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Determinants of the decreasing term structure of relative yield spreads for taxable and tax-exempt bonds

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The empirical finding that the relative yield spread for taxable and tax-exempt bonds decreases across the term structure is usually attributed to tax differentials and/or arbitrage opportunities. Using monthly data, it is found that the decreasing term structure of relative yield spreads is determined by the decreasing forward marginal tax rate; increasing default risk premium; increasing tax-timing option premium; and expected rate of inflation.

I. INTRODUCTION

While the coupon payments from taxable bonds (such as treasuries and corporates) are subject to income tax depending on the tax status of each investor, the coupon payments from municipal bonds are tax-exempt.[1] The tax implications for discount and premium bonds are different, and will be discussed subsequently in detail.

Since financial markets set the nominal yields of taxable bonds higher than those of tax-exempt bonds with the same term to maturity and level of risk, the yield spread is expressed commonly by a relative measure called the 'implicit tax rate'. Based on the empirical evidence, the relative yield spread decreases as maturity increases. This is also true across time as shown in Fig. 1 using real data.

Mussa and Kormendi (1979) interpret this downward sloping term structure as the nominal rates of subsidy for state and local governments. Buser and Hess (1986) find that extending the Miller (1977) model to include financing costs explains various possible contemporaneous relationships between the tax rate estimates of the marginal investor implied by one-period yield spreads and the corporate tax rate. In their studies, Kochin and Parks (1988) suggest that arbitrage opportunities exist. On the contrary, Green (1993) attributes the anomalous behaviour of taxable bond yields to a possible formation of a portfolio of taxable bonds that will postpone the tax payment. While Kochin and Parks assume away some of the plausible determinants of this anomaly, Green assumes that the arbitrage portfolio is related only to the taxable bonds and his approach is dependent upon the realism of specific trading strategies.

Since investors are unlikely to expect that more distant forward tax rates will be significantly lower than less distant rates, relative yield spreads may be a very noisy proxy for the tax effect. Other plausible factors may contribute to the downward slope of the relative yield spreads across maturities. Thus, the primary objectives of this paper are two-fold: first, to incorporate various plausible factors into a unified model of the term structure of relative yield spreads; and secondly, to assess empirically the power of this model to explain the downward sloping term structure of relative yield spreads.

The factors are the maturity-varying forward tax rate, default risk premium, tax-timing option value and expected rate of inflation. Unlike conventional empirical tests which focus on the yield spreads between one long-term and one short-term yield, the empirical tests reported herein focus on various cumulative (from shorter to longer term) and contingent segments of the term structure for the whole period and three subperiods thereof. The empirical approach used herein has two advantages over the conventional approach. First, it is able to reveal the direction and magnitude of the

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[1] This refers to the American federal tax rate. Municipal bonds are issued by state and local governments in the United States.

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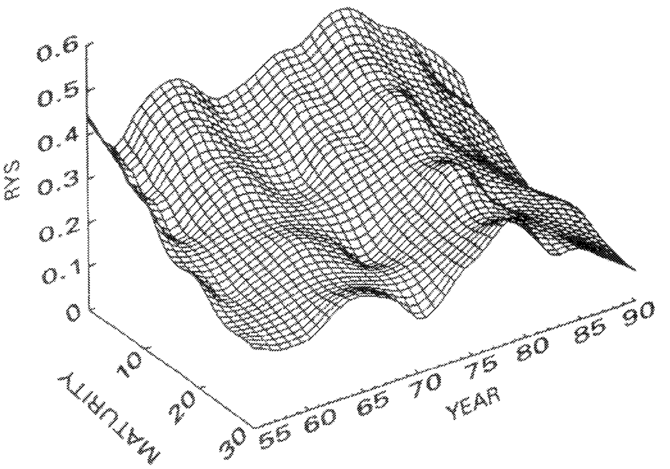

Fig. 1. *The term structure of relative yield spreads*

effect of each determinant on any partition of the term structure of yield spreads. Secondly, our approach easily accommodates the plausible hypothesis of market segmentation.

The remainder of this paper is organized as follows. In Section II, the theoretical model, the null hypotheses, and the test methodology are discussed. In Section III, the data and estimation of the model are described, and the empirical findings are presented and analysed. And finally, in Section IV, some concluding remarks are offered.

