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Municipal bonds: a contingent claims perspective

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Abstract

The purpose of this paper is to provide an overview of the municipal bond market with an emphasis on the numerous embedded contingent claims. Embedded contingent claims include the standard call features, sinking funds, the advance refunding option, the synthetic advance refunding option, the credit risk option (default risk), marketability, and the numerous tax-related events. Municipal bond investors must carefully assess the relative value of these contingent claims before investing in municipal bonds. Also, due to unique risk premiums within the municipal bond market, it is important to carefully structure the municipal bond holdings, paying particular attention to duration, within the context of an overall financial plan. There appears to be a benefit to lengthening the duration of the municipal bond portion of the portfolio. © 1999 Elsevier Science Inc. All rights reserved.

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1. Introduction

Of the bond markets tracked by The Bond Markets Association ($12.9 trillion in all), the relative size of the U.S. municipal bond market at the end of 1998 was 11.30%. U.S. Treasuries comprised 26.0%, government agency mortgage-backed securities 15.6%, corporate bonds 18.5%, U.S. Federal government agencies 8.3%, money market securities

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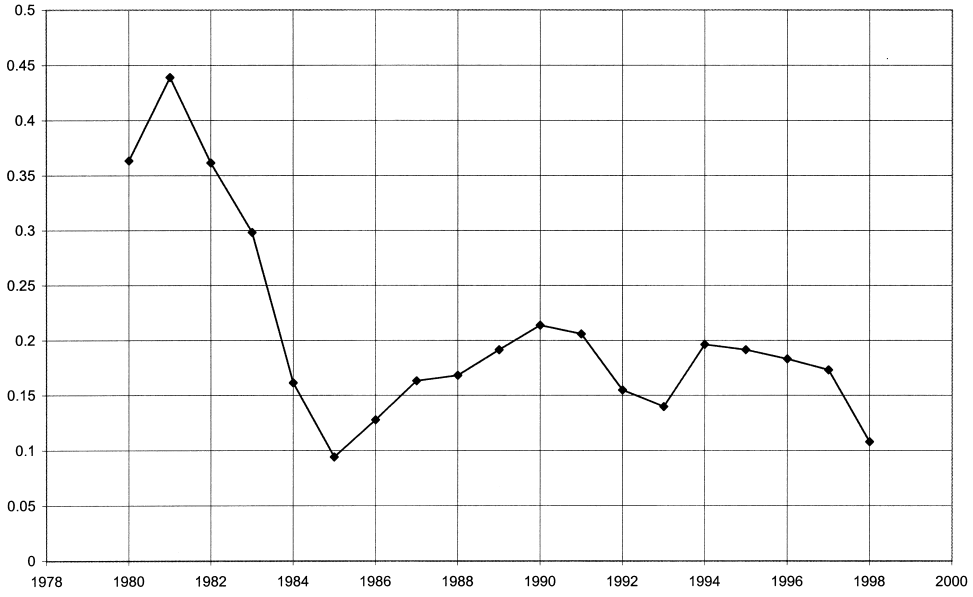

Fig. 1. Percentage of Municipal Debt Issued as Short-Term

15.3%, and asset-backed securities 4.9%. The municipal bond market had $1.46 trillion outstanding at the end of 1998, and hence it is relatively large (www.bondmarkets.com).

According to The Bond Market Association, municipal bonds were held in the following proportions at the end of 1998: 30.5% households, 16.6% mutual funds, 13.2% money market funds, 4.3% closed-end funds, 7.2% trusts, 7.2% commercial banks, 13.4% insurance companies, and 7.6% other. It is interesting to note that based on IRS estimates, 30% of municipal interest reported was from taxpayers with less than $50, 000 of adjusted gross income (www.bondmarkets.com and Feenberg and Poterba, 1992).

1.1. Municipal bond market maturity preferences

The propensity for tax-exempt issuers to prefer long-term bonds seems different from other debt markets. For example, Fig. 1 illustrates the percentage of short-term bonds issued in the municipal market. Clearly there is a strong preference for longer-term fixed rate bonds. For example, the average maturity of U.S. Treasury securities is estimated to be 5 years and 4 months as of September 30, 1997 (www.treas.gov/treasury/financial/domfin/debtprof.htm). Hence there seems to be a greater preference for longer-term debt by municipal governments than by the Federal government. Kidwell and Koch (1983) noted that municipal ". . . borrowers can use long-term debt for current operations only by constitutional amendment or public referendum . . . " making it difficult for municipalities to substitute between long and short-term debt.

