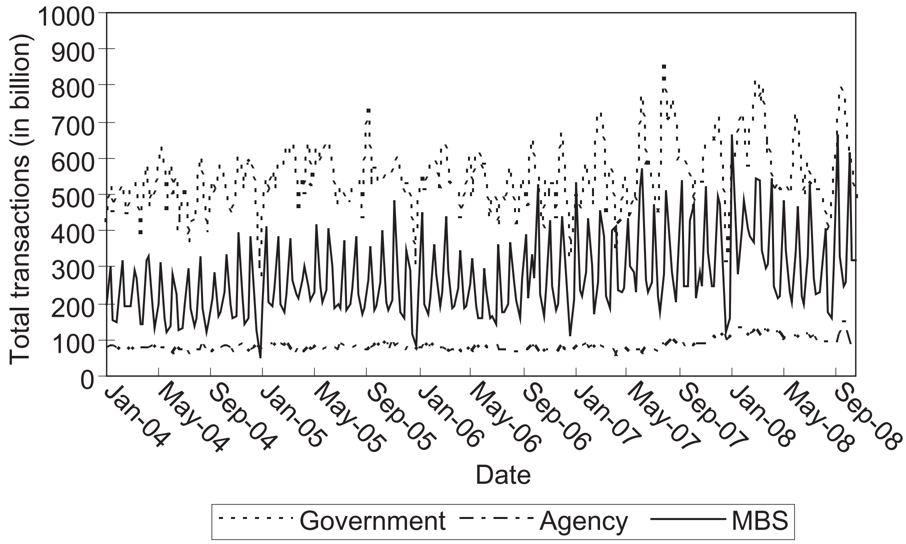

EXHIBIT 2
Annual Averages of Daily Total Transactions: 2004–2007

	Government	Agency	MBS
2004	491,577	74,332	207,508
2005	540,855	78,758	251,557
2006	516,618	74,502	253,551
2007	557,716	82,708	321,428

Notes: This exhibit summarizes the annual averages of daily total transactions. Units are millions of dollar.

Source: Data from Federal Reserve Bank of New York.

spread is a widely used measure that delivers information on how much market participants incorporate liquidity risk into pricing, by nature this measure is an *ex ante* evaluation of liquidity risk. Typically, the bid–ask spread of agency MBS tends to be as low and stable as that of Treasury bonds, which makes it difficult to perform high-frequency evaluations of MBS liquidity risk. With this in mind, this article captures the liquidity risk *ex post* from total transaction changes. Thus, another phase of liquidity risk is investigated that is based on historically realized mismatches between market demand and supply. If we observe a sudden drop in transactions, then it should be the result of the amount of mismatch between demand and supply and the drop in prices that corresponds to lack of demand.

Of course, not every change in transactions is the result of liquidity issues. As Bangia, Diebold, Schuermann, and Stroughair [2001] suggest, the overall risk of an asset can be split into pure market risk and liquidity risk components. To derive the liquidity risk component from the available data, it is necessary to properly control for pure market risk. Accordingly, I first control the market risk component using a set of market risk factors and focus on the negative tails of liquidity-driven changes.

METHODOLOGIES AND DATA

The primary focus of this article is to compare the historically observed short-term changes in total transactions of U.S. MBS with those of government and agency securities, which are known to be highly liquid and involve minimal credit risk. If I observe the total transaction (*TR*) of a candidate security class as of time *t*, then the one-period change of the total transaction (*TC*) can be calculated as $TC_t = \log(TR_t) - \log(TR_{t-1})$.

As noted previously, it is necessary to first control for transaction changes that are caused by pure market risk. To properly control for pure market risk component, I apply the linear factor model approach to include several market variables as a set of risk factors to capture bond market risk. Fama and French [1993] and Lettau and Ludvigson [2001] suggest various bond market variables that properly capture market risk, and I consider three main bond risk factors from these choices. These factors include 1) term premium (*TRM*), which is the difference between 10-year and 1-year Treasury bond yields to represent the risk premium from longer maturity or duration; 2) default premium (*DEF*), which is the difference between Baa-rated and Aaa-rated corporate bond yields to capture the credit risk; and 3) relative T-bill rate (*RREL*), which is the change of the three-month Treasury bill rate from the previous average, to reflect interest rate movements.