II. THEORETICAL MODEL AND TESTABLE HYPOTHESES

Before the unified model is proposed, it is useful to examine four factors that may explain the downward sloping term structure of relative yield spreads. The first factor is a maturity-varying, implicit marginal tax rate. A direct test for such a tax rate is very difficult because the expected forward tax rate embedded in future coupon payments and its associated risks are unobservable. Implicit tax rates must be calculated from *ex post* yields on taxable and tax-exempt (default-risk-free) bonds for marginal investors in equilibrium (see Constantinides and Ingersoll, 1984). Elmer (1986) argues for a constrained equilibrium in which the relatively low, observed marginal tax rates for long-term municipal bonds are largely caused by segmentation effects due to tax and regulatory constraints on investor behaviour.

The second factor is the maturity-varying default risk premium. The realized rate of return is higher if bond default occurs later in the life of a bond, since such bonds have coupon payments for a longer period of time. Altman (1987) and Asquith, Mullins and Wolff (1989) find that the likelihood of default increases as the term to maturity increases for higher yield bonds. While Kochin and Parks (1988) assume that default risk is not material for tax-exempts, Loviscek and Crowley (1990) conclude that the high rating of prime grade municipal bonds differs from that of federal debt issues. Furthermore, Trzcinka (1986) finds that the risk hypothesis better explains the rising term structure for municipal bonds than does the institutional demand (segmentation) hypothesis.

The third factor is the maturity-varying tax-timing option. Since only realized capital gains (and losses) have tax implications, a sophisticated bondholder will adopt a trading strategy where the objective is to minimize the present value of the stream of tax payments. This can be accomplished by realizing capital losses to reduce income tax payable and by purchasing bonds of longer maturities to defer the realization of capital gains. Because such an option has value to the bondholder for minimizing (maximizing) tax payments (cash flows), the bond's price will be higher and its yield will be lower. Thus, the bondholder can be viewed as having bought a 'put' option when purchasing the bond. The value of this option is closely related to the direction and the magnitude of the changes in general interest rates and term to maturity. Constantinides and Ingersoll (1984, Table 5) show that the value of the tax-timing option embedded in a bond's price can be substantial for various tax regimes. Litzenberger and Rolfo (1984) find that the tax-timing option effect of Constantinides–Ingersoll is significant for three government bonds with the same maturity.

Although taxable and tax-exempt bonds have embedded tax-timing options, their values differ. In general, the value of the tax-timing option of the tax-exempt bond is less than or equal to that of the taxable counterpart. The main difference between the optimal trading policies for tax-exempt and taxable bonds is that no trades are ever made at a price above par for the tax-exempt bonds. While the price of the tax-exempt bond at premium is amortized to adjust the price basis, it has no tax implication. The converse exists for the taxable bond (see Constantinides and Ingersoll, 1984, pp. 333–34).

The fourth factor is inflation expectations. According to Fisher (1930), nominal returns equal the expected real return plus the expected rate of inflation. Darby (1975) and Feldstein (1976) suggest that the Fisher hypothesis is misspecified due to the omission of tax effects.[2] Fama (1975) finds evidence that supports the Fisher hypothesis for tax-exempt and taxable yields. Hein and Mercer (1990) conclude that changes in the taxable/tax-exempt yield spread are not sufficient to explain all of the contemporaneous variation in inflation rates.

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[2] Based on the assumption that investors concentrate on after-tax real rates of return, their theory implies that an increase (decrease) in inflation expectations generally will lead to a greater-than-proportional increase (decrease) in the nominal interest rate. Thus, a taxable bond yield is more sensitive to the inflation rate than the yield on a tax-exempt bond, since the inflation mark-up is higher for the former.

The unified model, which will incorporate the above four factors, for the term structure of relative yield spreads is derived as follows. Let Y_{mt}^T and $Y_{\tau t}^T$ be the yields to maturity of the municipal (m) and the government (τ) bonds, respectively, maturing at T as of time t. The relative yield spread between the taxable and tax-exempt bonds is given by:

$$\theta_t^T = 1 - Y_{mt}^T / Y_{\tau t}^T \tag{1}$$

The empirical evidence finds that θ_t^T is decreasing in T. The term structure of the relative yield spreads, ranging from $T - k$ to T in terms of maturity at time t, can be denoted as:

$$S_t(T, T - k) = \theta_t^T - \theta_t^{T-k} \tag{2}$$

where $0 < k < T$ and k is an integer.