Municipal bond investors also have preferred maturities and these preferences are reflected in observed yields. These preferences, as revealed in observed market yields, are

different between the taxable and tax-exempt bond markets. For example, The Bond Market Association (1998) reported that for the first quarter of 1998, of the $75.9 billion of newly issued municipal debt, 94% have a long maturity. However, it is known that municipal bond investors have a strong preference for shorter maturities. For example, McEntee (1998) reported ". . . a gap exists between supply and demand in tax-free money market, that hold about $175 billion in assets. Short-term notes offer about $45 billion of eligible investments yearly and VRDNs (Variable Rate Demand Notes) trigger about $30 billion of debt annually, leaving sizable room for synthetic derivative products to grow." In other words, derivative securities are creating the additional supply of synthetic short-term municipal debt demanded by the market.

The supply of municipal debt is thought to be relatively interest-inelastic and the equilibrium marginal tax rate will be a function primarily of investor demand, which may vary by maturity. Therefore changes in the quantity of investor funds pursuing municipal bonds will influence the relative pricing of municipal bonds. Rosenbloom (1976) documented when insurance company demand for municipal bonds declined, municipal yields rose relative to the taxable market. Rosenbloom (1976) observed that a rise in the ratio of tax-exempt to taxable yields ". . . has been further aggravated by a decline in the demand for municipals by fire and casualty insurance companies in the first quarter of 1975, because of a low level of industry profits." Prior to the 1980s commercial banks were dominant holders of short-term debt and hence the ratio of tax-exempt to taxable yield for the shorter maturities was related to the corporate tax rate. This relationship does not hold for longer maturities and some conclude other investors must demand those municipal bonds. Poterba (1986) and Metcalf (1992) as well as others found empirical support for the yield ratio being a function of the corporate tax rate.

Empirical evidence supporting the strong preference of tax-exempt issuers for longer-maturity bonds is found in the yield to maturities of municipal bonds when compared to constant maturity treasuries of similar maturities. Recall that the tax-exempt rate is technically equal to the taxable rate times one minus the tax rate. Using the yields on taxable and tax-exempt bonds, we can compute the implied tax rate with the well-known relationship $y_{TE} = (1 - \mathrm{T})y_T$ where y_T is the yield on the taxable rate, y_{TE} is the yield on the tax-exempt rate, and T is the implied tax rate. In this case, we solve for the tax rate. The implied marginal tax rate ($IMTR_t$) from these two interest rates is:

$$IMTR_t = 1.0 - \frac{y_{TE,t}}{y_{T,t}} \tag{1}$$

where the subscript t denotes a point in calendar time.

1.2. The role of taxes

If the tax-exempt yield curve is steeper than the taxable yield curve, then the implied tax rate will be lower for longer maturities. Fig. 2 provides an illustration of the historical pattern of implied marginal tax rates by bond maturity. The taxable rate is based on U.S. Treasuries and the tax-exempt rate is based on AAA credit, general obligation municipal bonds. Notice

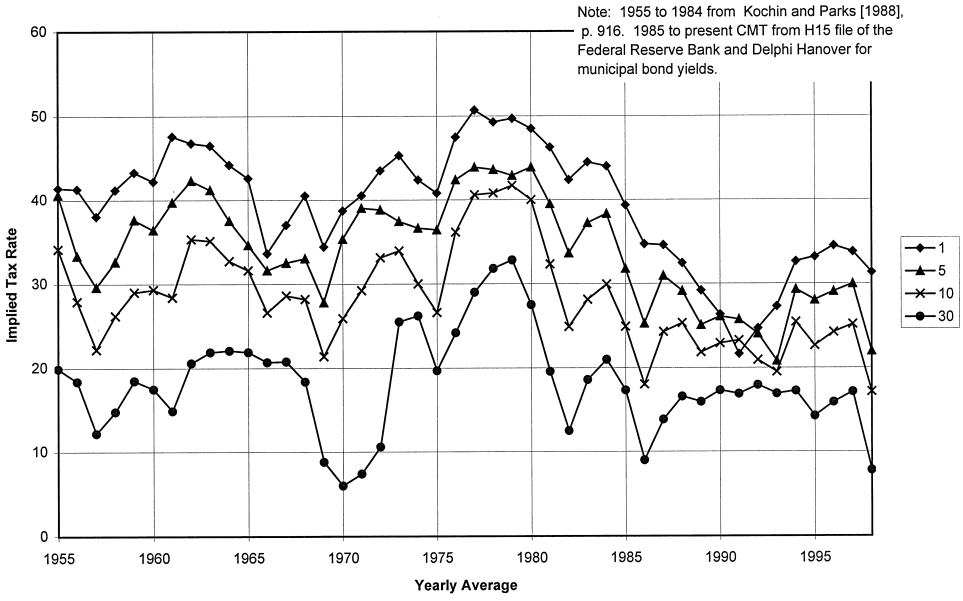

Fig. 2. Implied Marginal Tax Rate by Maturity

that the average implied tax rate was almost always lower for longer maturity bonds. Hence the tax-exempt yield curve is almost always steeper.

