This study examines investors’ risk-averse behavior in the municipal bond market during the financial crisis of 2008. It employs a dataset from 1989 to 2014 and the Box-Jenkins time series technique to estimate the yield spreads of short-term and long-term fixed income securities. The results demonstrate that the short-term risk premium increased dramatically over the event window but did not persist, while the observed long-term risk premium increased less dramatically, but fluctuated more and lasted longer. The point estimates show that the financial crisis cost short-term issuers an average of 134 basis points in interest costs, whereas long-term issuers paid an average of 100 basis points more than they would have. These findings suggest that when facing a severe financial crisis, municipal issuers should consider adjusting the timing of bond issuance, solve informational asymmetries to the extent possible, and be very cautious about using pricing estimates based on risk-neutral models.

INTRODUCTION

On Monday, September 15, 2008, the U.S. stock market suddenly fell sharply on a trilogy of Wall Street woes: Lehman Brothers’ bankruptcy filing; Merrill Lynch’s acquisition by Bank of America; and AIG’s unprecedented request for short-term financing from the
Following the examples of Yawitz (1978) and Benson et al. (1981), we use the terms “difference in returns,” “yield differential,” “yield spread,” “risk spread,” and “risk premium” interchangeably in this study.

Scholars have long noted that the occasional sharp increase in bond yields in response to financial crises cannot be explained by traditional risk-neutral models, and literature in both the private and public sector has generally attributed this phenomenon to the nonlinear risk-averse behavior of investors who demand a relatively large extra yield premium as compensation for even small amounts of perceived or potential increase in default risk. In the market for equity and corporate bonds, the risk premium generally widens during an economic downturn and narrows during periods of economic expansion. In the municipal bond market, Kriz (2004) confirmed that substantial risk aversion also exists, but he did not explain how it changes over time. The unprecedented financial event of the financial crisis in late 2008 has provided an excellent research opportunity to study the mechanics, especially the fluctuation of risk aversion, in the municipal market.

This article attempts to model and estimate risk aversion using a long historical financial dataset covering the entire course of the Great Recession. The first section reviews existing literature on yield spreads in equity, corporate, and municipal markets. The second develops a model in which the risk premium increases suddenly and reverts back to long-term average levels slowly, and develops a testable hypotheses from this model. The third section describes methodology and the data analyzed in the study. The last two sections present empirical results and discuss findings and implications.

**LITERATURE REVIEW**

Yield spreads\(^1\) between risky common stocks or bonds and risk-free government securities are widely studied in finance literature (Collin-Dufresne, Goldstein, and Martin, 2001; Delianedis and Geske, 2001; Duffie and Liu, 2001; Elton et al., 2001; Huang and Huang, 2012; Liu, Longstaff, and Mandell, 2004; Longstaff and Schwartz, 1995; and many

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\(^1\) Following the examples of Yawitz (1978) and Benson et al. (1981), we use the terms “difference in returns,” “yield differential,” “yield spread,” “risk spread,” and “risk premium” interchangeably in this study.
Classical risk-neutral models, which calculate the expected value of an asset’s future payoff discounted at the risk-free rate, cannot justify the observed yield spreads, even after they are adjusted for default risk, and scholars have turned to other possible explanations. In the equity market, Mehra and Prescott (1985) found that the difference in returns for common stocks was due to a very high degree of risk aversion. In the corporate bond market, Longstaff, Mithal, and Neis (2005) found that the majority of the corporate spreads was due to default risk, while the remaining component was strongly related to illiquidity. Elton et al. (2001) and Huang and Huang (2012), however, showed that credit risk accounted for only a small fraction of the observed corporate-Treasury yield spread. Van Horne (1970) studied the trend of yield differential between Treasuries and Aaa and Baa corporate bonds during the 1945–1968 years and found that both differentials widened during recessionary periods but narrowed during periods of economic prosperity. This cyclical behavior pattern of yield spread was also documented by Francis (1976), Jaffee (1975), Kidwell and Trzcinka (1979) and Sloane (1963). More recently, Siegel (1998) studied the long-run risk premium trend and found that it was substantially lower in early years than in more recent times; although the risk premium averaged 9.5% from 1926 to 1999, it averaged only 1.4% from 1802 to 1870, and 4.4% from 1871 to 1925. Van Horne (1970) interpreted this trend as reflecting either a higher default probability or greater investor risk aversion.