Let τ_t^T be the implicit tax rate imposed at time t on the rate of return of the taxable bond given that the bond is to be held to maturity T. Let $\lambda_t(p, T)$ be the default risk premium at time t for the tax-exempt bond which has a default probability of p, and matures at T. Let $o_t(di_t, T)$ be the difference in the tax option premia at time t between the taxable and tax-exempt bonds. This difference increases as the state variable, change in interest rates (denoted by di_t), increases, and as the term to maturity (denoted by T) increases. $o_t(di_t, T)$ is implicitly related to the taxable bond price because di_t is inversely related to bond prices. Let $E_{t-1}\pi_t$ be the expected rate of inflation at time t given the information at $t - 1$. The following non-arbitrage condition is used:

$$Y_{mt}^T - \lambda_t(p, T) = o_t(di_t, T)\, Y_{\tau t}^T + (1 - \tau_t^T)\, Y_{\tau t}^T \tag{3}$$

Here $Y_{mt}^T - \lambda_t(p, T)$ represents the default-risk-adjusted yield on the tax-exempt bond. The right-hand side of Equation 3 represents the after-tax yield on the taxable bond adjusted by a possible tax-timing option premium difference between the two types of bonds. The no arbitrage condition ensures that the equality holds.[3]

When the expected rate of inflation is considered, Equation 2 becomes a perturbed equation by the addition of the term, $E_{t-1}\pi_t$, to yield:

$$S_t(T, T - k) = \theta_t^T - \theta_t^{T-k} + \gamma_{T-k}^T E_{t-1}\pi_t \tag{4}$$

where $0 < k < T$, k is an integer, and γ_{T-k}^T is a coefficient which measures the sensitivity of the term structure of relative yield spreads to inflation expectations.

Combining Equations 1, 2, 3 and 4 yields:

$$\begin{aligned} S_t(T, T - k) = {} & (\tau_t^T - \tau_t^{T-k}) + \lambda_t(p, T - k)(1/Y_{\tau t}^{T-k}) \\ & - \lambda_t(p, T)(1/Y_{\tau t}^T) - (o_t(di_t, T) \\ & - o_t(di_t, T - k)) + \gamma_{T-k}^T E_{t-1}\pi_t \end{aligned} \tag{5}$$

Using the Taylor expansion of the fourth term on the right-hand side of Equation 5 around $di_t = 0$ and the fact that $o_t(di_t, T)|_{di_t=0} = 0$ for all T, Equation 5 is approximated by:

$$\begin{aligned} S_t(T, T - k) = {} & (\tau_t^T - \tau_t^{T-k}) + \lambda_t(p, T - k)(1/Y_{\tau t}^{T-k}) \\ & - \lambda_t(p, T)(1/Y_{\tau t}^T) - \alpha di_t + \gamma_{T-k}^T E_{t-1}\pi_t \end{aligned} \tag{6}$$

where $\alpha = \{\partial o_t(di_t, T)/\partial di_t|_{di_t=0} - \partial o_t(di_t, T - k)/\partial di_t|_{di_t=0}\} > 0$.[4]

When the implicit tax rate, default risk premium and the marginal changes in the option value differences follow stationary and orthogonal stochastic processes, Equation 6 can be written as:

$$\begin{aligned} S_t(T, T - k) = {} & \beta_0 + \beta_1(1/Y_{\tau t}^{T-k}) + \beta_2(1/Y_{\tau t}^T) \\ & + \beta_3 di_t + \beta_4 E_{t-1}\pi_t + \varepsilon_t \end{aligned} \tag{7}$$

where

$$\begin{aligned} \beta_0 &= (\mu_\tau^T - \mu_\tau^{T-k}) \\ \beta_1 &= \mu_\lambda^{T-k} \\ \beta_2 &= -\mu_\lambda^T \\ \beta_3 &= -(\mu_o^T - \mu_o^{T-k}) \\ \beta_4 &= \gamma_{T-k}^T \end{aligned}$$

The μ_f^T is the mean of the stochastic process representing factor f associated with the bond with maturity T. ε_t is a random error term.

Based on Equation 7, four hypotheses are tested. The first hypothesis, H_0^1: $\beta_0 = 0$, states that the implicit tax rates imposed on the taxable bond are constant across the term structure from $T - k$ to T. If the implicit tax rates decrease along the term structure, β_0 is expected to be negative. The second hypothesis, $H_0^2: \beta_1 + \beta_2 = 0$, states that the default risk premia of the tax-exempt bonds are constant along the term structure from $T - k$ to T. The theory predicts that, if the default risk premia increase along the term structure, then β_1 and β_2 should be positive and negative, respectively, and $|\beta_2| > |\beta_1|$. The third hypothesis, $H_0^3: \beta_3 = 0$, states that

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[3] Equation 3 holds for the yield to maturity. Hence, the statistical analyses are performed on such data herein.

