What Makes the Municipal Yield Curve Rise?

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Yield curves are fundamental to the understanding of bond values. In the taxable market, the standard benchmark is the Treasury curve, which indicates the levels at which the U.S. government can borrow for different maturities. The yield curves of other issuers are quoted as spreads to the Treasury benchmark. From these, it is a simple matter to calculate discount rates appropriate for valuing such issuers' bonds.

In this article, we focus on yield curves in the tax-exempt municipal market, usually referred to as *scales*. Although taxable yield curves may sometimes be inverted, it is well known that municipal yield curves are always upward sloping. We will provide a straightforward explanation for this oddity of the tax-exempt market. A secondary conclusion of our study is that, in its raw form, a municipal yield curve is not suitable for valuation.

THE SHAPE OF THE MUNICIPAL YIELD CURVE

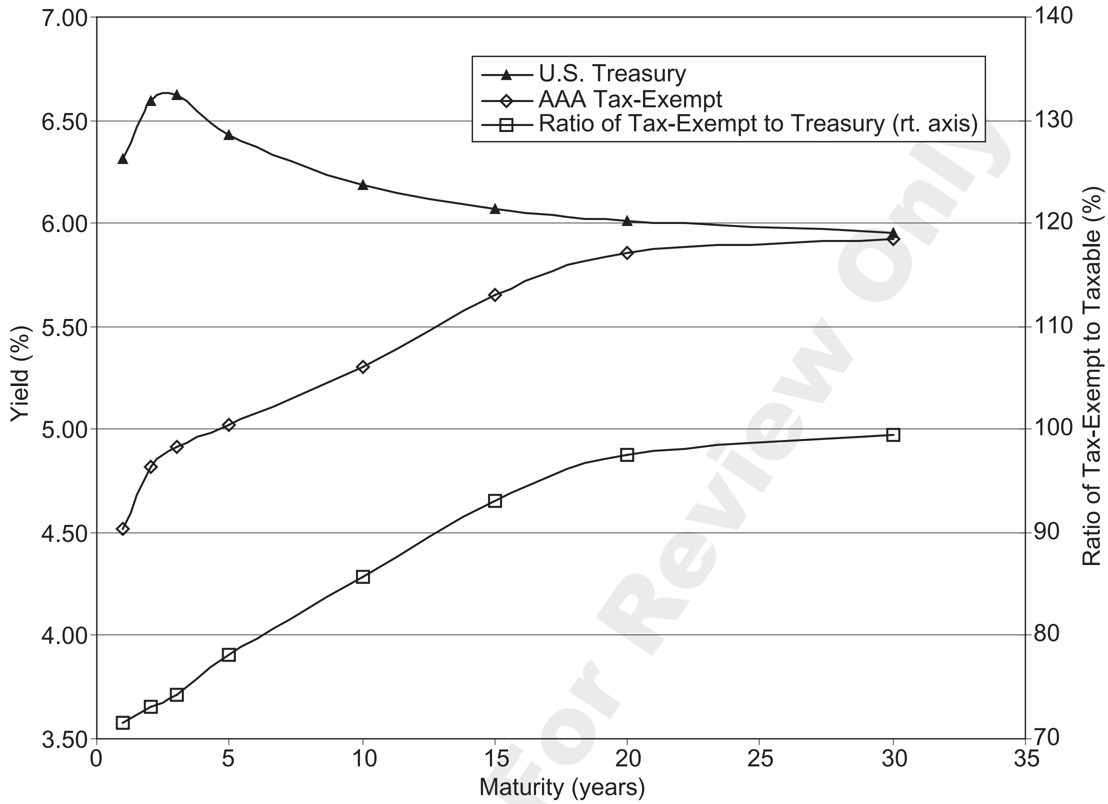
Because interest paid on municipal bonds is exempt from federal income tax, the yield of a municipal bond is lower than that of an otherwise strictly identical taxable bond.[1] The relationship between tax-exempt and taxable yields has been the subject of extensive academic research,[2] focusing on the ratio of tax-exempt to taxable yields of various maturities. We will use TEXT (for Tax-EXempt to Taxable) as shorthand for this ratio term structure. Although the TEXT is not the primary topic of this article, it is instructive to briefly review the theories related to it.