The phenomenon of yield spreads in the tax-exempt bond market has only recently received attention from academia, and it has not been explored as thoroughly as in the corporate literature. Van Horne (1970) examined the yield differential between prime municipal bonds and long-term Treasury bonds (assuming a 50% tax rate on income) between 1945 and 1968 and found that there was little correspondence between the differential and the business cycle. Benson and Rogowski (1978), however, found evidence that the cyclical behavior of yield differential also existed in the municipal market and that municipal yield spreads were inversely related to the level of economic activity. Furthermore, Benson et al. (1981) found that yield spreads between tax-exempt general obligation (GO) bonds of different bond-rating classes varied systematically with both economic activity and commercial bank investment activity, and that this impact generally increased for municipal bonds of lower rating. They attributed these variations to the increased default risk during an economic downturn or the market segmentation effect, which may prohibit investors from substituting between tax-exempt securities of varying default risk. Kriz (2004) analyzed a more up-to-date dataset and found that a significant level of risk aversion existed in the municipal bond market, much as in the corporate bond market, and that this risk-averse behavior...
increased borrowing costs for municipal issuers in the range of 90 to 100 basis points. More recently, Peng, Kriz, and Wang (2014) studied the yield ratios of higher and lower rated municipal bonds and comparable corporate bonds. They concluded that since the inception of the 2008 financial crisis, these ratios not only fluctuated greatly but also behaved differently.

In summary, the literature reviewed above has made it clear that a large part of the spread differential between risky and risk-free securities cannot usually be explained by risk-neutral models and that this is a common phenomenon in corporate stock, bond, and municipal bond markets. Market segmentation, changes in default risk, and risk aversion are the three most commonly cited reasons for the high observed corporate-Treasury yield spreads, even after they are adjusted for default risk. Among these three reasons, market segmentation usually exhibits its effect over an extended period of time, and it is unlikely to be affected by fiscal events in the short run. Therefore, unless the structure of market segmentation can change very promptly as the financial crisis strikes the market, it is of little relevance to the sudden widening of yield spreads during certain financial events. In contrast, a change in default risk can cause sudden and dramatic changes in yield spread, especially if it occurs as a result of a financial event. However, after examining the default history of U.S. municipal bonds between 1970 and 2011, Moody’s (2012) found that default rates for rated municipal bonds remained very low even during the Great Recession, and that only one out of 9,700 rated GO issuers defaulted on its GO bond in the 2008–2011 period. Following Kriz (2004) and others, we explicitly calculated the default probability (assuming no risk aversion) for a constant maturity bond index,\(^2\) and we also found that the default probability varied very little both historically and pre/post the period of the financial crisis. Therefore, actual changes in default probability do not seem to be the main reason for the sudden increase in municipal bond yield spread either. The sole remaining candidate left is risk aversion, which has to do with perceived default risk instead of actual default experience. For these reasons, the rest of this article will focus on modeling and analyzing risk premia and the yield spread of municipal bonds.

**THEORETICAL MODEL**

Risk aversion is a fundamental element in standard theories of asset pricing, contracts, and insurance that describes the behavior of consumers and investors in response to risk. Risk aversion posits that as risk increases, investors will demand additional payment in the form of risk.

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\(^2\) The results are not reported here.
premium on investments in exchange for their willingness to assume an additional amount of inherent risk. Therefore, in most cases, municipal bonds will trade at a premium to risk-free (Treasury) securities with similar maturity and issue characteristics. In times of fiscal distress, when issuers have their ability to pay impaired, the risk premium on a given issue will rise, increasing the spread between municipal securities and risk-free issues. Appendix A sketches the basic model of risk-averse bond pricing.