[4] Note that:

$$\partial o_t(di_t, T - k) / \partial di_t|_{di_t=0} > 0,$$

if $T - k > t$ and $k \geqslant 0$, and

$$\partial o_t(di_t, T) / \partial di_t|_{di_t=0} > \partial o_t(di_t, T - k)/\partial di_t|_{di_t=0},$$

if $T > t$, $t < T - k < T$. These conditions imply that changes in the difference of the option premium, α, are always positive and increase as the holding period of the bond increases.

marginal option value differences, due to responses of the term structure of relative yield spreads to interest rate changes, are constant along the term structure from $T - k$ to T. The theory predicts that β_3 should be less than zero. The fourth hypothesis, H_0^4: $\beta_4 = 0$, states that the term structure of relative yield spreads does not respond to the expected rate of inflation along the term structure from $T - k$ to T. Based on the existing literature, the sign and magnitude of β_4 are unknown.

III. EMPIRICAL FINDINGS

Monthly data for the US taxable and tax-exempt bonds, and the CPI for the period 1954:1–1978:2 are used in this paper. Both types of bonds have five yield series with maturities of 1, 2, 5, 10, 20 and 30 years, respectively. The bond data are obtained from the *Analytical Records of Yields and Yield Spreads* prepared by Salomon Brothers Inc.

The first two explanatory variables in Equation 7 are the transformations of the yields of taxable bonds with maturities T and $T - k$, respectively. The other two variables are changes in interest rates and inflation expectations. The series of interest rate changes were calculated using the average of the differences of logarithms of the one year government bond yields over an aggregate window $[t - 2, t + 2]$ based on the preliminary tests which indicated that this series had a close contemporaneous relationship with the term structure of the relative yield spreads.[5] Inflation expectations are calculated as the log-difference of the CPI. Given investor rationality, the expected rate of inflation is assumed to be the actual rate plus a white noise term (as in Hein and Mercer, 1990).

Through the preliminary empirical identification, the regression with the first-order autoregressive error is shown to be appropriate for Equation 7. The maximum likelihood procedure was used to estimate the models. Regressions for Equation 7 are run for various T and $T - k$. The first type of maturity partitioning examines the impact of each factor when the term structure segments from year one become longer and eventually encompass all of the maturity dates. To this end, term structure segments of 1–2 years, 1–5 years, 1–10 years, 1–20 years, and 1–30 years, are examined herein. The second type of maturity partitioning examines the impact of each factor for various contingent segments of the term structure, such as 1–2 years, 2–5 years, 5–10 years, 10–20 years, and 20–30 years. The models estimated herein are fitted well (see, for example, the R^2 and DW statistics reported in Tables 1 and 3). The parameter estimates reveal the determinants of the term structure and/or the magnitude of the impact from those determinants. These estimates show clearly that decreasing term structure of relative yield spreads is determined by not only the implicit tax rate, but also by the differences in default risk premia, the tax-timing option values, and expected rate of inflation.

The regression results for Equation 7 for various cumulative segments of the term structure over the entire period, which are presented in Panel A of Table 1, are now summarized. The estimated differences of the implicit tax rates, $\hat{\beta}_0$, decrease with increasing maturity. All of the $\hat{\beta}_0$'s are either zero and insignificant, or negative and significant at the 0.01 level. The absolute values of the $\hat{\beta}_1$ (the risk premia for the tax-exempt bonds with the shorter maturity) are smaller than those for the $\hat{\beta}_2$ (the risk premia for the tax-exempt bonds with the longer maturity) across all the equations. Thus, the risk premia increase with longer maturities. The $\hat{\beta}_3$'s (the marginal differences in the tax-timing option values) are negative as expected, and their magnitudes increase with increasing maturity as was theoretically conjectured earlier. The $\hat{\beta}_4$'s (the impact from the expected rate of inflation) are significant at the 0.05 level only for the long cumulative term segment of the term structure of 1–30 years. For the shortest cumulative segment of the term structure of 1–2 years, neither the changes in the implicit tax rates nor inflation expectations have a significant impact on the term structure of relative yield spreads.

Test results for the four hypotheses for the models listed in Panel A of Table 1 are presented in Panel A of Table 2. Based on the Wald statistics for H_0^1, while the implicit tax rates do not change significantly over the 1–2 year segment of the term structure, they do differ significantly for all longer cumulative segments of the term structure. Based on the Wald statistics for H_0^2, the default risk premia differ significantly for all cumulative segments of the term structure. Based on the Wald statistics for H_0^3, the marginal option value differences are significantly different from zero. Based on the Wald statistics for H_0^4, the impact of the expected rate of inflation is significant only over the longest cumulative segment of the term structure (namely, 1–30 years).