There are two well-known empirical observations about the TEXT. First, for very short maturities, the level of the TEXT is usually close to (1 minus the tax rate). This is in line with intuition, because a taxable investor should be indifferent between short-term taxable and tax-exempt bonds. Second, the TEXT is always upward sloping; that is, the longer the term, the higher the ratio. It is less clear why this should be the case. Various explanations have been proposed, with the most prominent ones referring to tax risk, default risk, and liquidity risk. As we will show, none of these explanations is satisfactory.

Exhibits 1 and 2 provide examples of the TEXT for two different trading days, June 1, 2000, and November 16, 2006, respectively. The short end of both ratio curves provides a reasonable proxy for the marginal tax rate. In both cases the TEXT shows an upward slope even though the Treasury yield curves are inverted.

A common explanation for the upward slope is tax risk. Tax rates may be reduced through legislation, thus diminishing the appeal of tax-exempt bonds relative to taxable bonds. This argument is not entirely convincing, because tax rates may be as likely to increase

EXHIBIT 1
Tax-Exempt vs. Taxable Rates on June 1, 2000



Source: Delphis Hanover (used by permission).

as to decrease. But even in the absence of legislative change, the relative value of tax-exempt bonds might be adversely affected by declining demand attributable to tax considerations. For example, if major institutional investors become temporarily unprofitable, and thus effectively non-tax-paying, they may prefer to purchase taxable bonds instead of munis. This happened in the mid-1980s, when property and casualty insurance companies stopped buying munis for a while. Similar events may occur in the future.

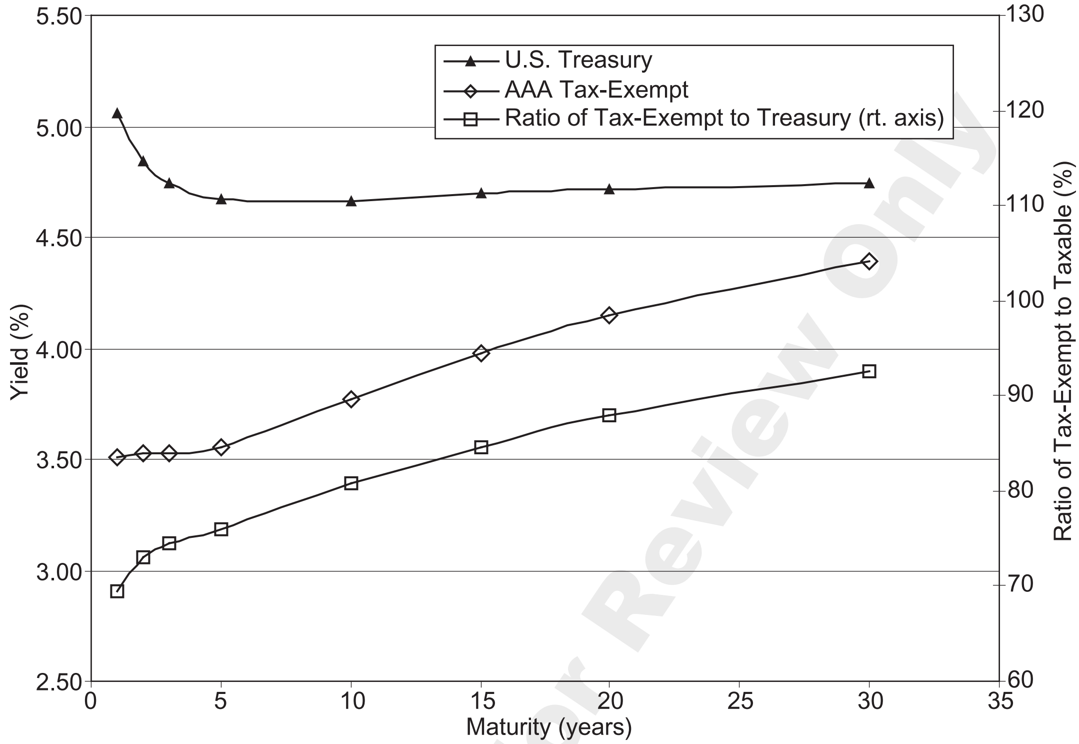
Another explanation is default risk. For example, Yawitz, Maloney, and Ederington [1985] argued that there is significant default risk even in AAA munis. The observable yields of prerefunded municipal bonds expose an obvious flaw of this logic. Because they are fully collateralized by direct obligations of the U.S. Treasury, prerefunded bonds are essentially risk free, yet their yields are virtually the same as those of AAA munis.[3] Also pointing away from the default risk argument is the fact that the TEXT of the same municipal issuer is always higher than would be expected based solely on tax rates.