Despite their almost universal applicability, basic models of risk aversion and bond pricing cannot alone explain the dramatic increase in spreads at the time of the financial crisis (as noted in previous papers). The increase in risk premia associated with such a dramatic rise in spreads would indicate a large, abrupt change in the risk of owning municipal bonds. However, the signal received by the municipal market during the financial crisis did not involve any direct evidence of greater risk in holding municipal bonds. Rather, the signal was indirect and diffuse, in that liquidity for all types of securities might be reduced because of the financial crisis. The large reaction to such a diffuse signal is not suggested anywhere in rational models of bond pricing.

Until the 1970s, there were almost no models of financial markets that incorporated the potential for irrational or at least temporarily nonrational behavior on behalf of market participants. Most of the work of financial economists emphasized efficient markets that acted, in a sense, as information aggregators, efficiently processing available information and producing pricing on investments that reflected the underlying fundamental value of a security. However, budding work on behavioral psychology and cognitive science that analyzed systematic errors in rational decision making (e.g., Tversky and Kahneman, 1974), along with notable and unpredictable market volatility starting in the 1980s, spurred interest in the development of models that emphasize short-term and even long-term deviations of asset prices from the underlying value of securities.

There are several formulations of these types of models (for a good review of the models through the late 1990s, see Hirshleifer, 2001). We choose to focus on one type of model given the situation of the financial crisis. Daniel, Hirshleifer, and Subrahmanyam (1998; hereafter referred to as DHS) develop a model featuring overconfidence of investors in their ability to ascertain or interpret a private signal of value (in this case, the default probability of municipalities issuing bonds) and investor self-attrition of investing success to their own actions. Given that this is present, the reaction to a diffuse private signal of value is likely to produce overreaction by investors. This arises because the investors become convinced that their estimate of value is so much superior to the market estimate of value before the information arrival. They take excessive action in response to their overconfidence, through either buying or selling much
more of a security than a rational investor would otherwise trade. This is termed by DHS as the overreaction phase of an event. Over time, as public information arrives, investors moderate their positions if they are merely overconfident, which DHS refer to as the “correction phase.” However, if traders make profits off the initial overreaction and they mistakenly self-attributed the results to their skill at interpreting the private market signal, then the overreaction will persist.

The DHS model is best demonstrated in Figure 1. The light solid line represents the value of a security over time given a rational market reaction to a given information release. The bold solid line represents the reaction with overconfident investors. The difference between those two lines shows the level of overreaction of the market. The dashed line represents the continuation of an overreaction due to self-attribution effects.

We can test the DHS model against the rational model by observing the response of municipal bond risk premia during a period where there is a cascade of private information but little public information release. Because there was no public information release during the financial crisis regarding the likelihood of default for municipal bonds, the rational model would predict either no impact on observed yield spread or a rise in the yield spread that was maintained over time. We take the “no impact” scenario as the null hypothesis for our research. One potential alternative hypothesis is that there is a permanent rise in the risk premia for municipal bonds.

**Figure 1: Price Reactions to Market Signals**

![Figure 1: Price Reactions to Market Signals](source: Daniel, Hirshleifer, and Subrahmanyam (1998).)
securities given an indirect, diffuse information release. This would also be consistent with the predictions of the traditional bond pricing model, indicating that the riskiness of municipal bonds did in reality increase with the release of information. The other alternative hypothesis is that there would be a temporary rise in risk premia for municipal bonds, followed by a return to the long-term level of default riskiness predicted before the information release. This is the prediction of the DHS model. In the next section of the paper, we develop a model to test these hypotheses.

METHODOLOGY AND DATA

The research question and hypotheses stated above require a methodology capable of measuring the unanticipated changes in risk aversion that were triggered by panicked news reports on financial markets during the third week of October 2008. As the financial world seemed to “fall apart” around market participants, our model suggests that all participating parties would ratchet up their views of default risk probabilities and, therefore, increase their required return on investments dramatically. Once the municipal investors realized that default risks were not increasing as dramatically as feared, they would shift their required return back toward a level more supported by historical evidence on default rates.

