Systematic Risk and the Muni Puzzle

**Abstract** - The muni puzzle refers to the empirical fact that relative to taxable bond yields, long–term tax–exempt yields are significantly higher than predicted by theory, while short–term yields conform well to theory. The systematic risk hypothesis is a candidate to explain the muni puzzle. I find that risk characteristics of government and municipal bond portfolio returns are very similar across the term structure. From this evidence, I conclude that systematic risk is unlikely to explain the muni puzzle. I also illustrate that a tax adjustment to duration is important when comparing the expected volatility of bonds with different tax status.

**INTRODUCTION**

The municipal bond market provides economists with unique opportunities to study the effects of taxes on security prices. The coupons received from most municipal bonds are exempt from Federal tax, while the coupons received from Treasury bonds and corporate bonds are subject to Federal taxes. Miller (1977) and Fama (1977) provide theory that implies that the municipal yield, $y_m$, should equal one minus the corporate tax rate, $\tau$, times the taxable bond yield, $y_G$, or $y_m = (1 - \tau) y_G$, where the corporate tax rate is the highest marginal corporate tax rate. Short–term bond yields are generally consistent with the Fama and Miller hypotheses as shown in Jordan and Pettway (1985), while Poterba (1989), among others, demonstrates empirically that long–term tax–exempt bond yields are much higher than their theoretical values. In fact, there are many instances where long–term tax–exempt rates are so high that investors facing marginal tax rates less than ten percent would appear to benefit from investing in tax–exempt bonds.1 This phenomenon is often referred to in the literature as the muni puzzle.

Faced with this puzzle, several hypotheses have been suggested to reconcile relatively high municipal yields with financial theories. These hypotheses generally posit shortcomings of muni bonds relative to taxable bonds including higher default risk (Trzcinka, 1982),2 lower liquidity, less valuable tax–timing options (Constantinides and Ingersoll, 1984), more exposure to tax–law uncertainty, and the importance of

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1 For example see Erikson, Goolsbee and Maydew (2003) for evidence on the underutilization of what would appear to be arbitrage opportunities by corporations.

portfolio tax-avoidance strategies (Green, 1993). While some of these explanations show promise, the muni puzzle has yet to be resolved.

This paper examines the hypothesis that municipal bonds expose investors to higher levels of systematic consumption risk relative to comparable taxable bonds, where the term “consumption risk” refers to the idea from asset-pricing theory that assets that have large payoffs when consumption is high (and marginal utility of consumption is low) and small payoffs when consumption is low (and marginal utility of consumption is high) will require higher returns relative to assets with payoffs that have a lower covariance with consumption growth.4 In other words, investors seek to smooth their consumption over time and value assets that hedge consumption risk. Ironically, taxes on bond returns may create a feature that makes taxable bonds relatively attractive from a consumption-risk perspective.

The idea that taxes are good for an investor is a peculiar concept. Paying taxes reduces the level of return available for consumption. As a result, we observe that taxable bonds offer higher before-tax rates of return than comparable municipal bonds—as expected. However, taxes may bestow a benefit in that the fraction of a taxable bond’s return that is paid in taxes may vary in a manner that is beneficial. To illustrate this idea, suppose that the economy is good, and that most consumer/investors in the economy receive high income and, due to progressivity in the tax system, face high marginal tax rates and, therefore, low after-tax payments from taxable bonds.5 These investors are likely to have high consumption levels and, therefore, realize a low marginal utility of consumption. Now suppose the economy is bad. In this case, most consumer/investors receive less income, face lower marginal tax rates, are likely to consume less and, therefore, have higher marginal utility of consumption and the after-tax payoffs from the taxable bond are higher. Because the tax bite out of a taxable bond co-varies negatively with the marginal utility of consumption, taxes can bestow an attractive risk characteristic onto taxable bonds.6 While taxes reduce the average return available for consumption, which is bad, variation in the tax bite taken from a taxable bond embeds lower exposure to consumption risk. If this benefit is important, it is possible that market clearing prices and yields of taxable bonds will reflect lower-than-expected required rates of return, due to lower levels of systematic consumption risk when compared to otherwise identical municipal bonds.

In this paper, I estimate and compare the risks of portfolios of municipal and government bonds. Most of the risk measures I estimate are measured with respect to returns to financial assets rather than measures of consumption. While this is common practice, consumption risk drives the pricing theory, and so it is sensible to briefly assess the connections between the underlying asset-pricing model and the methods used to test the hypothesis in this paper.

At a general level, Cochrane (2005)7 makes the point that “all factor models are derived as specializations of the consumption-based model.” There are certain theoretical assumptions that allow one

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4 See Breeden (1979), Rubinstein (1976) or for an excellent textbook treatment see Cochrane (2005).
5 The source of progressivity is not critical to the story. As long as there is a potential change in the tax share out of the bond’s value, the intuition will follow.
6 Piros (1987) models an agent’s municipal bond risk premium relative to a taxable bond. The factors that are important are the shape of the tax schedule, the variance of taxable income, the level of yields, and investors’ absolute risk aversion.
7 See chapter 9 in particular.
to show that the relevant systematic risk due to consumption risk can be measured directly with returns on financial market portfolios. For example, Cochrane shows that if investors have quadratic utility, log utility, or exponential utility and normal returns, the CAPM, which uses the market return as a factor, can be derived directly from the consumption–CAPM. Regardless of how risk is measured empirically, the underlying interpretation of systematic risk is that it captures the covariance of an asset’s returns with aggregate consumption risk. This does not imply that testing an asset pricing model requires that we use measures of consumption to estimate systematic risks. However, substituting market returns for consumption growth does impose assumptions on the theoretical model and raises concerns about how well market returns capture the aggregate variation in consumption risk.