Fig. 2 suggests that longer maturity municipal bonds offer relatively higher yields. Therefore in a bond portfolio, perhaps longer maturity bonds should be tax exempt and shorter maturity bonds should be taxable. This relationship has been studied for decades, for example, Yawitz (1978) studied this relationship in detail over 20 years ago.

Green (1993) presented a model for the relationship between the taxable and tax-exempt markets based on arbitrage activities within the taxable bond market. He asserts that taxable investors can synthetically create zero coupon bonds that result in no tax liability until expiration, at which time there is a taxable capital gain. This arbitrage activity will influence the appropriate tax-exempt yield and hence the tax-exempt to taxable yields ratio. Empirical evidence in Green (1993) and Chalmers (1998) found that Green's model is not rejected. Based on continuous compounding and \$1 par, the present value based on the tax-exempt rate (P_{TE}) can be expressed as:

$$P_{TE} = \$1e^{-y_{TE}t} \tag{2}$$

where t denotes time to maturity in years and y_{TE} is the tax-exempt yield to maturity. The present value based on the taxable rate can be expressed two ways as:

$$P_T = \$1e^{-y_T t} = [\$1 - T(\$1 - P_T)]e^{-y_{TE}t} \tag{3}$$

where the second expression is the after-tax cash flow discounted at the tax-exempt rate. The implied marginal tax rate is given in equation (1), and substituting Eq. (1) into Eq. (3) and solving for the implied marginal tax rate, we have:

Table 1
Implied marginal tax rate based on tax deferral and continuous compounding[a]

Maturity	y_T = 5%	y_T = 10%	y_T = 15%	y_T = 20%	y_T = 25%
0	40.00%	40.00%	40.00%	40.00%	40.00%
1	39.40%	38.81%	38.22%	37.64%	37.06%
2	38.81%	37.64%	36.48%	35.35%	34.25%
3	38.22%	36.48%	34.80%	33.17%	31.61%
4	37.64%	35.35%	33.17%	31.10%	29.15%
5	37.06%	34.25%	31.61%	29.15%	26.88%
10	34.25%	29.15%	24.81%	21.22%	18.30%
15	31.61%	24.81%	19.69%	15.94%	13.21%
20	29.15%	21.22%	15.94%	12.47%	10.13%
30	24.81%	15.94%	11.19%	8.49%	6.81%
Infinite	0.00%	0.00%	0.00%	0.00%	0.00%

[a] We assume a 40% marginal tax rate and markets are in equilibrium.

$$IMTR_t = \frac{-\ln[\$1 - T(\$1 - e^{-y_T t})]}{y_T t} \tag{4}$$

Assuming a constant tax rate (T), the $IMTR_t$ declines as the maturity is increased. The ability to defer taxes has the effect of lowering the implied marginal tax rate. Table 1 illustrates the influence of tax deferral on the implied marginal tax rate given in Eq. (4). We see that tax deferral is equivalent to lowering the implied marginal tax rate. For example, at a 10% taxable yield to maturity and a 40% tax bracket, deferring taxes for 10 years lowers the implied tax bracket to 29.15%. It remains somewhat unclear how effectively high tax entities can defer taxes on investments. However, the ability to defer taxes influences the implied tax rate as well as the relative attractiveness of tax-exempt bonds.

1.3. Short maturity municipal market

We turn now to examine the short maturity municipal market. Most variable rate municipal issues are AAA insured making these issues relatively homogeneous. The reference floating interest rate is called the BMA rate or technically the BMA Municipal Swap Index or The Bond Market Association Municipal Swap Index. (On Bloomberg, for example, type MUNIPSA). The BMA rate (or BMA index) is an index of rates based on high grade, 7 day, tax exempt, variable rate demand obligations (VRDOs) that is reset each Wednesday. The index is constructed by Municipal Market Data, a Thomson Financial Services Company. For a VRDO issue to be considered for the index, it must be weekly reset effective on Wednesday, not subjected to alternative minimum tax, have at least $10 million outstanding, have the highest short-term rating (VMIG1 by Moody's or A-1+ by S & P 500), pay interest on a monthly basis, and be calculated on an actual/actual day count basis. Issues included in the index are screened for outliers and participating remarketing agents cannot represent more than 15% of the index. The BMA index includes roughly 250 issues in any given week (www.bondmarkets.com). Fig. 3 provides weekly BMA index values and 3-month LIBOR