The methodology chosen for this analysis is an event study. An event study is a methodology that combines a forecast of expected rates of return (or prices) on an investment in the absence of an event and the impacts of that event in creating abnormal returns (Ball and Brown, 1968). Event studies have a long history of use in many areas of economics and finance, including analyzing the effect of stock split events (Dolley, 1933) and the effect of a change in regulations on the value of firms (Schwert, 1981), and also in areas of applied economics such as assessing legal damages (Mitchell and Netter, 1994). The methodological approach can be summarized in Equation (1) below:

$$AR_{i\tau} = R_{i\tau} - E(R_{i\tau} | X_{\tau}).$$

Equation (1) states that the abnormal return $AR_{i\tau}$ for security $i$ at the event date $\tau$ is the difference between the actual return $R_{i\tau}$ and the expected return at the event date given conditioning information $X_{\tau}$. There are several important structural elements in developing an event study. The first step is to define the event window, or the period over which the returns for securities affected by the event will be calculated. Typically, the event window encompasses a period around the event date so that changes before and after the event date can be examined. Second, researchers using an event study must define the security that is affected by the event. Next, the conditional expected return must be modeled using one of many different methodologies. Last, the estimation window for developing the
conditional return model must be clearly specified, and it must be long enough to permit a solid forecast of the expected return throughout the event window (MacKinlay, 1997).

For our study, the event date is defined as September 15, 2008. On that day, Lehman Brothers declared bankruptcy and ceased trading operations (Landy and Irwin, 2008). The event window starts on September 9, 2008, and lasts until October 10, 2008. The starting period for the window coincides with the advent of bad news regarding Lehman Brothers’ financial position; the prevailing tone of news coverage regarding the firm’s financial health did not turn extremely pessimistic until that point. The ending point of the window is chosen to reflect the introduction of new rules for the Troubled Asset Relief Program (TARP) that allowed for the federal government to directly inject capital into troubled financial institutions (Andrews and Landler, 2008). We define the security as the spread between municipal securities and Treasury securities of a similar maturity. Although this is not represented by any specific security, the spread between the taxable-equivalent yield of municipal securities and Treasury securities is a proxy for the level of risk aversion that the marginal investor possesses (Kriz, 2004). We will examine the spread on two pairs of indices. The spread representing risk aversion in the long-term municipal market will be defined as the spread between the Bond Buyer 20 index and the 20-year Treasury Constant Maturity index. The Bond Buyer 20 index is the benchmark return for municipal securities, published daily by The Bond Buyer trade journal. It has the same average maturity as the 20-year Treasury Constant Maturity index, therefore avoiding problems of maturity mismatch. For short-term spreads, we use the difference between the Bond Buyer One-Year Note index and the 1-Year U.S. Treasury Constant Maturity index. According to the Bond Buyer website, the index is an estimate of the yields of theoretical one-year note issues from 10 frequent state and local note issuers (Source Media, 2015).

We next define the estimation window to maximize the amount of conditioning information for the expected return distribution. The estimation window for the short-term yield spread runs from July 14, 1989 (when data

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3 We follow Kriz (2004) and estimate the taxable-equivalent yield using a 30% marginal tax rate. Using another marginal tax rate will change only the scale of point estimates, but not the general structure of time series analysis.

4 In an earlier version of the paper, we used the SIFMA swap index as a measure of short-term municipal interest rates. However, we switched to the Bond Buyer index due to a much appreciated comment by a reviewer that because the SIFMA index consists heavily of variable-rate demand obligations, it is difficult to interpret it as a short-term yield measure—because VRDOs are, in fact, long-term debt issues with periodic rate resets.
The dynamics of the spread between the two indices over time are shown in Figure 2. One can see that the short-term spread averages between –80 (–0.8%) and 160 (1.6%) basis points throughout the period. The series is relatively volatile, but with a long-term underlying mean to which the series appears to revert. Near the end of the estimation period (in March 2008, subsequent to the Bear Stearns collapse), there was a brief rise in the spread to the top of the historical range; however, by late summer/early fall, the spread had fallen to nearly zero.