A third theory attributes the upward slope of the TEXT to a lack of liquidity, which arguably reduces prices and consequently increases yields. Again, the evidence does not adequately support the case. A convenient way to measure the value of liquidity is to compare yields of illiquid private placements to those of large publicly traded issues of the same borrower. In the taxable market, for an investment-grade issuer, the difference is unlikely to exceed 20 basis points (bps), but it would require a considerably larger reduction than 20 bps to bring long-term municipal yields in line with taxable yields.

To summarize, much scholarly effort has been concentrated on the fact that the TEXT slopes upward, yet no single theory exists that adequately explains why this should be so. Here, we take a slightly different tack. We will focus on the raw municipal yield, observing that it

EXHIBIT 2

Tax-Exempt vs. Taxable Rates on November 16, 2006



Source: Delphis Hanover (used by permission).

is always upward sloping, regardless of the shape of the prevailing taxable curve. If we can explain why this should be the case, it will follow that the TEXT *must* also always slope upwards.

The shape of the raw municipal curve, while receiving less scrutiny than the TEXT, has not entirely eluded researchers' attention. For example, Temel [2001] asserted that "The yield curve for municipal bonds is almost always upward sloping... The primary reasons are: (1) the greater volatility of longer-term municipal bonds, (2) the heavy supply of intermediate- and long-term bonds as a percentage of the total market, and (3) the relatively limited demand for longer-term securities by corporate purchasers of tax exempt bonds" (p. 205). RSW Investments [2005] noted that "[i]n fact, an inverted yield curve has not occurred in the municipal bond market due to its unique supply/demand dynamics." Needless to say, neither of these explanations is theoretically defensible.

In fact, there is a simple, straightforward explanation for why municipal yield curves always slope upward—because, at longer maturities, they are derived from the prices of callable bonds, rather than the prices of optionless bonds. The entrenched convention in the world of municipal bonds is to assume, unless explicitly stated to the contrary, that long-term bonds are callable. In particular, the yields reported in the industry-standard municipal benchmark curves are based on reference bonds callable after 10 years. This convention is in direct contrast to every other market sector. For example, the yields used in the U.S. Treasury curve or the LIBOR swap curve always refer to the yields of optionless bonds or swaps. Previous researchers have evidently not been aware of the difference between the convention in the municipal bond market and the rest of the fixed-income world. We will show that as long as the quoted municipal yields refer to those of callable bonds, the long end of the corresponding yield curve must be upward sloping.

THE CALL PROVISION OF MUNICIPAL BONDS

In contrast to Treasury bonds, long-term municipal bonds are almost always callable (subject to *optional redemption* in industry parlance) after 10 years. Historically, long-term muni bonds were redeemable at a price of 102 (or occasionally 101) at the end of the tenth year. Thereafter, the call or redemption price would decline annually in even decrements until the end of the twelfth year, after which they would be redeemable at a price of par. It has recently become customary for the initial call price to be set at 100, instead of 102 or 101.