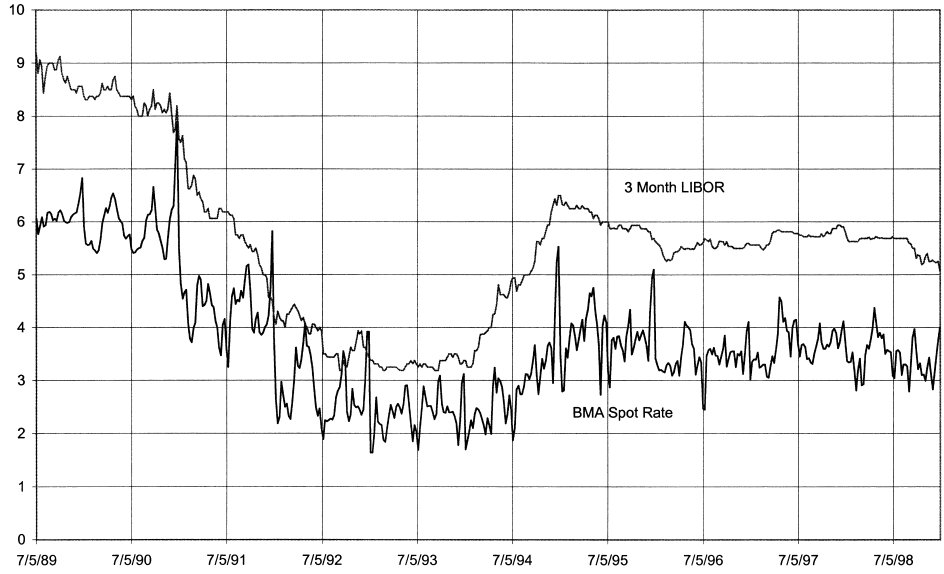

Fig. 3. The BMA and 3 Month LIBOR July 5, 1989 Through December 30, 1998

from July 5, 1989 through December 30, 1998. The BMA index is quite volatile and the seasonal trends are clearly evident, especially at year-end. Fig. 3 also includes the 3-month LIBOR rate that is a popular rate upon which the taxable interest rate swaps are based and is a very close proxy for negotiated bank certificate of deposit rates. Three month LIBOR exhibits much less short-term variability and is less seasonal. Although other proxies for the taxable rate are possible, such as the U.S. Treasury rates, we use LIBOR due to its highly liquid swap market and because it represents banks' marginal cost of funds.

Fig. 4 presents the implied marginal tax rate (IMTR) based on the 90-day average of BMA index and the initial 3-month LIBOR. We use the 90-day average for two reasons. First, we need to compare the 90-day LIBOR to a comparable term. Second, BMA swaps are settled based on 90-day average BMA. Although there is variability in the IMTR, it does seem related to current corporate and individual tax rates. The ratio has also been more stable in the recent past.

2. Enumeration of embedded derivatives

In this section we identify and discuss several embedded derivatives in most municipal bonds. Embedded contingent claims include the standard call features, sinking funds, the advance refunding option, the synthetic advance refunding option, the credit risk option (default risk), the numerous tax-related events, and marketability. Municipal bond investors should carefully assess the relative value of these contingent claims before investing in municipal bonds.

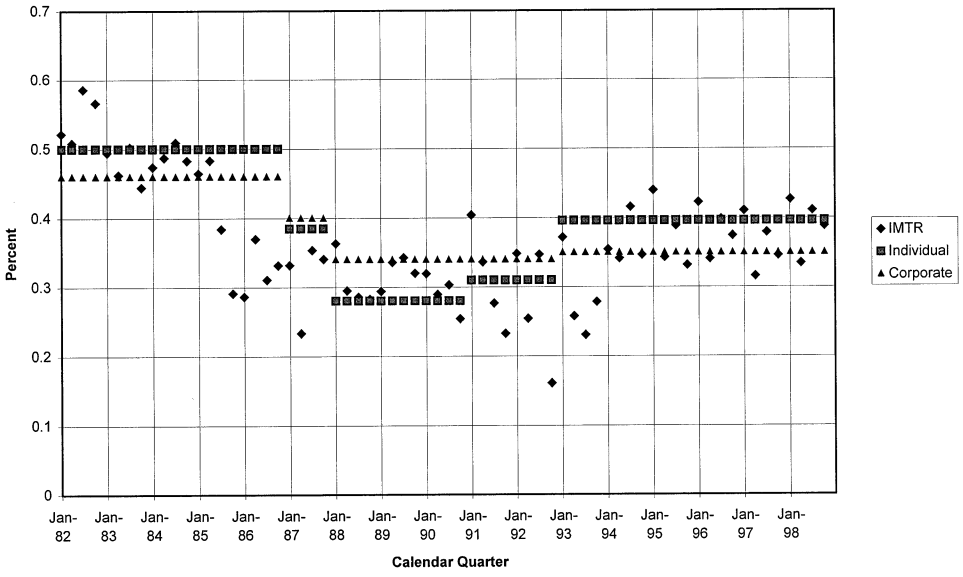

Fig. 4. Tax Rates and Implied Marginal Tax Rates

2.1. The call option

Most municipal bonds are callable after 10 years. The value of the embedded call makes the yields higher because the bond investor is short the option. However, municipal bonds are different in many ways.