As for the longer term bonds, the Bond Buyer 20 Index has been calculated since the 1950s, but the 20-Year Treasury Constant Maturity Index has existed only since October of 1993. Figure 3 shows the dynamics of the long-term spread since this later date. The short-term volatility of this spread is also apparent. However, there appears to be no stable long-term mean but only longer term cycles. The Bear Stearns event is also clearly detectable in the longer term spread series, with a return to more normal levels at the end of the estimation window.

**ESTIMATION RESULTS**

For each of the two spreads, we modeled the conditional expected return using an ARIMA forecasting model during the estimation window. ARIMA modeling is a nonlinear method for modeling the dynamics of
We appreciate an anonymous reviewer who pointed out the possibility of seasonality in municipal bond spreads, owing to Greer (2015) and Cusatis and Tawatnuntachai (2011). Multiplicative seasonal ARIMA models essentially add periodic lags of the dependent variable (here the weekly yield spread) to the regression model. In this sense, the predicted yield spread is dependent on recent observations (the nonseasonal portion of the model) and the spread relative to its position on the calendar (e.g., week 12). The periodic lagged spread variable hence becomes one more predictor of the yield spread for a given week.

In Equation (2), $p$ indicates the number of autoregressive (AR) terms that enter the estimation, $d$ indicates degree of differencing, and $q$ indicates the number of moving average (MA) terms in the estimation; $P$ indicates the number of seasonal autoregressive terms, $D$ the degree of seasonal differencing, and $Q$ the number of seasonal moving average terms. The order of $p$, $q$, $P$, and $D$ were determined by the minimum of the Akaike Information Criteria (AIC) and through examination of the autocorrelation function and partial autocorrelation function of the residuals from estimation of Equation (2). The order of differencing $d$ and seasonal differencing $D$ are determined through tests for stationarity using the method of

\[(1 - \phi_1 B - \phi_2 B^2 - \cdots - \phi_p B^p) (1 - \Phi_1 B^s - \Phi_2 B^{2s} - \cdots - \Phi_P B^{Ps})(1 - B)^d(1 - B^s)^D = (1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q) (1 - \Theta_1 B^s - \Theta_2 B^{2s} - \cdots - \Theta_Q B^{Qs}) \alpha_t. \tag{2}\]
Kwiatkowski et al. (1992). The final estimated model in each case was confirmed by examining the Portmanteau Q test results to determine if the residuals were white noise; the cumulative periodogram was also implemented to rule out the possibility of nonrandom periodicity. The p-value of the Q-statistic (12 lags) was 0.463 for the short-term model and 0.087 for the long-term model, showing that, in both cases, there is no evidence that the residuals deviate from white noise. The cumulative periodogram of the residuals from both the short-term and long-term model remained close to the 45-degree line and well within the confidence bands; thus, the residuals do not exhibit any signs of nonrandom periodicity.

For the short-term spread model, the final model estimated was an ARIMA (4,0,0)(1,1,0) model, indicating that four autoregressive lag terms and one seasonal autoregressive lag terms were needed to reduce the residuals to white noise and minimize the AIC. Additionally, the data had to be seasonally differenced once to induce stationarity ($D = 1$). The results from this estimation are shown in Table 1. The fit of the model is good, as indicated by a log-likelihood value of 417.432 and through visual examination of the model fit (Figure 4). The predicted values by our model missed some of the “peaks” of the dynamics of the time-series relationship, but they captured the actual short-term yield spread very well as a whole.

For the long-term spread, the final model estimated was an ARIMA ([1,6,10],1,0) model, indicating that only three autoregressive terms (at lags 1, 6, and 10) were necessary to reduce the residuals to white noise and minimize the AIC. Additionally, the data had to be first differenced once to induce stationarity. The results from this estimation are shown in Table 2.