Therefore, when I use the term “systematic risk,” I mean those risks that affect prices because of their systematic correlation with consumption risk. I use financial market returns in my tests primarily because they present fewer empirical obstacles. While empirical asset pricing has found some recent successes using consumption data, consumption data present empirical challenges. Given the relatively short time-series of municipal bond returns that I am working with, quarterly consumption data would cut my observations to below 30 observations. This is why the primary tests in this paper estimate risk relative to factors drawn from the stock and bond markets, though I do provide some robustness tests using Aït-Sahalia, Parker and Yogo’s (2004) luxury goods’ consumption as a factor.

If systematic risk explains the muni puzzle, I should find two features in the data. First, it must be that municipal bonds have more systematic risk than taxable bonds. Second, the degree to which muni bonds’ systematic risk exceeds taxable bonds’ systematic risk must grow with term to maturity. To test what I will term the “systematic risk hypothesis,” I estimate betas for well-matched portfolios of tax-exempt and taxable bonds. I test for differences in the betas estimated for the muni- and taxable-bond portfolios. These tests provide little evidence to suggest that systematic risk is higher in munis than in taxable bonds. Moreover, given that I do not find differences in systematic risk, it is not surprising that differences in systematic risk do not grow with maturity. I report a variety of risk measures and appeal to the consistency of the results to allay concerns that the failure to find support for this hypothesis is due to my choices on how to measure systematic risk. Despite these efforts, I cannot exclude the possibility that my tests mismeasure systematic consumption risk, perhaps because of noisy proxies for the consumption factor in returns. Nonetheless, and with this caveat in mind, I conclude that

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8 For examples and discussion, see Breeden, Gibbons and Litzenberger (1989), Hansen, Heaton, and Li (2005), Lettau and Ludvigson (2001), Aït-Sahalia, Parker and Yogo (2005).
9 This is plausible given the empirical facts that long-term bond returns subject investors to more volatility than short-term bonds and that levels of systematic risk are correlated with volatility. Buser and Hess (1986) find that the changes in the ratio of short-term tax-exempt to taxable bond yields are positively related to changes in term and credit spreads, while Chen, Roll and Ross (1986) argue that similar measures of credit and term spreads are systematic factors in stock returns. Together, these results suggest that a relation exists between short-term relative yields and market-wide risk factors. If these market-wide risk factors affect short-term bond yields, they are likely to be magnified for long-term relative bond yields.
10 In most of my tests, the municipal portfolios are constructed with municipal bonds that are secured by U.S. Treasuries thus, alleviating the concern that municipal default risk is causing the municipal bonds to display higher levels of systematic risk.
11 These findings are consistent with Skelton (1983) who finds that a portfolio of twenty municipal bonds (with various maturities) and a corporate bond index exhibit similar risk characteristics.
the systematic risk hypothesis does not appear to provide a promising explanation for the muni puzzle.

Finally, and somewhat tangentially, the results in this paper also demonstrate the importance of taxes in measuring portfolio risk. With these data, I provide evidence that the distinction between pre–tax and after–tax duration that Hessel and Huffman (1981) derive is important. A common argument is that the lower coupon on a municipal par bond relative to a comparable maturity taxable par bond results in a larger duration and, therefore, riskier municipal bonds. I find that the standard deviation of municipal and government portfolios are nearly identical, even though municipal portfolios have substantially larger duration values than do comparable maturity taxable bonds. I use a tax correction to the duration calculation for taxable bonds to demonstrate that, consistent with the observed standard deviation of returns, the after–tax durations of municipal and taxable bonds are similar.

CALCULATION OF BOND PORTFOLIO RETURNS

The vast majority of research that examines the muni puzzle is appropriately conducted in terms of yields on newly issued taxable and tax–exempt bonds. These yield data allow researchers to calibrate the muni puzzle most directly. However, the systematic risk hypothesis cannot be tested directly in terms of yields. While par–bond yields reflect the level of systematic risk upon issue, returns are necessary to estimate the systematic risk of the bond portfolios.

I calculate portfolio returns from a sample of up to 1,400 pre–refunded municipal bond prices. There are at least two reasons that pre–refunded municipal bonds are particularly well suited to this analysis. First, pre–refunded bonds are tax–exempt bonds that are secured by U.S. Treasury securities. Consequently, these bonds are effectively default–free. Second, when bonds become pre–refunded, call options, which are usually attached to new issue municipal bonds, are extinguished. Thus, these bonds are cleaned of many of the problems usually associated with municipal bond data. J.J. Kenny provides the pre–refunded bond data on a monthly basis from January 1984 through August 1991. The taxable bond portfolio returns are constructed with U.S. government bonds. The government bond sample includes all non–callable U.S. government notes and bonds listed on the CRSP bond tape.

For convenience, I define the term “maturity portfolio” to mean a portfolio of bonds that includes only those bonds that mature within a given term to maturity range. I form 12 maturity portfolios for the municipal and government bond samples. The portfolios are labeled 1, 2, ..., 10, 15 and 20 year portfolios. The maturity portfolios are reconstituted every three months. The 1 through 10 year portfolios include bonds with terms to maturity within six months of the portfolio’s target maturity. For example, a bond with 1.51–2.49 years to maturity is assigned to the two–year maturity portfolio, and a bond with 1.49 years remaining is assigned to the one–year maturity portfolio. Bonds with less than six months to maturity are dropped from the sample. The 15–year maturity portfolio contains bonds with term to maturity greater than 10.5 years and less than or equal to 17 years. The 20–year maturity portfolio contains bonds with maturities greater than 17 years and less than or equal to 22.5 years.