Municipal bonds have lower coupons, hence higher durations, implying more interest rate risk. Van Horne (1987) observes that higher interest rate risk must be compensated with a higher yield that would explain the higher tax-exempt to taxable yield ratio. Mallman (1981) and Stock (1985) also address this issue. Leibowitz (1981) and Sorensen (1983 suggested that different interest rate risk levels account, in part, for the higher tax-exempt to taxable yield ratio. Fortune (1991) observed that "... the exposure of municipal bonds to capital gains taxes when market discounts emerge will place municipal bonds at a disadvantage in periods when bond prices are more volatile." Chalmers (1998) presented strong evidence that embedded call options do not completely explain the higher tax-exempt to taxable yield ratio for longer maturities. Thus, there seems to be significant other factors to consider with municipal bonds.

2.2. Sinking funds

Sinking fund provisions within municipal debt require the retirement of a portion of the debt usually on an annual basis. Sinking funds typically contain a whole set of embedded options that are inter-related. Kalotay and Williams (1992) provide a detailed review of the sinking fund options.

For example, some bond indentures include a sinking fund acceleration option giving the

issuer the option to accelerate the sinking fund retirement. This option is equivalent to a series of partial European-style options that are usually noncumulative. Sinking funds typically include a delivery option that gives the issuer the opportunity to satisfy the requirements of the sinking fund provisions with open market purchases of the bonds. This option is more valuable when rates rise because the bonds can be retired at an open market price below par.

There may also be a designation option that allows issuer to apply bonds the firm has purchased in the open market to future sinking fund requirements. If the firm optimally exercises this option, it will tend to reduce the value of the remaining outstanding bonds.

There is a very subtle ownership option related to sinking funds. If the bonds are held in large blocks, this limits the ability of the firm to conduct outright purchases without paying a premium. The ownership option reduces the value of the delivery option.

When purchasing municipal bonds with sinking funds, it is important to understand the terms of the sinking fund.

2.3. The advance refunding option

Because municipal bonds are tax-exempt, one would expect the coupon rate on the municipal bonds to be lower than the yields on U.S. Treasury securities, even when overall interest rates have fallen since the municipal bonds were issued. Due to tax laws prohibiting arbitrage transactions, municipal issuers are permitted only one (typically) advance refunding opportunity. Municipal bonds are advance refunded by issuing more tax-exempt bonds and using the proceeds to purchase U.S. Treasury securities to defease the original issue. Hence, after the advance refunding, the original municipal bonds are still outstanding but they are backed by U.S. Treasury securities and therefore the municipality does not have to make the subsequent coupon payments from their operating cash flow. Therefore, the original bonds receive essentially a credit enhancement to AAA.

The benefit of an advance refunding is that it permits the municipality to monetize the embedded call option. Typically the municipality receives a cash payment from the advance refunding process and it is somewhat erroneously called “present value savings.” It is erroneous because an asset was sold, specifically the embedded call options.

Municipal finance directors are under increasing pressure to manage the municipality’s interest rate risk efficiently. Often they are solicited to conduct a refinancing of their existing bonds. It is generally accepted that the marginal benefits derived from a municipal bond refunding should exceed the marginal costs. The marginal cost is the extinguishing of the embedded options and the marginal benefit is the present value savings.

A callable bond can be represented as a non-callable bond less the value of the call option. Because the issuer has the right to call the bonds, the bond investor is short this call option. Mathematically, the relationship can be expressed as

$$P_t^C = P_t^{NC} - CO_t \tag{5}$$

where P_t^C denotes the callable bond, P_t^{NC} the non-callable bond with identical maturity and coupon, and CO_t denotes the embedded call option premium. As illustrated for corporate bonds in Emery and Lewellen (1990) and Jordan and Jorgensen (1998), one can illustrate the

Table 2
Balance sheet of a municipality (in market value and in millions)

Assets		Liabilities and equity	
Cash	$400	Floating debt	$100
Other assets	$600	Fixed debt	$310[a]
		Other liability	$90
		Equity	$500
Total assets	$1,000	Total liability and equity	$1,000

[a] Suppose originally issued 30-year tax-exempt bonds, callable in 10 years at par, $300 million par value, and carry a 5.3% coupon. Five years have elapsed and interest rates have fallen.

refunding decision using hypothetical balance sheets. Table 2 illustrates in over-simplified terms, a municipality with debt and "equity." In all the subsequent tables, the dollar amounts are given in current market value.