Table 1: Results from ARIMA Estimation of Equation (2) for the Short-Term Spread ($T = 948$)

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.00488446</td>
<td>0.0369687</td>
<td>-0.1321</td>
</tr>
<tr>
<td>AR1</td>
<td>0.928687</td>
<td>0.0323461</td>
<td>28.7109</td>
</tr>
<tr>
<td>AR2</td>
<td>-0.107378</td>
<td>0.0441508</td>
<td>-2.4321</td>
</tr>
<tr>
<td>AR3</td>
<td>-0.00987512</td>
<td>0.0442159</td>
<td>-0.2233</td>
</tr>
<tr>
<td>AR4</td>
<td>0.0977561</td>
<td>0.0323615</td>
<td>3.0208</td>
</tr>
<tr>
<td>Seasonal AR1</td>
<td>-0.50274</td>
<td>0.0316167</td>
<td>-15.9011</td>
</tr>
</tbody>
</table>

Contrary to the analysis for the short-term spread, which indicated seasonal effects and thus necessitated the use of a multiplicative seasonal ARIMA model, examination of the autocorrelation and partial autocorrelation functions for the long-term spread indicated no seasonal effects were present.
The fit of the model is exceptionally good, as indicated by a log-likelihood value of 788.785, diagnostic test results, and through examining Figure 5. The two ARIMA models were then used to forecast the expected spreads through the event window. The forecasted values were then compared with the actual observed spreads to calculate the impact of the financial crisis on the spread. Visually, this analysis is shown in Figure 6 (short-term spread) and Figure 7 (long-term spread). It is apparent that both the observed long-term and short-term spreads were far greater than the predicted spreads during the financial event, even at a 95% confidence level. The short-term spread widened dramatically to a point estimate of 243 basis points (2.43%) above the expected value for the week of October 17, 2008. The spread began to fall back toward the expected value during
Figure 5: Actual and Fitted Values from ARIMA Estimation, Long-Term Spread, Estimation Window: October 6, 1993, to September 8, 2008

Figure 6: Predicted and Observed Short-Term Spread, October 13, 2006, to December 28, 2012
the second half of October. Eventually, the spread converged back to the predicted range, entering the upper 95th predicted range during the second week in November 2008 as investors increased their risk-taking behavior (this was two weeks after central banks around the world announced coordinated rate cuts and the U.S. Treasury announced a second round of bank capital injections). There was a short return to higher-than-predicted spreads during the Christmas period of late December 2008 to early January 2009, but the levels reached during that period were not close to the earlier crisis spreads. So the effects of the financial crisis event in the short-term municipal market were intense but did not persist. Ever since that event, the short-term yield spread has never deviated beyond the 95% confidence interval and has remained relatively stable. Due to historically low short-term interest rates in recent years, the short-term spread has also been floating very close to zero.

The same cannot be said for long-term spreads. As shown in Figure 7, long-term spreads did not widen as far as short-term spreads during the event window, reaching a maximum point estimate of 190 basis points on October 15, 2008. But the consequences of the financial crisis for the long-term spread lasted far longer than for the short-term spread. Our estimates
indicated that the long-term spread did not resume expected levels until the week of April 22, 2009. An examination of the period between the end of the event and the most recent week of the data (December 3, 2014) indicated that the long-term spread, similar to its short-term counterpart, stayed within the 95% confidence interval ever since the event ended, but fluctuated in a much wider range than the short-term spread during the post-crisis period.

Table 3 shows the point estimates of the effect of the financial crisis on the short-term spread (Panel A) and long-term spread (Panel B). Our point estimate is that the financial crisis cost short-term issuers an average of 134 basis points in interest costs (with a 95% confidence interval of 88 to 181 basis points), while long-term issuers paid an average of 100 basis points more than they would have (95% confidence level = 72 to 127 basis points).