Monthly returns are calculated from the average prices and coupons of the bonds assigned to each maturity portfolio. Bond coupons are assumed to be paid in 12 equal installments and accrued interest is computed separate from the price. Equation [1],
is used to calculate the monthly maturity portfolio returns, \( r_t(T) \), for each portfolio with maturity \( T \). \( \bar{P}_t(T) \) is the average price of all bonds in the maturity portfolio of maturity \( T \) at time \( t \). The same set of bonds comprises the portfolio at time \( t-1 \) and is used to calculate \( \bar{P}_{t-1}(T) \). \( \bar{C}(T) \) is the average coupon of the bonds in the portfolio. \( Accint_{t-1} \) is the average accrued interest on all bonds at time \( t-1 \). Thus, the denominator is the cost of the bond portfolio at month \( t-1 \), and the numerator of equation [1] is the dollar return to the maturity portfolio \( T \), if sold at month \( t \).

RELATIVE RISKS OF MUNICIPAL AND GOVERNMENT BONDS

If systematic risk explains the relatively high long–term municipal yields, long–term municipal bonds must bear significantly higher levels of systematic risk than long–term government bonds and short–term municipal bonds must exhibit similar levels of systematic risk as short–term government bonds. The following three subsections compare the riskiness of the municipal and government portfolio returns using different risk measures.

Monthly Returns and Standard Deviations

Table 1, panel A reports the average returns, standard deviations, duration, after–tax duration, price, and number of bonds for the maturity portfolios. These data are plotted in return and standard deviation space in Figure 1. The complete monthly data set is available for the sample period beginning April 30, 1984 and ending August 31, 1991. The 20–year maturity portfolios are missing 12 observations due to the unavailability of 20–year government bonds over the period from February 1989 through January 1990. For comparison, Table 1, panel B and Figure 1 include: the value and equal weighted NYSE returns, \( R_{VW, stock} \) and \( R_{EW, Stock} \); a municipal bond return index constructed from over one million bonds and published by Standard & Poors, \( R_{S&P, Muni} \); an equally weighted index of five Treasury return indices published by Ryan Labs, Inc.; \( R_{Ryan, Govt} \); and the components of \( R_{Ryan, Govt} \): the Ryan 2, 3, 5, 10 and 30 year Treasury indices of on–the–run Treasury securities.

The returns in Table 1 imply that this is an unusual sample period. Average monthly bond returns have rivaled the returns to the stock indexes. For example, 15–year bonds earned an average monthly pre–tax return of 1.00 percent for municipal bonds and 1.17 percent for government bonds. These returns compare to the average monthly value–weighted NYSE, which earned 1.37 percent over the same time period. While the realized returns are comparable, the stock market indices are almost two times more volatile than the 15–year bond returns. Because this time period appears to be somewhat unique, some out–of–sample evidence is provided for robustness. Table 3 provides the average monthly returns to six Vanguard Bond Funds over the period from November 1991 through September 2004. Monthly returns to a Vanguard money market fund, intermediate–term bond fund, and long–term bond fund are collected for both Treasury and high–grade municipal funds of each maturity type. Table 3 reports the analysis of these data. The average returns appear normal in the sense that the bond returns are not nearly as high relative to the stock market returns as they were in the sample period covered by the pre–refunded bond portfolios.

There is no evidence in Tables 1 or 3 that the municipal portfolios of any maturity expose investors to greater overall risk than do comparable maturity government bond portfolios. There is little difference
# TABLE 1

## MUNICIPAL AND GOVERNMENT BOND HOLDING PERIOD RETURNS

### Panel A: Maturity Portfolio Summary Statistics

<table>
<thead>
<tr>
<th>Portfolio Maturity</th>
<th>Municipal Maturity Portfolios</th>
<th>Government Maturity Portfolios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Return</td>
<td>Std Dev Returns</td>
</tr>
<tr>
<td>1 Yr</td>
<td>0.49%</td>
<td>0.34%</td>
</tr>
<tr>
<td>2 Yr</td>
<td>0.52%</td>
<td>0.67%</td>
</tr>
<tr>
<td>3 Yr</td>
<td>0.61%</td>
<td>0.91%</td>
</tr>
<tr>
<td>4 Yr</td>
<td>0.66%</td>
<td>1.18%</td>
</tr>
<tr>
<td>5 Yr</td>
<td>0.71%</td>
<td>1.47%</td>
</tr>
<tr>
<td>6 Yr</td>
<td>0.71%</td>
<td>1.64%</td>
</tr>
<tr>
<td>7 Yr</td>
<td>0.75%</td>
<td>1.80%</td>
</tr>
<tr>
<td>8 Yr</td>
<td>0.80%</td>
<td>2.02%</td>
</tr>
<tr>
<td>9 Yr</td>
<td>0.84%</td>
<td>2.19%</td>
</tr>
<tr>
<td>10 Yr</td>
<td>0.88%</td>
<td>2.40%</td>
</tr>
<tr>
<td>15 Yr</td>
<td>1.00%</td>
<td>2.71%</td>
</tr>
<tr>
<td>20 Yr</td>
<td>1.12%</td>
<td>3.22%</td>
</tr>
</tbody>
</table>

Notes: The municipal maturity portfolios are calculated with pre-refunded municipal bond data. The Government maturity portfolios are calculated with the non-callable U.S. Treasury Notes and Bonds from the CRSP bond tape. Eighty-nine monthly return observations, from 4/30/84 through 8/31/91, are used for all portfolios except the 20–year portfolios. The Government and municipal 20–year portfolios are calculated with only 77 observations because 20–year Government bonds did not exist for the 12 months from 2/28/89 to 1/31/90. The maturity portfolios are reformed every three months with bonds that have maturities that occur within six months of the portfolios' labeled maturity, except for the 15– and 20–year portfolios. Mean Return is the average monthly holding period return over the 89–month time–series. Std Dev Returns is the standard deviation of the time–series of monthly returns. Mean Duration, Mean Price and N are the average duration, average price and average number of bonds in each of the maturity portfolios over the time–series. After–tax duration is calculated for the Government bond sample assuming that the marginal tax rate is 48 percent prior to 1986 and 34 percent from 1986–1992. The marginal tax rate is applied to the coupon payments and the yield to maturity in the duration calculation.