Because interest rates have fallen, the bonds are trading well above par. However, the call feature prevents the price from rising too far. If we split the callable bond into its component pieces we can represent the balance sheet as given in Table 3. The embedded call option on the bond is worth say $23 million and the 25 year fixed rate bond is worth say $333 million. The explicit recognition of the option as an asset helps one understand the appropriate method for assessing the refunding decision.

Suppose an investment bank suggests doing an advance refunding on the fixed rate debt. Also assume the advance refunding produced proceeds of $15 million. To simplify the analysis, we assume the new bonds will be 25 year fixed rate bonds so they will have the same market value as the old bonds without the embedded option. The balance sheet is illustrated in Table 4.

Clearly the firm has increased its cash position but decreased its equity. Advance refundings are popular with municipalities and bondholders do not complain because their original bonds get a credit enhancement (recall the original debt's rating goes to AAA because they are backed by U.S. Treasury bonds). Advance refunding also generally resolves the uncertainty about when the municipal bonds will be called. The advance refunded municipal bonds will be called on the first call date.

Table 3
Typical balance sheet of a municipality (in market value) explicitly accounting for embedded option

Assets		Liabilities and equity	
Cash	$400	Floating debt	$100
Option	$23	Fixed debt	$333
Other assets	$600	Other liability	$90
		Equity	$500
Total assets	$1,023	Total liability and equity	$1,023

Table 4
Typical balance sheet of a municipality (in market value) advance refunding at 5% savings (issue non-callable debt)

Assets		Liabilities and equity	
Cash	$415	Floating debt	$100
Other assets	$600	Fixed debt	$333
		Other liability	$90
		Equity	$492
Total assets	$1,015	Total liability and equity	$1,015

2.4. The synthetic advance refunding option

The refunding bonds, the bonds used to advance refund the original bonds, could be synthetically advance refunded even though they cannot be advance refunded. If a forward refunding transaction is conducted, then the embedded call option will be exercised on the first call date. This actually should increase the value of the refunding bonds because the time value of the call option is eliminated.

Alternatively the embedded call option could be sold directly (at least from an economic viewpoint). Suppose the decision to call the bonds is essentially sold to an investment banking firm. In this case, the investment-banking firm will likely more efficiently make the call decision lowering the value of the refunding bonds. For example, the municipality might decide not to call the bonds if they are trading at 101 percent of par whereas the investment-banking firm might efficiently call the bonds.

2.5. Credit risk (default option)

Municipal bonds have higher default risk than U.S. Treasury securities, and hence the tax-exempt to taxable yield ratio is higher. Table 5 reports the actual municipal default experience since 1940. According to The Bond Market Association, “The default rate for municipal securities is extraordinarily low. Of the 403, 152 issues sold since 1940, only 0.5% or 2, 020 issues have had either a technical or actual default. This figure also includes issues

Table 5
Municipal default experience[a]

Period	Number of defaulted issues	Total number of long-term issues	Default rate
1940–49	79	40,907	0.20%
1950–59	112	74,592	0.2
1960–69	294	79,941	0.4
1970–79	202	77,620	0.3
1980–94	1,333	130,092	1
Total	2,020	403,152	0.5

[a] Source: The Bond Market Association, www.bondmarkets.com.

that defaulted but where investors ultimately received either full or partial payment of principal and interest. It is worth noting that the default rate of corporate bonds is substantially higher, in excess of 2%" (www.bondmarkets.com). However, there are reasons to be concerned about default risk for municipal bonds. Many times it is difficult to understand political motivations. Also municipal assets are difficult to seize when there is default and financial statements of municipalities are generally lacking in quality.

By examining refunded municipal bonds, Chalmers (1998) concluded the high ratio of tax-exempt to taxable yields for longer maturities is not based on municipal default risk. However, numerous prior studies came to the opposite conclusion, for example, Trzcinka (1982). However, other prior studies, such as Buser and Hess (1986), failed to find evidence of default risk playing a significant role.

2.6. Marketability

It is generally accepted that marketability has market value and hence more liquid bonds trade at lower yields. There are clearly differences in liquidity between municipal bonds and U.S. Treasury bonds. For example, The Bond Market Association (1997) reported that the average daily trading volume for municipal bonds was $8.6 billion with U.S. Treasuries $242.2 billion average daily volume. Thus the ability to alter the general marketability of the municipal bonds will influence its value. Wilson and Stewart (1990) provide evidence that marketability could also be improved with better reporting practices.