Table 3: Estimates of Event Effect, Event Window (All figures in %)

<table>
<thead>
<tr>
<th>Panel A: Short-Term Spread Estimates</th>
<th>Event Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
<td>Actual Spread</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td>9/12/2008</td>
<td>0.250</td>
</tr>
<tr>
<td>9/19/2008</td>
<td>1.067</td>
</tr>
<tr>
<td>9/26/2008</td>
<td>1.179</td>
</tr>
<tr>
<td>10/3/2008</td>
<td>1.896</td>
</tr>
<tr>
<td>10/10/2008</td>
<td>2.174</td>
</tr>
<tr>
<td>10/17/2008</td>
<td>2.593</td>
</tr>
<tr>
<td>Average</td>
<td>1.342</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Long-Term Spread Estimates</th>
<th>Event Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
<td>Actual Spread</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td>9/10/2008</td>
<td>2.196</td>
</tr>
<tr>
<td>9/17/2008</td>
<td>2.986</td>
</tr>
<tr>
<td>9/24/2008</td>
<td>3.061</td>
</tr>
<tr>
<td>10/1/2008</td>
<td>3.277</td>
</tr>
<tr>
<td>10/8/2008</td>
<td>3.594</td>
</tr>
<tr>
<td>10/15/2008</td>
<td>4.096</td>
</tr>
<tr>
<td>Average</td>
<td>0.998</td>
</tr>
</tbody>
</table>

7 In comparison, the credit spreads for corporate bonds did not return to pre-Lehman levels until July 2009. See Appendix B.
With regard to our hypotheses, the results shown in Figures 6 and 7 and Table 3 support the DHS model of a distinct overreaction in yield spreads to the diffuse information release of the financial crisis and a gradual correction back to long-term equilibrium levels of risk premia.

Because the estimates of the expected spreads were calculated using a time-series methodology and a relatively long historical dataset, most of the threats to internal validity should have already been accounted for. The only plausible threat is that a history event happened to change the expectation of the spread exactly at the time of the financial crisis. One possible explanation for this would be a sudden unexpected change in economic condition at the time of the crisis. To address this, we modeled the time-series relationship once more using the weekly average of the Aruoba-Diebold-Scotti Business Conditions Index (Aruoba, Diebold, and Scotti, 2009) and then again using the weekly unemployment claims as controls for economic condition. Neither variable proved to change the expected values of the spreads, so our results seem to be robust against the potential history threat.

CONCLUSION AND RECOMMENDATIONS

This study has provided empirical evidence that risk-averse behavior not only is present in the municipal bond market, but also fluctuates greatly during a severe financial crisis such as the one experienced in late 2008. After employing the common time series techniques of modeling and estimating the yield spreads of fixed income securities, we find that both the observed long-term and short-term risk-aversion premium increased dramatically over the event window. This increase can neither be explained by the risk-neutral model nor predicted by historical risk-aversion premia in the municipal market. Instead, a model incorporating overconfidence coupled with self-attribution bias on the part of bond investors seems to fit the facts much better.

Based on the sample used in this study, we estimate that this risk-averse behavior has caused an additional increase of as much as 243 basis points (or 2.43%) in the borrowing costs for short-term bond issuers and an additional increase of as much as 190 basis points (or 1.9%) for long-term bond issuers during the financial event. In addition, we have also found that the correction phase in the short-term municipal securities market was faster than in the long-term market, indicating the potential for greater self-attribution bias (or slower public information release) in the long-term market. Our results are robust to history and other threats to internal validity and are consistent over different estimation methodologies.

This study has contributed to the public finance literature by documenting the change of municipal investors’ risk-averse behavior during the financial crisis, and the findings have several important implications for
municipal bond issuers. First, because the borrowing costs for municipal bonds can increase dramatically due to the increased risk-aversion premium in the face of certain financial events, it will be necessary for municipal issuers to monitor market conditions closely and try to adjust the bond issuance timeline in order to avoid soaring borrowing costs at the peak of a financial crisis. As this study has shown, postponing the bond issuance for a few months (or even for a few weeks) would make a significant difference, especially for short-term bond issuers. The second implication relates to the informational asymmetries in the municipal bond market. For a municipal issuer, it is better to have more information on the true risk of its bonds so that it can credibly communicate with investors, because a large portion of the increased risk premium is not due to actual changes in default risk but, rather, to investors’ short-term overreaction to the sudden inflow of negative news. As such, techniques that can solve or mitigate informational asymmetries, including imposing disclosure requirements, using third-party intermediaries, purchasing bond insurance, etc., may have a greater impact in reducing borrowing costs during a financial crisis than during a normal period. Third, municipal issuers and investors alike should be very cautious about using the results or forecasts based on risk-neutral bond pricing models, especially during times of fiscal crisis.