### Panel B: Comparison Asset’s Returns

<table>
<thead>
<tr>
<th></th>
<th>Mean Returns</th>
<th>Std Dev Returns</th>
<th>Minimum</th>
<th>Maximum</th>
<th>N Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R_{VW,Stock})</td>
<td>1.37%</td>
<td>4.83%</td>
<td>-21.83%</td>
<td>12.92%</td>
<td>89</td>
</tr>
<tr>
<td>(R_{EW,Stock})</td>
<td>0.96%</td>
<td>5.36%</td>
<td>-26.80%</td>
<td>13.27%</td>
<td>89</td>
</tr>
<tr>
<td>(R_{6P,Mean})</td>
<td>0.76%</td>
<td>1.13%</td>
<td>-3.19%</td>
<td>3.83%</td>
<td>89</td>
</tr>
<tr>
<td>(R_{Ryan, Govt})</td>
<td>0.96%</td>
<td>1.89%</td>
<td>-3.08%</td>
<td>5.61%</td>
<td>89</td>
</tr>
<tr>
<td>Ryan 2 Yr TSY</td>
<td>0.81%</td>
<td>0.77%</td>
<td>-1.00%</td>
<td>2.85%</td>
<td>89</td>
</tr>
<tr>
<td>Ryan 3 Yr TSY</td>
<td>0.84%</td>
<td>1.06%</td>
<td>-1.55%</td>
<td>3.46%</td>
<td>89</td>
</tr>
<tr>
<td>Ryan 5 Yr TSY</td>
<td>0.92%</td>
<td>1.68%</td>
<td>-2.73%</td>
<td>5.23%</td>
<td>89</td>
</tr>
<tr>
<td>Ryan 10 Yr TSY</td>
<td>1.04%</td>
<td>2.53%</td>
<td>-4.81%</td>
<td>7.92%</td>
<td>89</td>
</tr>
<tr>
<td>Ryan 30 Yr TSY</td>
<td>1.20%</td>
<td>3.66%</td>
<td>-6.39%</td>
<td>11.81%</td>
<td>89</td>
</tr>
</tbody>
</table>

Notes: Summary statistics for alternative bond and stock indices are presented here. Each statistic is calculated from monthly returns from 4/30/84 through 8/31/91. \(R_{VW,Stock}\) and \(R_{EW,Stock}\) are the value and equal weighted NYSE monthly returns. \(R_{6P,Mean}\) is the S&P Municipal One Million index. \(R_{Ryan, Govt}\) is an equal weighted index of the 2, 3, 5, 10 and 30 year Ryan Treasury return series. \(R_{Ryan, 2, 3, 5, 10, and 30 Yr TSY}\) are indices of returns for on-the-run Treasuries calculated by Ryan Labs, Inc. for 2, 3, 5, 10, and 30 year maturities.
Figure 1. Municipal and Government Bond Holding Period Returns and Standard Deviations

Notes: Figure 1 plots data from Table 1 in mean, standard deviation space. The municipal maturity portfolios are calculated with pre-refunded municipal bond data and the data markers plot in ascending order of maturity. The Government maturity portfolios are calculated with non-callable U.S. Treasury Notes and Bonds. Return is the mean monthly holding period return for each portfolio over the 89-month time-series. Std Dev is the standard deviation of the time-series of monthly returns. Value and equal weighted NYSE monthly returns are included for comparison. \( R_{\text{S&P Muni}} \) are the monthly returns from the S&P Municipal One Million index. The average maturity of the bonds that compose the S&P Muni varies between 6.6–7.5 years over the sample period. Ryan Labs Inc. calculates Treasury Note and Bond returns from “on the run” coupon issues with 2, 3, 5, 10, and 30 year maturities. \( R_{\text{Ryan Govt}} \) is an equal weighted index of the 2, 3, 5, 10 and 30 year Ryan Treasury return series. Each variable is calculated over the same time interval as the maturity portfolios that are in Table 1.
### TABLE 2
MATURITY PORTFOLIO MARKET MODEL BETAS