3. Tax-related events

Holding municipal bonds subjects investors to unique risks related to unanticipated changes in tax policies. In this section, we survey these risks and their influence on the relative attractiveness of owning municipal bonds. Essentially, governments hold an option on tax rates and tax policies. Tax policy risk should be fully reflected in the tax-exempt bonds because tax policy will directly influence the after-tax value of the future cash flows. Lowering the marginal tax rates will result in an increase in the yields on tax exempt bonds, an increase in the ratio of tax-exempt to taxable yields, and the current market value of longer maturity municipal bonds will fall.

Fig. 5 illustrates the highest marginal tax rates for both individuals and corporations during most of this century. The main insight from this figure is the fact that tax policy is quite volatile.

There are numerous issues encompassed in tax policy risk. We enumerate a few here.

First, municipal bonds are a hedge against federal tax policy risk. An increase in federal income tax rate implies lower municipal bond yields. These lower yields imply capital gains on municipal bond investments at a time when an investor is experiencing losses from higher taxes.

Second, Congress may entirely eliminate tax-exemption status of all municipal bonds. The U.S. Supreme Court in the case of South Carolina versus Baker, established that the U.S. government has the right to rescind the tax-exemption feature of municipal bonds, and more

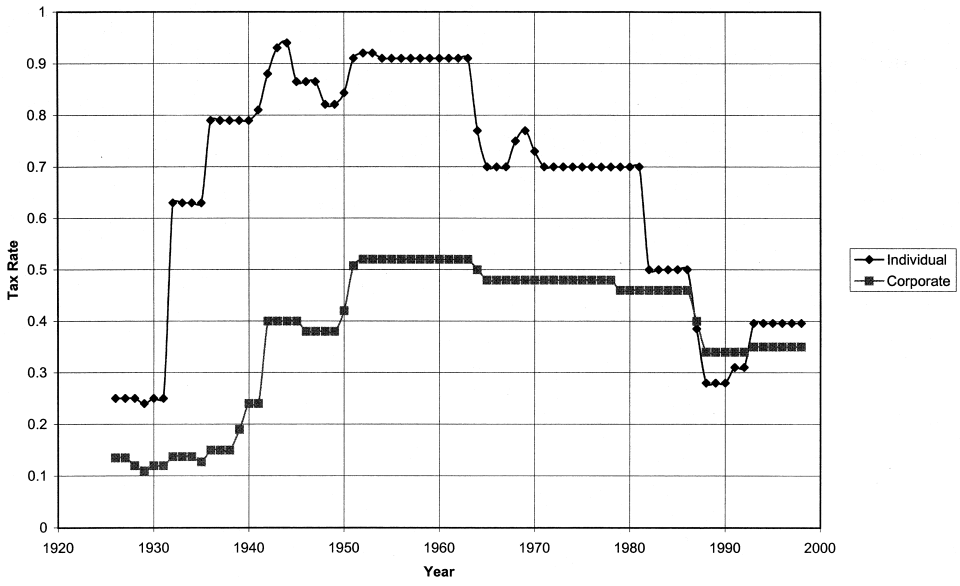

Fig. 5. Highest Marginal Tax Rates

broadly, the U. S. government has the constitutional right to tax interest on municipal bonds. Poterba (1989) and Chalmers (1998) provide more details.

Evidence that the tax-exemption status of all municipal bonds could be eliminated is seen in the following historical account by Ott and Meltzer (1963).

> Interest income from securities issued by state and local governments was specifically exempted from the federal income tax under section 103(a)(1) of the first Income Tax Act passed pursuant to the Sixteenth Amendment. Virtually every Secretary of the Treasury since its passage has favored removing the exemption feature . . . Congress has some six times defeated proposals to remove the exemption . . . (p. 1)

Also, according to Ott and Meltzer (1963), there were 114 resolutions from 1920 to 1943 to repeal the tax exemption of municipal interest.

Third, Congress may change various features of the Federal tax code, such as lowering the marginal tax bracket, adjusting the alternative minimum tax (AMT), broadening the scope of Individual Retirement Accounts (IRAs) and so forth. For example, Arak and Guentner (1983) noted,

> Of the possible explanations for these phenomena (ratio of tax-exempt to taxable bond yields being too high), we find that neither liquidity considerations, nor the behavior of banks and property and casualty companies, nor the recession can explain the entire rise.