In addition, I include two more risk factors. One is the mortgage spread (*MTG*), which is the market mortgage rate over the three-month LIBOR, as the performance of the bond market, especially MBS, may be affected by the gap between mortgage and deposit rates. The other risk factor used is equity premium (*EQ*), which is the S&P 500 weekly return over the Treasury-bill rate, to reflect the effect of equity market performance on the bond market. Two lags are also added to the set of explanatory variables to control for serial correlations.

By regressing the changes of total transactions on the chosen set of risk factors, I control the pure market risk component and derive liquidity-driven transaction changes. The regression equation is as follows:

$$\begin{aligned} TC_t = \alpha &+ \beta_{TRM} TRM_t + \beta_{DEF} DEF_t \\ &+ \beta_{RREL} RREL_t + \beta_{MTG} MTG_t + \beta_{EQ} EQ_t \\ &+ \beta_{LAG1} TC_{t-1} + \beta_{LAG2} TC_{t-2} + \varepsilon_t \end{aligned} \tag{1}$$

Once I control the pure market effect using Equation (1), I define liquidity-driven transaction changes (*LTC*) as follows:

$$\begin{aligned} LTC_t = TC_t - \hat{\alpha} &- \hat{\beta}_{TRM} TRM_t - \hat{\beta}_{DEF} DEF_t \\ &- \hat{\beta}_{RREL} RREL_t - \hat{\beta}_{MTG} MTG_t - \hat{\beta}_{EQ} EQ_t \\ &- \hat{\beta}_{LAG1} TC_{t-1} - \hat{\beta}_{LAG2} TC_{t-2} \end{aligned} \tag{2}$$

where $\hat{\alpha}$ and $\hat{\beta}$ are the estimated values of α and β.

To analyze liquidity risk based on tail performance, it is necessary to specify a certain underlying distribution to generate *LTC*. Accordingly, once I derive the liquidity-driven transactions of government, agency bonds, and MBS, a goodness-of-fit test is applied to identify their distributions. It is natural to first test if these residuals are normally distributed, thus, I employ the Jarque–Bera test (Jarque and Bera [1980]) to check if the *LTC* is normally distributed.

The Jarque–Bera test is a goodness-of-fit measure of deviation from normality based on the sample skewness and kurtosis. The test statistic *JB* is defined as

$$JB = \frac{n}{6}\left(S^2 + \frac{(K-3)^2}{4} \right) \tag{3}$$

where n is the number of observations, S is the sample skewness, and K is the sample kurtosis. The statistic has an asymptotic chi-square distribution with two degrees of freedom and is used to test the null hypothesis that the data are generated from a normal distribution.

The government and agency bonds and MBS average daily total transactions data are from the Federal Reserve Bank of New York's primary dealer statistics, which are constructed by the primary U.S. government securities dealers' reports of purchases and sales in the market and updated weekly. The data used to construct the bond market risk factors, the three-month Treasury bill rate, 1-year and 10-year Treasury yields, and Aaa-rated and Baa-rated corporate bond yields are from the Federal Reserve Board's economic research and data online site. Bankrate market average mortgage rate, S&P 500 stock index price, and three-month LIBOR data are from Bloomberg.

EMPIRICAL RESULTS

Exhibit 3 shows the results of regressions of the changes of total transactions on the set of risk factors to control the market risk effects for government, agency securities and MBS. Instead of calculating one-week changes of transactions, I take changes from the last four-week average, in order to consider liquidity risk as a larger drop from the "normal" level, and to mitigate the effect of an abnormal observation. I choose the sample periods as the recent five years, from January 2004 to October 2008. These periods are chosen not only because the primary focus of this article is on recent years' performance, but also because the market mortgage spread over LIBOR begins to show decreasing patterns from early 2004 that are distinguished from the previous periods.