<table>
<thead>
<tr>
<th>Maturity</th>
<th>Municipal Market Model $\beta_m$'s</th>
<th>Government Market Model $\beta_m$'s</th>
<th>$\beta_{OD}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha$</td>
<td>$\beta_m$</td>
<td>Adj R²</td>
</tr>
<tr>
<td>1 Yr (N = 89)</td>
<td>0.0046* (0.0004)</td>
<td>0.0216* (0.0071)</td>
<td>0.08</td>
</tr>
<tr>
<td>2 Yr (N = 89)</td>
<td>0.0047* (0.0007)</td>
<td>0.0377* (0.0143)</td>
<td>0.06</td>
</tr>
<tr>
<td>3 Yr (N = 89)</td>
<td>0.0052* (0.0010)</td>
<td>0.0631* (0.0191)</td>
<td>0.10</td>
</tr>
<tr>
<td>4 Yr (N = 89)</td>
<td>0.0056* (0.0012)</td>
<td>0.0758* (0.0249)</td>
<td>0.09</td>
</tr>
<tr>
<td>5 Yr (N = 89)</td>
<td>0.0058* (0.0015)</td>
<td>0.0959* (0.0309)</td>
<td>0.09</td>
</tr>
<tr>
<td>6 Yr (N = 89)</td>
<td>0.0057* (0.0017)</td>
<td>0.1003* (0.0347)</td>
<td>0.08</td>
</tr>
<tr>
<td>7 Yr (N = 89)</td>
<td>0.0060* (0.0019)</td>
<td>0.1066* (0.0383)</td>
<td>0.07</td>
</tr>
<tr>
<td>8 Yr (N = 89)</td>
<td>0.0064* (0.0021)</td>
<td>0.1201* (0.0430)</td>
<td>0.07</td>
</tr>
<tr>
<td>9 Yr (N = 89)</td>
<td>0.0065* (0.0023)</td>
<td>0.1411* (0.0462)</td>
<td>0.09</td>
</tr>
<tr>
<td>10 Yr (N = 89)</td>
<td>0.0067* (0.0025)</td>
<td>0.1512* (0.0508)</td>
<td>0.08</td>
</tr>
<tr>
<td>15 Yr (N = 89)</td>
<td>0.0072* (0.0028)</td>
<td>0.2033* (0.0560)</td>
<td>0.12</td>
</tr>
<tr>
<td>20 Yr (N = 77)</td>
<td>0.0075* (0.0036)</td>
<td>0.2499* (0.0699)</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Notes: Government and municipal bond maturity portfolio market model betas are presented below. The dependent variables include pre-refunded municipal and U.S. Government maturity portfolio monthly returns for 1–10, 15 and 20 year maturities that are reformed on a quarterly basis. Except for the 20-year portfolios, the sample period for the maturity portfolio returns includes 89 monthly returns from 4/30/84 through 8/31/91. The 20-year Government portfolio is missing 12 returns from 2/89–1/90. For comparability, the $\beta$'s for the 20-year municipal portfolio are calculated from identical dates. $R_{OD}$ are monthly returns from the CRSP value weighted NYSE index. Using equation [4], the column labeled $\beta_{OD}$ provides the differences between the municipal and Government market model betas and standard errors for the difference. For comparison, market model betas are estimated for the S&P One Million municipal index and the Ryan Labs Treasury return index for on-the-run Treasury coupon issues with maturities of 2, 3, 5, 10 and 30 years. $\rho_1$ is the first order autocorrelation coefficient of the residuals. Coefficient estimates marked with an asterisk have two-tailed p-values less than five percent. Standard errors are in parentheses.
Notes: Summary statistics, market–model betas and betas with respect to nominal luxury consumption growth are estimated for six Vanguard Bond funds with monthly returns from November 1991 through September 2004. Six open–end mutual funds are selected from the Vanguard Family of mutual funds to form these pairs.¹ A U.S. Treasury and High–Grade Municipal bond are paired for three maturity ranges—money markets, intermediate–term bonds, and long–term bonds. Average monthly returns, standard deviations and betas estimated with respect to the CRSP Value weighted market (NYSE/AMEX/NASDAQ) are estimated from 155 monthly observations. The luxury consumption betas are estimated from 41 quarterly observations. The columns labeled Test of Differences provide a statistical test of the beta differences in the market model and consumption model for the municipal and government bond fund pairs. Summary statistics are also provided for the Value weighted CRSP index over the matching time interval. T–statistics are in parentheses and * and ** indicate significance at the 10% and 5% levels, respectively.

¹The fund pairs are: for the short term (Vanguard Tax–Exempt Money Market, Vanguard Treasury Money Market), for the intermediate term (Vanguard Intermediate Term Tax–Exempt, Vanguard Intermediate Term Treasury), and for the long term (Vanguard Insured Long Term Tax–Exempt, Vanguard Long Term Treasury). Fund names change occasionally in the time series.

<table>
<thead>
<tr>
<th>Fund Maturity Type</th>
<th>Municipal Funds</th>
<th>Government Funds</th>
<th>Test of Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Return</td>
<td>Std Dev Returns</td>
<td>$\beta_m$</td>
</tr>
<tr>
<td>Money Market</td>
<td>0.23%</td>
<td>0.08%</td>
<td>0.0015</td>
</tr>
<tr>
<td>Intermediate–Term</td>
<td>0.50%</td>
<td>1.10%</td>
<td>0.0159</td>
</tr>
<tr>
<td>Long–Term</td>
<td>0.56%</td>
<td>1.57%</td>
<td>0.0314</td>
</tr>
<tr>
<td>Value Weighted NYSE/Amex/Nasdaq</td>
<td>0.92%</td>
<td>4.30%</td>
<td>0.1862</td>
</tr>
</tbody>
</table>

TABLE 3
MUNICIPAL AND GOVERNMENT BOND FUND RISK MEASURES
in the sample standard deviations of the municipal and government portfolios in Table 1, and in Table 3 the sample standard deviations of government bond funds are higher than those of the municipal bond funds. This contrasts with Robinson (1960) who finds that the standard deviation of municipal returns is 1.5 times greater than the standard deviation of comparable maturity taxable corporate bond returns.\(^{12}\)