Seven years have passed since the financial crisis of late 2008, and the municipal bond market has long returned to its normal state: stable and quiet. However, this does not mean that similar financial events will not happen again in the future. Municipal bond issuers, regulators, and investors should learn the lessons from the 2008 financial crisis and get well prepared for such an eventuality. We hope that this study has lent some new knowledge to the understanding of the risk-aversion premium in the municipal market, but much more research is needed to answer many important policy questions in this area.

**APPENDIX A: TRADITIONAL BOND-PRICING MODEL**

A general model of risk aversion was first developed by early economists such as Bernoulli (1738), Pratt (1964), and Arrow (1965). Let $u(.)$ be investor $Y$’s von Neumann-Morgenstern (VNM) utility function, $E(Y)$ is the expected return of investor $Y$ offering $W_i$ level of investment with

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8 An anonymous reviewer points out that these strategies impose costs on issuers and should be balanced against the benefit from reducing information asymmetries.

9 The VNM utility function is strictly concave if the individual is risk averse; it is linear if the individual is risk neutral; and it is strictly convex if the individual is risk seeking. For a detailed explanation, interested readers may refer to Jehle and Reny (2001), pp. 96–97.
probability \( P_i \) of receiving both principal and interest; \( u(Y) \) and \( u(E(Y)) \) can therefore be written as:

\[
u(Y) = \sum_{i=1}^{n} P_i u(w_i),
\]

\[ (A1) \]

\[
u(E(Y)) = u(\sum_{i=1}^{n} P_i w_i).
\]

\[ (A2) \]

Based on Equations (A1) and (A2), we can define that an individual is:

1. Risk averse if \( u(E(Y)) > u(Y) \);
2. Risk neutral if \( u(E(Y)) = u(Y) \);
3. Risk seeking if \( u(E(Y)) < u(Y) \).

The certainty equivalent yield (\( CE \)) of investor \( Y \) is the yield that is offered with certainty, such that:

\[
u(Y) \equiv u(CE).
\]

\[ (A3) \]

The risk-aversion premium (\( \Omega \)) is the additional return that investor \( Y \) requires for taking on additional risk, such that:

\[
u(Y) \equiv u(E(Y) - \Omega).
\]

\[ (A4) \]

From (A3) and (A4), we obtain:

\[
\Omega \equiv E(Y) - CE.
\]

\[ (A5) \]

Equation (A5) implies that if the marginal investor \( Y' \)'s expected return exceeds the certainty equivalent return, she is risk averse and the risk-aversion premium \( \Omega \) is positive; if the marginal investor’s expected return is less than the certainty equivalent return, she is risk seeking and \( \Omega \) is negative. In the case that the expected and certainty equivalent returns are equal, the investor is risk neutral and \( \Omega \) would be 0. Equations (A1) through (A5) portray a world in which the expected return on a security relies on an investor’s expectations regarding the state that the security will be in throughout its life and the risk-adjusted payoff associated with that state.

The general model described above was adapted to explain the risk premia on fixed income securities by Silvers (1973) and by Bierman and Hass (1975), and was later extended to address various questions about the relationship between default risk and risk premia by Yawitz, Maloney, and Ederington (1985), Wu (1991), and Wu and Yu (1996). Based on the common structure of early models explaining risk aversion, Kriz (2004) developed a model to study investors’ risk-averse behavior in the municipal bond market.
APPENDIX B: BANK OF AMERICA MERRILL LYNCH U.S. CORPORATE MASTER OPTION-ADJUSTED SPREAD

Source: Economic Research, Federal Reserve Bank of St. Louis at http://research.stlouisfed.org/fred2/graph/?s[1][id]=BAMLC0A0CM.

References


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