The set of risk factors, including two lags, is shown to explain the changes in total transactions reasonably well, with 44% of R^2 for the MBS regression. The effects of the term premium are not statistically meaningful, probably because the total values of transactions are summed across all maturities. Instead, as factors to affect overall

EXHIBIT 3
Regressions on Bond Risk Factors

$$TC_t = \alpha + \beta_{TRM}TRM_t + \beta_{DEF}DEF_t + \beta_{RREL}RREL_t + \beta_{MTG}MTG_t + \beta_{EQ}EQ_t + \beta_{LAG1}TC_{t-1} + \beta_{LAG2}TC_{t-2} + \varepsilon_t$$

	Government	Agency	MBS
α	–0.001 (–0.072)	0.002 (0.284)	–0.071 (–3.648)**
β_{TRM}	0.148 (1.387)	–0.014 (–0.212)	0.010 (0.050)
β_{DEF}	–0.263 (–1.252)	–0.279 (–2.181)**	–0.644 (–1.651)*
β_{RREL}	–0.106 (–1.931)*	–0.158 (–4.963)**	–0.133 (–1.321)
β_{MTG}	–0.038 (–0.457)	–0.140 (–2.719)**	–0.024 (–0.158)
β_{EQ}	–1.198 (–1.871)*	0.438 (1.128)	–2.826 (–2.355)**
β_{LAG1}	0.442 (7.289)**	0.129 (2.043)**	0.142 (2.904)**
β_{LAG2}	–0.281 (–4.632)**	–0.088 (–1.390)	–0.644 (–13.34)**
R^2	0.254	0.187	0.442

*Notes: The numbers in parentheses are the values of t-statistics. *means significant at 10% level; **means significant at 5% level.*

relative T-bill rate show marginal (or close to marginal) explanatory power. The equity premium has (near) significant effects on government bonds and MBS at the 5% significance level with a negative sign. This suggests that the bond market has a substitution effect with the stock market in the asset allocation choice. That is, when equity return performance is good, investors demand more equities than bonds, while bond market demands (hence transactions) increase when stock market performance goes down. Lastly, across all securities, the lagged variables show strong significance. This is partly because the transactions show persistent movement during short-term horizons but also because the changes of transactions are calculated not from the previous week, but from the prior weeks' average.

Exhibit 4 shows the results of the standard deviations, minimum values, and ratios of minimum to standard deviations, as well as the sample skewness and kurtosis, from the liquidity-driven transaction changes. MBS show about twice as high volatility as government bonds, and three times that of agency bonds. Also, the minimum to standard deviation ratio is –4.76, which shows greater standard deviation-normalized distance from the average than those of government and agency bonds, –3.22 and –3.57, respectively.

However, tail-based risk comparison should come from the specified underlying distribution, to be fair. The last row of Exhibit 4 shows the results of Jarque–Bera tests. Given that the critical value for the chi-square distribution with two degrees of freedom is 9.210 at the 1% significance level, while the government and agency cases are not strongly rejected (for government bond residuals, a standard deviation between 0.159 to 0.160 generates a JB statistic value between 7.604 to 9.397), MBS generate 30.703 of the test statistic, which shows strong rejection from the normal distribution assumption.

This strong rejection is likely the result of excess kurtosis. The sample kurtosis of the MBS case is 4.529, while those of government and agency cases are 3.922 and 3.208, respectively. Thus, excess kurtosis contributes

EXHIBIT 4
Distribution Test for Liquidity-Driven Transaction Changes

$$LTC_t = TC_t - \hat{\alpha} - \hat{\beta}_{TRM}TRM_t - \hat{\beta}_{DEF}DEF_t - \hat{\beta}_{RREL}RREL_t - \hat{\beta}_{MTG}MTG_t - \hat{\beta}_{EQ}EQ_t - \hat{\beta}_{LAG1}TC_{t-1} - \hat{\beta}_{LAG2}TC_{t-2}$$

	Government	Agency	MBS
Std. Dev.	0.159	0.096	0.297
Min.	–0.512	–0.344	–1.413
Min./Std. Dev.	–3.221	–3.566	–4.755
Skewness	–0.110	–0.060	–0.386
Kurtosis	3.922	3.208	4.529
JB	9.397	0.603	30.703

Notes: Std. Dev. denotes standard deviation, Min. denotes minimum, Min./Std. Dev. denotes the minimum to standard deviation ratio, and JB denotes the Jarque–Bera test statistic.

and 3.208, respectively. Thus, excess kurtosis contributes to the rejection from normality for the MBS case. This indicates that MBS liquidity-driven transaction changes have fat-tail distribution, while the transaction changes of government and agency securities are generated from normal distributions.

Under normality, the agency bond transactions show smaller standard deviation than government bond transactions. However, if I compare the minimum standardized by standard deviation, the greatest drop of agency bond transactions is 3.566 standard deviations away from the average, while that of government bond transactions is 3.221 standard deviations away. In the case that liquidity risk is measured by the collapse of transactions from vanishing demand or sudden depreciation, which is difficult to expect within the volatility bound, the greatest drop that is farther from the average in volatility unit may reflect greater liquidity risk.