From Table 1, this result is especially striking given that the average duration of the bonds that comprise the municipal portfolios is greater for every maturity portfolio than the average pre–tax duration of the government bond portfolios. The difference in duration is most pronounced in the 15– and 20–year maturity portfolios. In the 15–year portfolios, the average duration of the municipal bond portfolio is 8.56, while the average duration of the government bond portfolio is 7.51. However, the sample standard deviation of returns is 2.71 percent for the municipal portfolio and the standard deviation for the government portfolio is 2.80 percent.\(^{13}\) A simple adjustment to taxable bond duration is also presented in Table 1. To tax–adjust duration, I apply the highest marginal tax rate (0.48 pre–1986, and 0.34 post–1986) to the coupons and yields to maturity in the duration calculation. Consistent with the observed standard deviations, the tax–adjusted duration is much closer to the duration of the tax–exempt bonds. This demonstrates that using duration as a predictor of bond volatility without regard for the tax characteristics of the cash flows can be misleading. Hessel and Huffman (1981) show that not accounting for taxes will understate the duration of a bond with taxable coupon payments. In this case, the average bond duration would incorrectly lead to the prediction that municipal bond volatility is greater than taxable bond volatility. This is not the case and should be noted given the common misconception that par municipal bonds are riskier than comparable maturity taxable bonds because they have a larger pre–tax duration.\(^{14}\)

Table 1, panel B provides summary statistics for other asset return indices over the sample period. The alternative return indices are consistent with the maturity portfolio returns. Average returns on the S&P muni index are 0.76 percent and the standard deviation is 1.13 percent. Given that the S&P index average bond maturity is six to seven years, I compare it to the six– and seven–year municipal maturity portfolios. Average returns for the S&P index are similar to the six– and seven–year maturity portfolio returns; however the S&P index exhibits substantially lower volatility. The S&P index’s lower volatility most likely reflects the diversification of the S&P index, which includes over one million municipal bonds. Ryan Labs’ on–the–run Treasury indices are very comparable to the government maturity portfolio returns. For most maturities, the on–the–run index has a slightly lower return than the government maturity portfolios. This is consistent with the argument that on–the–run issues are more liquid than seasoned Treasury bonds.\(^{15}\)

\(^{12}\) While Robinson studies corporate bond returns rather than Treasuries, it is likely that taxable corporate bond returns are more volatile than Treasury bond returns. I find the volatility of municipals no higher than Treasuries. This implies that I find municipal return volatility no higher than corporate bond volatility.

\(^{13}\) The average number of bonds in the municipal portfolios is greater than the number of bonds in the government portfolios. If the correlation between the individual municipal bond returns is less than perfect, the lower standard deviation may be a function of portfolio diversification. This explanation is unlikely given that the municipal bonds are likely to be highly correlated. All the municipal bonds in each portfolio are secured by U.S. government bonds and each portfolio is composed of bonds with nearly identical maturities.

\(^{14}\) For examples, see Fortune (1996, p. 36) and Green (1993, p. 244).

\(^{15}\) For example see Warga (1992).
Systematic Risk and the Muni Puzzle

Market Model Measures of Systematic Risk

While the standard deviation of returns provides useful information, asset pricing models focus on systematic risks rather than overall measures of risk. Therefore, Table 2 presents market–model beta estimates from equations

\[ r_{Muni}(T) = \alpha + \beta_m R_{VW\_Stock} + \varepsilon, \]
\[ r_{Govt}(T) = \alpha + \beta_G R_{VW\_Stock} + \varepsilon, \]
\[ r_{Muni}(T) - r_{Govt}(T) = \alpha + \beta_{Diff} R_{VW\_Stock} + \varepsilon. \]

The dependent variables, \( r_{Muni}(T) \) and \( r_{Govt}(T) \), are the returns from the municipal and government maturity portfolios of maturity \( T \). \( R_{VW\_Stock} \) are the monthly returns from value weighted NYSE. In equation [4], the point estimates of \( \beta_{Diff} \) are equal to the difference between the municipal and government beta coefficients, and the associated standard error tests whether the municipal and government coefficient estimates are significantly different. The hypothesis that systematic risk drives long–term tax–exempt yields up relative to taxable bonds implies that \( \beta_{Diff} \) estimates should be positive, significant and increasing with the maturity of the bond portfolio.

In Table 2, market model estimates of \( \beta_m \) and \( \beta_G \) increase with the maturity of the bonds in the portfolio. Further, all of the \( \beta_m \) estimates are statistically significant at the five percent level, and all but the one–, two–, and three–year portfolios have statistically significant estimates of \( \beta_c \). Although the point estimates of \( \beta_m \) are generally higher than \( \beta_G \), none of the differences are statistically significant at the five–percent level. Therefore, the null hypothesis that systematic risk is equal for the government and municipal maturity portfolios cannot be rejected for each maturity. Despite these insignificant results for individual maturities, in ten of the 12 regressions the municipal beta point estimates are greater than the government point estimates, which suggests that a joint test is appropriate. Pooling the estimation and testing the hypothesis that the \( \beta_{diff} \) coefficients in Table 2 are jointly zero yields a p–value of 0.12 using OLS.16

Thus, when considered collectively, the estimates provide a stronger case for the systematic risk hypothesis but, nonetheless, remain short of conventional levels of significance.17

To explore further the robustness of these results, Table 3 uses the bond fund data discussed above to estimate two types of betas for three pairs of municipal and U.S. government bond funds. First, I calculate a standard wealth beta using market model regressions for each of the six mutual funds, using the return to the value weighted CRSP index to represent the market. The differences between \( \beta_m \) and \( \beta_G \) are insignificant with the exception of the marginally significant differences in the intermediate term bond funds.

However, these results are different from the results in Table 2 in that \( \beta_m \) and \( \beta_G \) are not significantly different from zero themselves.18 The second set of beta estimates are calculated with respect to nominal quarterly consumption growth rates for luxury goods as provided by Aït-Sahalia.