Why do participants in the municipal bond market prefer callable bonds to optionless bonds and prefer a call price at 100 rather than at a premium? The impetus would appear to come from underwriters, who undoubtedly prefer more transactions to less. The lower call price increases the likelihood that the bonds will be called at the end of the tenth year, creating the need to issue new (refunding) bonds. Furthermore, municipal bonds are usually eligible for advance refunding (Fabozzi, Kalotay, and Dorigan [2008]) and are often refunded well before the expiration of the 10-year call protection period.[4] Advance refunding has been a major source of revenues and profits for the participating investment banks. In addition to underwriting fees, advance refundings often entail the use of interest rate derivatives, the trading of which tends to be a virtually riskless source of profit for the investment banks. A review of the callable bonds issued during the past 30 years reveals that nearly all of these were refunded well before maturity. In light of these facts, it comes as no surprise that the investment banks are fervent advocates of callable bonds.

Also tilting in favor of more transactions is the recent practice of issuing bonds with a 5% coupon across the maturity spectrum. In 2007 more than 50% of the new issues came to market with a 5% coupon. Because during this time the yields of high-grade municipal bonds have been below 5%, many long-term bonds have been sold at a substantial premium to par. Needless to say, the likelihood of such bonds being refunded is much greater than bonds that were issued with lower coupons. In fact, it has become customary to express the prices of newly issued 5% bonds in terms of yield-to-call (YTC) rather than yield to maturity (YTM). Such a distinction is unnecessary for bonds callable at par that are sold at par, because in that case the YTM and YTC are the same.

From Optionless Yields to Callable Yields

In this subsection, we explore the shape of the "fair" callable yield curve that corresponds to a specified optionless curve. Investors charge a premium that provides compensation for the potential loss of income in the event that interest rates fall and the bonds are called. This premium can be expressed either in terms of dollars—how much less investors pay for a callable bond than for an otherwise identical optionless bond—or in terms of coupon—how many basis points the coupon would have to increase to preserve the bond's value if it were callable. We follow the latter convention and express the premium in terms of incremental coupon.[5]

The charge for the call option is determined by the market's collective expectation about the course of interest rates. Following industry convention, we assume that interest rates follow a lognormal random walk. Given the issuer's yield curve, the only parameter needed to price the call option is the volatility of short-term interest rates (for the sake of simplicity, we assume that the mean reversion is zero).

Before presenting the numerical results, let us discuss in qualitative terms what we expect to observe. For example, volatility should increase the coupon premium because of the greater probability that rates decline to a level that warrants refunding. While volatility also increases the likelihood that rates will move much higher, the coupon premium is dominated by the probability of lower rates.

Next, consider the effect of maturity. Because a longer maturity gives rise to more refunding opportunities, it increases the time value of the call option. In turn, the coupon premium for the call option on a long bond should be greater than that of a short bond.

In addition to interest rate volatility and maturity, we consider the shape of the optionless curve. The shape indicates the expected trend of interest rates, the so-called forward rates. An upward-sloping yield curve suggests that rates are more likely to increase than to decline and an inverted curve indicates the opposite. Of course, the actual evolution of rates may be quite different from expectations, and the degree of this uncertainty is captured by the specified volatility.

We will derive the callable yield curve that corresponds to a given optionless curve. The callable rate for any maturity is higher than the optionless rate, but what can be said about the shape of the callable curve? Could it be downward sloping?

If the optionless curve is upward sloping, rates are expected to increase and, thus, new bonds are less likely to be called. Therefore, the premium charged for the call option should be modest, but it should still be greater for longer bonds. In any case, adding these premiums to the underlying optionless rates will produce an upward-sloping callable curve. Similar considerations apply if the optionless yield curve is flat; that is, a longer maturity increases the premium for the call option, which results in an upward-sloping callable curve.