The fat-tailedness suggests that during normal times, it is more likely to observe greater upside movement of transactions, which can give an impression of high liquidity. However, the observed larger negative tail values also suggest that when there is a negative shock that has an impact on the liquidity, there will be a greater possibility of a larger shortage of market demand relative to supply or greater depreciation of overall market values of the asset class. Accordingly, those securities with more negative realized tail values may bear a greater relative liquidity risk.

RECENT OBSERVATIONS

In order to analyze liquidity risk by putting weight on more recent samples, I focus on the sample period since 2006 and repeat the analysis. Ironically, in addition to the shorter sample problems, it is possible that fewer negative tail values are observed, since the market risk components are fitted on the risk factors that already reflect current market situations, by weighing more recent periods with the greater downside risk of the overall market. Despite the potential shortcomings of the approach with the shorter sample periods, it is still interesting to see which patterns are observed by applying the same analysis to the recent distressed markets.

Exhibit 5 presents pure market-controlling regressions with the set of risk factors from January 2006 to October 2008. Overall, the results from these regressions are consistent with those of the five-year samples. R^2 values for the government and agency securities regressions are enhanced up to 34% and 29%, respectively, while that from the MBS regression remains almost the same. The default premium and relative T-bill factors have explanatory power, and the equity premium factor shows significance to explain the change in MBS transactions. Also, serial correlation effects are observed by the significance of the lagged variables.

Exhibit 6 presents the results of distributional analysis on liquidity-driven transactions. For all the candidate securities, the standard deviations from the recent period samples are shown to be almost the same as those of the longer samples. And as previously expected, the minimum values show smaller magnitudes of negative values, with much less negative tails, especially in the MBS case.

While the sample kurtosis is somewhat (or much) smaller for government bonds and MBS, the agency bond case shows greater kurtosis in the recent samples.

EXHIBIT 5
Regressions on Bond Risk Factors: Recent Sample

$$TC_t = \alpha + \beta_{TRM}TRM_t + \beta_{DEF}DEF_t + \beta_{RREL}RREL_t + \beta_{MTG}MTG_t + \beta_{EQ}EQ_t + \beta_{LAG1}TC_{t-1} + \beta_{LAG2}TC_{t-2} + \varepsilon_t$$

	Government	Agency	MBS
α	–0.011 (–0.806)	–0.003 (–0.357)	–0.086 (–3.196)**
β_{TRM}	0.160 (1.287)	–0.016 (–0.198)	–0.000 (–0.000)
β_{DEF}	–0.212 (–0.903)	–0.390 (–2.811)**	–0.538 (–1.248)
β_{RREL}	–0.129 (–2.064)**	–0.162 (–4.702)**	–0.179 (–1.568)
β_{MTG}	–0.016 (–0.173)	–0.126 (–2.235)**	0.045 (0.260)
β_{EQ}	–1.313 (–1.727)*	0.055 (0.121)	–2.986 (–2.107)**
β_{LAG1}	0.504 (6.204)**	0.137 (1.678)*	0.094 (1.416)
β_{LAG2}	–0.332 (–4.114)**	–0.051 (–0.601)	–0.636 (–9.702)**
R^2	0.335	0.288	0.434

*Notes: The numbers in parentheses are the values of t-statistic. *means significant at 10% level; **means significant at 5% level.*

EXHIBIT 6
Distribution Test for Liquidity-Driven Transaction Changes: Recent Sample

$$LTC_t = TC_t - \hat{\alpha} - \hat{\beta}_{TRM}TRM_t - \hat{\beta}_{DEF}DEF_t - \hat{\beta}_{RREL}RREL_t - \hat{\beta}_{MTG}MTG_t - \hat{\beta}_{EQ}EQ_t - \hat{\beta}_{LAG1}TC_{t-1} - \hat{\beta}_{LAG2}TC_{t-2}$$

	Government	Agency	MBS
Std. Dev.	0.160	0.094	0.297
Min.	–0.503	–0.341	–0.831
Min./Std. Dev	–3.155	–3.623	–2.796
Skewness	0.095	–0.110	0.032
Kurtosis	3.904	4.085	3.023
JB	5.229	7.505	0.028

Notes: Std. Dev. denotes standard deviation, Min. denotes minimum, Min./Std. Dev. denotes the minimum to standard deviation ratio, and JB denotes the Jarque–Bera test statistic.