16 Alternative, GLS specifications, using term and log of term as weights, lead to p–values of 0.07 and 0.12, respectively.
17 In Table 2, I also estimate market model parameters for the S&P muni index and the Ryan Labs government maturity indices. There are not any major discrepancies between the market model parameter estimates coming from these alternative return indices and the parameter estimates for the maturity portfolios.
18 These insignificant beta estimates are sensitive to the time period used for estimation. For example, if I exclude the years 2001–2004, the \( \beta_m \) and \( \beta_G \) estimates, and differences between them, look quite similar to the results in Table 2.
Parker and Yogo (2004). These consumption beta estimates are marginally significant for the municipal money market fund and significantly negative for the intermediate term government bond fund. The difference between the betas of the municipal and government intermediate funds is statistically significant and equal to 0.0727. From Table 3, I conclude that while there are some statistical differences in the intermediate term bond fund beta estimates, the fact that differences only exist for the intermediate funds, and not for the longer term bond funds, and that the $\beta_m$ and $\beta_G$ estimates are negative, suggest to me that my conclusions are robust. That is, there is little empirical evidence to support the systematic risk hypothesis.

Sharpe’s (1977) Multi–Factor CAPM Approach

While the results in Tables 2 and 3 are largely consistent with Skelton (1983), the market model risk estimates are measured relative to a market portfolio that does not include the returns from bonds. The omission of bonds from the proxy for the market portfolio seems particularly important in the case here because I am trying to measure the systematic risk of bond returns. This section addresses this issue with an additional test. In this section, I estimate a total market beta using Sharpe’s (1977) methodology. Sharpe (1977) shows that if the “true” market portfolio is composed of many component markets, the $\beta$’s with respect to each of the component markets can be aggregated into a total market $\beta$ which measures risk with respect to the more broadly defined market portfolio.

Following Sharpe (1977), if the true market portfolio is a linear combination of several component markets, then the systematic risk of the portfolio $i$ is measured by

$$\beta_{i,MKT} = \sum_{j=1}^{3} k_j \cdot \frac{\text{Var}(R_j)}{\text{Var}(R_{MKT})} \cdot \beta_{ij},$$

where $k_j$ represents the value weight of component market $j$; $\text{Var}(R)$ represents the variance of returns for component market $j$; $\text{Var}(R_{MKT})$ represents the variance of returns for the total market; and $w_j$ represents the weight placed on each component market. I assume that there are three component markets. The MKT portfolio is assumed to be a value weighted index of $R_{VW_Stock}$, $R_{Ryan_Govt}$, and $R_{S&P_Muni}$. The component market $\beta_{ij}$ estimates come from simple regressions. Using equation [5], the total market $\beta_{i,MKT}$ (for all $i = Muni(T), Govt(T)$ and $T = 1, 2, \ldots, 10, 15, 20$) reflects a weighted average of the component market $\beta_{ij}$’s for each maturity portfolio. These weights incorporate the value weight for each component market times the relative variance of that component market to the total market’s variance.

The value weights used to calculate $R_{MKT}$ and the $w_i$ are estimated by values in 1990. The NYSE market value is $2.819$ trillion, 19 the government bond market value is $2.001$ trillion and the municipal bond market valuation is $1.062$ trillion.20 The variance of realized returns for $R_{VW_Stock} = 0.0023$, for $R_{S&P_Muni} = 0.00013$, for $R_{Govt_Ryan} = 0.000358$, and the variance of returns for $R_{MKT} = 0.00070$. For the calculation of $\beta_{Govt(T),MKT}$ and $\beta_{Muni(T),MKT}$, the resulting weights used in equation [5] are $w_{S&P_Muni} = 0.03$, $w_{Ryan_Govt} = 0.17$, and $w_{VW_Stock} = 1.59$.

The results in Table 4 are consistent with the conclusions drawn from Table 2, i.e., there is no evidence to support the hypothesis that differences in systematic risk can

20 Market values for the municipal and U.S. government bond market were obtained from the Public Securities Association (PSA, 1990). PSA collects these data from the Federal Reserve System.
provide values of portfolio. The last three columns of Table 4 contain the component market explain the behavior of the relative yields.

Table 4 contains the component market portfolios, and the difference in the total market betas. The differences of the total market betas of these portfolios are very close to zero. Frequently, the market betas are larger for the government portfolios. For example, the seven–to–ten–year government portfolios have beta point

<table>
<thead>
<tr>
<th>Maturity (T)</th>
<th>Muni maturity portfolio simple regression βs for component markets</th>
<th>Govt maturity portfolio simple regression βs for component markets</th>
<th>Equation [5]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Yr (N = 89)</td>
<td>0.021*</td>
<td>0.1621*</td>
<td>0.0637*</td>
</tr>
<tr>
<td>2 Yr (N = 89)</td>
<td>0.0377*</td>
<td>0.3997*</td>
<td>0.1615*</td>
</tr>
<tr>
<td>3 Yr (N = 89)</td>
<td>0.0631*</td>
<td>0.6333*</td>
<td>0.2868*</td>
</tr>
<tr>
<td>4 Yr (N = 89)</td>
<td>0.0758*</td>
<td>0.8492*</td>
<td>0.3937*</td>
</tr>
<tr>
<td>5 Yr (N = 89)</td>
<td>0.0959*</td>
<td>1.0449*</td>
<td>0.5045*</td>
</tr>
<tr>
<td>6 Yr (N = 89)</td>
<td>0.1003*</td>
<td>1.1729*</td>
<td>0.5976*</td>
</tr>
<tr>
<td>7 Yr (N = 89)</td>
<td>0.1066*</td>
<td>1.2884*</td>
<td>0.6447*</td>
</tr>
<tr>
<td>8 Yr (N = 89)</td>
<td>0.1201*</td>
<td>1.4462*</td>
<td>0.7055*</td>
</tr>
<tr>
<td>9 Yr (N = 89)</td>
<td>0.1411*</td>
<td>1.5476*</td>
<td>0.7246*</td>
</tr>
<tr>
<td>10 Yr (N = 89)</td>
<td>0.1512*</td>
<td>1.6815*</td>
<td>0.7865*</td>
</tr>
<tr>
<td>15 Yr (N = 89)</td>
<td>0.2033*</td>
<td>1.9880*</td>
<td>0.8354*</td>
</tr>
<tr>
<td>20 Yr (N = 77)</td>
<td>0.2499*</td>
<td>2.1740*</td>
<td>1.0890*</td>
</tr>
</tbody>
</table>