A key additional factor appears to be the Economic Recovery Act of 1981 (ERTA), implying that the reduced benefits of tax exemption to issuers will persist. . . . "(ERTA) reduced marginal tax rates and widened the availability of income tax deferral through IRAs, Keoghs, and other plans." (Guentner (1983), p. 145). Fama (1977) examined the role of municipal bonds in commercial bank portfolios.

Chalmers (1998) regressed the implied tax rate on maturity and observes "*[i]t* is also notable that the slope has become less negative in the period following the Tax Reform Act of 1986. Furthermore, during economic downturns and times of tax law uncertainty it appears that implied tax rates are lower for all maturities and the differences across maturities are less pronounced." (p. 298–99). Metcalf (1992) also examined tax policy influence on municipal bond supply.

Recent news related to this aspect include the House of Representatives vote on July 17, 1998 to sunset the current tax code effective December 31, 2002. Clearly, the future of tax policy is uncertain.

Fourth, due to unforeseen issues to the municipal bond investors, the particular municipal bonds are declared fully taxable by the IRS due to fraud or error in compliance. Although the municipal bond investor bears the risk of an unfavorable IRS ruling, most municipal issuers will choose to settle with the IRS to maintain their integrity within the municipal bond investor community.

Fifth, changes in laws about who can own municipal bonds. For example, there are restrictions on companies with regard to the quantity of municipal bonds they can own. For example, Chalmers (1998) observed, ". . . the tax code continues to allow all nonfinancial U.S. corporations to hold up to 2% of their assets in tax-exempt bonds and simultaneously deduct the interest on attributed debt from their taxable income." (p. 284–5).

Sixth, investors have some flexibility as to when tax liabilities are incurred. This flexibility could be viewed as a tax timing option.

Seventh, U.S. Treasury bonds are exempt from state and local taxes. Most studies of the taxable versus tax-exempt market use only U.S. Treasury bonds. This state tax exemption may slightly bias the reported results that compare municipal bonds with U.S. Treasury bonds.

Eighth, tax treatments for taxable and tax-exempt bonds are not symmetric with regard to capital gains and losses. Municipal bonds' coupon payments and original issue discount (OID) bonds are not subject to Federal taxes, but capital gains are subject to Federal taxes. Premium municipal bonds must amortize the bond's basis, but the amortized premium cannot be taken as an expense for tax purposes. The amortization is for the purpose of computing capital gains. Premium taxable bonds may be amortized and taken as an annual tax-deductible loss over the life of the bond.

On the subject of asymmetric treatment of capital gains, Sorensen [1983] stated that ". . . the tax treatment of investor income is a major contributory factor to changes in the municipal yield curve shape." (p. 61). Leibowitz (1981) developed a comprehensive interest rate model and concludes that tax-exempt bonds are more volatile in general and discount tax-exempt bonds are more volatile than premium tax-exempt bonds due to these asymmetric tax treatments. Also we note that almost all states exempt their own bonds from state taxes. Johnson and Johnson (1996) review in detail various tax issues related to municipal bonds.

Ninth, changes in expected future taxes influence the tax-exempt to taxable yield ratio. Poterba (1989) observed that tax news explains some changes in the yield ratio and he estimated forward tax rates. Recently, Koch and Stock (1997) observed that the yield ratio is a function of individual tax rates but not corporate tax rates (they asserted that corporate taxes actually have the opposite effect). Fortune (1991) also examined this yield ratio and

documented an inverse relationship with forward tax rates and concluded that ". . . anticipated future income tax rates will have a strong impact on municipal bond yields" (p. 35).

Tenth, state and local tax issues influence the observed relationship between tax-exempt and taxable markets. Chalmers (1998) reported that, " . . . anecdotal evidence in Green (1993) implies that while state tax differences induce small parallel shifts in municipal yield curves, state taxes do not affect the slope of the municipal term structure" (p. 291). Severn and Stewart (1992) focused on the role of state taxes in the U.S. Treasury market and concluded that the break-even state tax rate was low. Also, in many states, a municipal bond issued in another state is fully taxable with regard to the state income tax. This influences the relative attractiveness of various states' municipal debt. Singh and Dresnack (1998) provide a comparative analysis of the performance of tax-exempt state funds and other tax-exempt funds.

4. Summary

The purpose of this paper was to review the major issues related to investing in municipal bonds. Also, the numerous embedded contingent claims related to municipal bonds were discussed. Municipal bonds have the same types of embedded contingent claims as corporate bonds as well as many others. The tax-exempt term structure of interest rates is much steeper than the taxable term structure suggesting various duration-related strategies when managing a personal portfolio that contains both taxable and tax-exempt bonds. There has been a historical benefit to lengthening the duration of a municipal bond portfolio, due perhaps to a tax risk premium.

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