Finally, what if the optionless curve is inverted? In this case rates are likely to decline, the likelihood of a call is substantial, and the premium for the call option will be greater. This premium will depend, among other factors, on the difference between the initial call date and the final maturity. As we will see, however, if the difference is large—say, a 10-year call and a 20- or 30-year maturity—*the long end of the callable curve will slope upward even if the optionless curve is inverted*.

Examples. We will consider three optionless curves. In each case, the 30-year rate is anchored at 5%. For the upward- and downward-sloping cases, we fix the short-term rate at 3% and at 6%, respectively. The bonds are callable at par 10 years after issuance and the interest rate volatility is 9%.

The results reported in Exhibit 3 confirm our predictions. First, consider maturity. The premium for the call on the 20-year bond is always less than the premium on the 30-year bond (17 bps versus 24 bps for the upward-sloping case, 29 bps versus 44 bps for the flat case, and 39 bps versus 58 bps for the downward-sloping case).

Turning to the shape of the yield curve, we note that the call option costs less when the curve is rising than when it is inverted. For the 20-year callable bond, the call premium is 17 bps when the curve slopes upward and almost 39 bps when it is inverted. For the 30-year callable bond, the premium is 24 bps when the curve slopes upward and the premium exceeds 58 bps when the curve is inverted.

Finally, and most importantly, note the shape of the callable curve. *The callable curve slopes upward, independent of the shape of the underlying optionless curve.* Even when the curve is inverted and the 20-year optionless rate is higher than the 30-year optionless rate (5.10% versus 5.00%), the relationship is reversed for callable rates (5.49% versus 5.58%).

EXHIBIT 3
Coupon Premium for Callable Bonds

Yield Curve	20-Year Bond			30-Year Bond		
	Callable (%)	Non-Callable (%)	Coupon Premium (bps)	Callable (%)	Non-Callable (%)	Coupon Premium (bps)
	A	B	B minus A	C	D	D minus C
Upward Sloping	4.970	4.800	17.0	5.241	5.000	24.1
Flat	5.294	5.000	29.4	5.444	5.000	44.4
Downward Sloping	5.486	5.099	38.7	5.582	5.000	58.2

Note: The premium varies depending on maturity and slope of yield curve. Upward-sloping curve begins at 3% and moves to 5% in Year 30; flat curve is 5% across all maturities; downward-sloping curve begins a 6% and falls to 5% by Year 30.

Bonds are assumed callable after 10 years at par. Coupons are determined using an interest rate volatility of 9%.

EXHIBIT 4
AAA MMD Benchmark Yield Curve on August 15, 2007

Maturity (Yrs)	2	3	5	10	15	20	25	30
Yield (%)	3.64	3.68	3.77	4.10	4.35	4.45	4.54	4.59

Note: Published yields are at selected points in the term structure. For the NC-Life bonds up to the 10-year maturity, yields are yield-to-maturity (YTM), then yield-to-call (YTC) thereafter. Benchmark bonds are structured as NC-10 callable at par for maturities beyond 10 years. Source: Thomson's Municipal Market Data (MMD).

Stripping Out the Call Option

This procedure of estimating callable yields from optionless yields needs to be reversed if the benchmark yield curve is based on callable yields, as is the case in the municipal world. From the given callable yields, we can infer the underlying optionless yields. As an example, consider the municipal benchmark curve shown in Exhibit 4.

To avoid ambiguity, we need to specify the structure of the optionless bonds (e.g., bonds valued at par, zero-coupon bonds, 5% bonds, or any other coupon structure). In the following examples, we estimate the yields of par bonds from the 5% callable benchmark curve. Converting these par yields to the YTMs of other optionless structures is straightforward.

The critical input into the estimation of the optionless yields from callable yields is interest rate volatility. As discussed earlier, the value of the call options increase with volatility, which widens the spread between callable and optionless yields. To provide some insight about the effect on the implied rates, we next consider three volatilities: 7%, 9%, and 11%.