Notes: Following Sharpe (1977), these tests calculate a “true market” β for the Government and municipal maturity portfolios. The true market is assumed to consist of three asset classes: the monthly CRSP value weighted NYSE returns proxy for the stock market, the S&P One Million municipal index proxies for municipal bond market returns, and Ryan Labs’ “on the run” Treasury coupon issues with maturities of 2, 3, 5, 10, and 30 years, which are used to create an equally weighted index of Government bond market returns. The dependent variables are pre–refunded municipal and U.S. Government maturity portfolio monthly returns for 1–10, 15 and 20 year maturities. The maturity portfolios are re–balanced on a quarterly basis. Except for the 20–year portfolios, the sample period for the maturity portfolio returns includes 89 monthly returns from 4/30/84 through 8/31/91. The 20–year Government portfolio is missing 12 returns from 2/89–1/90. For comparability, the βs for the 20–year municipal portfolio are calculated from identical dates. The component market β estimates are estimated with simple regressions. The total market β (for all = Muni(T), Govt(T) and T = 1, 2, ..., 10, 15, 20) reflects a weighted average of the component market βs. The weights used are the value weights for each component market times the relative variance of that component market to the total market variance. Equation [5] is used to calculate these market βs. wj represents the value weight of component market j. Var(RT) represents the variance of returns for component market j. For the purposes of these calculations, the market values are taken as of 1990. The NYSE market value is $2.819 trillion, the Government Bond market value is $2.001 trillion and the municipal bond market valuation is $1.062 trillion. The total market is defined as a value weighted combination of the three component markets. The variance of realized returns for the value weighted NYSE is 0.0023, for the Muni returns, 0.00013, for the Government returns, 0.000358, and for the value weighted index the variance of returns, MKT, 0.00070, using weights from 1990 for all three component returns. For the calculation of β_muni and β_muni,mkt the resulting wj’s are S&P Muni = 0.03, Ryan Govt = 0.17, VW Stock = 1.59.
estimates which are 0.05–0.07 greater than the municipal maturity portfolios. Therefore, I conclude that Table 4 provides no evidence to support the hypothesis that municipal bonds of increasing maturity bear an increasingly disparate level of systematic risk relative to taxable bonds. The results in Table 4 reinforce the conclusion drawn from Tables 2 and 3 that the systematic risk explanation is not the explanation for the relatively high yields on long–term municipal bonds.21

CONCLUSIONS

This paper addresses the puzzle that, relative to taxable bonds, the yields on long–term municipal bonds are much higher than predicted by theory. In many cases, it would appear that investors in tax brackets as low at ten percent may find tax–exempt bonds attractive. I find little support for the hypothesis that long–term municipal yields are relatively high because they bear a disproportionate level of systematic risk relative to taxable bonds.

While this result does not provide a solution to the long–standing puzzle posed by the relative yields of tax–exempt and taxable bonds, it focuses attention on other promising solutions, a short list of which includes: the effect of tax–timing options (Constantinides and Ingersoll, 1983; Jordan and Jordan, 1990), the impact on relative yields of the Federal Government’s option to rescind the tax–exemption feature, the impact of liquidity on the relative yields, and the impact of taxes when taxable bond portfolios can be constructed to lessen the tax burden (Green, 1993). Furthermore, the reasons that systematic risk does not explain the muni puzzle are interesting to ponder. If it were true that the marginal investor in the taxable and tax–exempt bond markets is a very wealthy investor, then consumption risk may play a very small role in the relative pricing of these assets. Work by Guo (2001), Vissing–Jorgensen (2002) and others on limited participation in stock markets might have interesting parallels in the pricing of municipal assets that are worthy of further research.

More generally, I find that the standard deviation of municipal bond portfolio returns is nearly identical to the standard deviation of comparable maturity government bond portfolio returns. This is interesting given that the average durations of the municipal bonds that comprise the portfolios are always greater than the average durations of the government bonds in the government portfolios. This observation is contrary to the argument that municipal bonds are riskier than comparable maturity taxable bonds because they have larger durations. Evidence in this paper implies that this analysis is incomplete because it ignores the impact of taxes on duration. A tax adjustment similar to that derived by Hessel and Huffman (1981) appears to be important when comparing assets with differing tax status.

Acknowledgments

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21 Two additional robustness tests are not reported. First, coefficients from a statistical factor model of returns are estimated with respect to the stock market, government market, and municipal market in a multivariate regression rather than simple regressions used to implement Sharpe’s methodology. While beta estimates are uniformly higher for their own market indexes, the differences appear to offset each other and are consistent with the conclusion that municipal and government bond returns have similar levels of systematic risk. Second, given evidence in Fama and French (1992) that book–to–market is a priced factor in returns, I also estimate the risk weights on book–to–market using time–series book–to–market data from Pontiff and Schall (1998). For most maturity portfolios, the book–to–market estimates are not significant. More importantly, risk weights on book–to–market are not significantly different for the government and municipal portfolios.
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