This means that large drops of agency bond transactions are more frequently observed during recent periods.

By the smaller magnitude of negative tail with the still-high standard deviation, the likelihood of fat-tail distributions for MBS transactions becomes much smaller. This can be confirmed by the results of normality tests. For the recent samples, none of the securities are rejected from the normality, so the liquidity-driven transaction changes can be considered to follow normal distributions.

In this regard, by focusing only on recent samples, it seems difficult to apply the fat-tail distributions argument, since the MBS liquidity-driven transactions are not rejected from the normality. In addition, based on the sample statistics, the minimum of the MBS transactions is only 2.8 standard deviations below the mean, compared with 3.2 and 3.6 for government and agency securities, respectively.

The MBS minimum value gives a smaller volatility-normalized drop mainly because of the larger standard deviation, which is almost twice as large as that of government securities. Still the worst drop shows a more than 80% decrease from the previous average level. Accordingly, while comparison based on fat-tailedness seems not applicable to the recent samples, high volatility and the magnitude of the worst drop in transactions suggest that MBS bear relatively large potential liquidity risk. Thus, the argument for comparison with government and agency securities based on the negative minimum normalized by the standard deviation is still effective.

CONCLUDING REMARKS

This article investigates the liquidity risk of U.S. MBS in comparison with U.S. government and agency securities from an empirical viewpoint. I consider historically observed large drops in total transactions in the market during short time periods as an empirical measure of the liquidity risk. Changes in total transactions, however, can be triggered not only by liquidity risk, but also by pure market risk factors with no significant shock on liquidity. Accordingly I first control market-risk-driven changes in the total transactions using a set of risk factors and then take the liquidity-driven transaction changes to analyze tail-based liquidity risk.

The set of bond market risk factors include the term premium to capture duration risk, the default premium to control for credit risk, and the relative T-bill rate for interest rate movement. The mortgage spread over deposit rate is included for its potential impact on the bond market, and the equity premium factor is added from the asset allocation perspective, as well as two lags to control for serial correlations.

Once market risk effects are controlled using this set of risk factors, I focus on the negative tail of liquidity-driven transaction changes based on underlying distributions. For the samples from January 2004 to October 2008, MBS transaction changes show a large sample kurtosis and are rejected from the null hypothesis of normal distribution. This means that liquidity-driven changes in the MBS transactions are likely generated by fat-tail distribution. Also, this implies that MBS may bear greater liquidity risk as these can generate greater drops in terms of transactions, corresponding to negative liquidity shock with higher probability in the negative fat-tailed area of the underlying distribution. The liquidity-driven transaction changes of government and agency securities are not rejected from normality, and agency bond transactions show smaller standard deviations than government bond transactions. However, the observed negative tails normalized by the standard deviation suggest that in terms of distance in standard deviation units, the minimum of the agency bond case is farther below the average than that of the government bond case.

I repeat the analysis with more recent samples to see which patterns are observed by weighing the more recent distressed market, from January 2006 to October 2008. While the current market is expected to have greater downside risk, the results of analysis show that negative tails from the recent samples have less extreme values once the effects of market risk are controlled. This is because the current market movement, and possibly the impact of common liquidity shock, are already incorporated in the market risk factors and may also be the result of the small-sample effect. Despite these points, the results are still meaningful in the sense that liquidity-driven transactions may be able to show the asymmetric responses of securities that cannot be captured by common market movements. As the minimum values are less negative with standard deviations that are about the same magnitude as the longer samples, it is difficult to apply a fat-tail distribution-based comparison, as none of the three securities are rejected from normality. Admitting this problem, the high level of volatility and much greater magnitude of the worst drop, in comparison with other security cases, still suggest that MBS are likely to bear greater liquidity risk.

Even if the importance of liquidity is well recognized by every market player and researcher, it is true that there is no unified empirical measure of liquidity risk. Again, this article considers liquidity risk based on the changes of total transactions in the market, which is not captured by market risk factors. While this approach is not complete by explaining liquidity risk as the "unexplained," it may offer a complementary perspective in the development of an empirical liquidity risk measure.

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