The calculation of the implied optionless rates ("stripping out the call option") is an iterative procedure. Starting on the short end, the rates up to Year 10 are optionless. Using these rates, along with the callable Year 11 rate, we can solve for the optionless 11-year rate. Next, we can move on to solving for the optionless Year 12 rate, using the optionless rates through Year 11 and the callable Year 12 rate. And on it goes. The procedure is straightforward, but tedious, and is analogous, both in method and tedium, to calibrating a tree.

The results of the stripping procedure are presented in Exhibit 5. The upward-sloping benchmark curve is based on the yields of bonds callable after Year 10 at par, but what about the implied optionless curve? According to Exhibit 5, the 24-bp increase (4.59% minus 4.35%) from Year 15 to Year 30 may be an illusion. At a volatility of 7%, this difference declines to a mere 4.4 bps (448.4 minus 444.0). At volatilities of 9% and 11%, the implied optionless par curve is inverted between Year 15 and Year 30 at –4.3 bps (434.1 minus 438.4) and –13.1 bps (418.9 minus 432.0), respectively.

It is evident from the example that, in its raw form, a benchmark municipal yield curve is unsuitable for valuation. As a preliminary step, it is necessary that the call option be stripped out of the benchmark curve. Meaningful discount rates then can be obtained from the resulting implied optionless curve.

EXHIBIT 5

Implied Noncallable Par Rates on August 15, 2007: Deriving Par Curve from Benchmark Curve

Maturity (Years)	Published Yield 5% Coupon Benchmark (%)	Implied Noncallable Par Rates (%)		
		7% Vol	9% Vol	11% Vol
2	3.640	3.640	3.640	3.640
3	3.680	3.681	3.681	3.681
5	3.770	3.772	3.772	3.772
10	4.100	4.108	4.108	4.108
15	4.350	4.440	4.384	4.320
20	4.450	4.474	4.376	4.272
25	4.540	4.508	4.382	4.249
30	4.590	4.484	4.341	4.189

Note: Yields are yield-to-maturity (YTM) for the NC-Life bonds up to the 10-year maturity, then yield-to-call (YTC) thereafter. Benchmark bonds are structured as NC-10 callable at par for maturities beyond 10 years.
Source: Thomson's Municipal Market Data (MMD).
Implied noncallable coupon rates are for bonds priced at par.
Calculations via iteRate analytics from Andrew Kalotay Associates, Inc.

CONCLUSION

It is a well-known fact that the municipal yield curve is always upward sloping. Several theories have been proposed to explain this phenomenon, although none are very convincing. Previous researchers have apparently overlooked the fact that the yields under consideration refer to those of bonds callable at, or close to, par after 10 years. In this article, we have shown that as long as the yields are based on callable bonds, the curve will always be upward sloping, regardless of the shape of the underlying optionless curve. The optionless yields implied by the callable yields can be obtained iteratively, by stripping out the call options. Our analysis suggests that there may be days when the optionless municipal curve is actually inverted. This phenomenon deserves scholarly attention beyond the scope of this article.

ENDNOTES

[1]Because there are no so-called risk-free tax-exempt issues, the yield of even the highest-rated tax-exempt issue may, at times, rise above the taxable curve.

[2]See Mosley [2008] for a summary.

[3]The MMD Benchmark Yields indicate that the five-year benchmark rate for AAA munis was 3.33% on June 30, 2008. The yield on a five-year prerefunded bond was 3.38% (See Thomson's MMD "Data-Line" at https://www.tm3. com/mmd/14902_w.html).

[4]At the close of August 2008, prerefunded and escrowed bonds in the S&P Main Municipal Bond Index had a market value in excess of $148 billion, which was over 14% of the index's total market value and the second largest sector after insured bonds.

[5]Note that the incremental coupon can be converted to incremental YTM. But by assuming that all the bonds in question are sold at par, the latter conversion is not necessary.

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