The regression results for Equation 7 for various contingent segments of the term structure over the entire period, which are presented in Panel A of Table 3, can be summarized as follows. The estimated differences of the implicit tax rates, $\hat{\beta}_0$, are significant and negative at the 0.05 level for only two segments of the term structure; namely, 2–5 and 5–10 years. This may result from market segmentation. Not only do both default risk premia, $\hat{\beta}_1$ and $\hat{\beta}_2$, increase in absolute value from the shorter end to the longer end of the term structure, but also $|\hat{\beta}_2| > |\hat{\beta}_1|$ for all contingent segments of the term structure. The $\hat{\beta}_3$'s, which are the

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[5] It was observed that the higher the growth of interest rates, the more downward sloping was the term structure of relative yield spreads. This is consistent with the tax-timing option conjecture.

Table 1. *The regression results for various cumulative segments of the term structure of relative yield spreads based on Equation 7 for the whole period and three subperiods*

Models[a]	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	DW	R^2
Panel A: 1954:2–1987:12 (406 observations)								
1–2	0.00[c]	0.52	−0.62	−0.05	−0.39	0.56	2.08	0.41
	(0.10)[b]	(8.02)	(−7.53)	(−4.50)	(−0.96)			
1–5	−0.03	0.52	−0.77	−0.11	0.84	0.73	2.00	0.65
	(−2.36)	(11.34)	(−8.32)	(−6.93)	(1.49)			
1–10	−0.09	0.54	−0.68	−0.14	0.97	0.80	2.00	0.72
	(−5.02)	(9.68)	(−5.60)	(−7.88)	(1.53)			
1–20	−0.15	0.41	−0.77	−0.18	1.29	0.86	2.02	0.71
	(−5.28)	(7.97)	(−4.72)	(−9.33)	(1.90)			
1–30	−0.17	0.40	−0.84	−0.18	1.47	0.87	2.03	0.73
	(−5.31)	(7.52)	(−4.63)	(−9.53)	(2.14)			
Panel B: 1954:2–1979:9 (308 observations)								
1–2	0.00	0.54	−0.65	−0.06	−0.29	0.59	2.07	0.44
	(0.63)	(7.52)	(−6.98)	(−3.93)	(−0.59)			
1–5	0.00	0.55	−0.90	−0.11	0.80	0.74	1.98	0.68
	(0.06)	(11.00)	(−8.18)	(−5.89)	(1.17)			
1–10	−0.06	0.45	−0.79	−0.16	1.16	0.78	1.98	0.75
	(−2.44)	(9.24)	(−5.52)	(−7.63)	(1.53)			
1–20	−0.11	0.40	−0.91	−0.19	1.28	0.86	2.01	0.73
	(−2.64)	(7.25)	(−4.44)	(−8.29)	(1.56)			
1–30	−0.12	0.39	−1.01	−0.20	1.33	0.88	2.03	0.75
	(−2.56)	(6.87)	(−4.29)	(−8.45)	(1.61)			
Panel C: 1979:10–1982:9 (36 observations)								
1–2	−0.04	4.32	−4.11	−0.01	0.59	0.43	2.05	0.83
	(−3.68)	(9.45)	(−8.21)	(−0.54)	(1.61)			
1–5	−0.09	3.71	−3.36	−0.03	−0.38	0.81	2.21	0.74
	(−1.85)	(4.88)	(−3.22)	(−1.34)	(−0.41)			
1–10	−0.21	2.54	−1.37	−0.07	−0.88	0.89	1.91	0.84
	(−2.66)	(3.38)	(−1.00)	(−2.26)	(−0.85)			
1–20	−0.21	2.54	−1.37	−0.07	−0.88	0.89	1.92	0.84
	(−2.66)	(3.38)	(−1.00)	(−2.26)	(−0.85)			
1–30	−0.23	2.03	−1.64	−0.11	−0.67	0.91	1.91	0.82
	(−2.36)	(2.62)	(−1.11)	(−3.30)	(−0.56)			
Panel D: 1982:10–1987:12 (63 observations)								
1–2	0.02	2.96	−3.43	−0.05	−0.36	0.20	1.91	0.26
	(1.24)	(3.12)	(−3.32)	(−1.19)	(−0.33)			
1–5	−0.04	3.63	−4.49	−0.13	2.04	0.70	1.90	0.42
	(−0.91)	(3.48)	(−3.61)	(−2.82)	(1.51)			
1–10	−0.12	1.63	−2.14	0.03	0.37	0.70	1.89	0.42
	(−2.12)	(1.58)	(−1.56)	(0.49)	(0.21)			
1–20	−0.22	2.55	−3.03	−0.06	2.52	0.67	1.80	0.54
	(−3.83)	(2.96)	(−2.32)	(−1.03)	(1.43)			
1–30	−0.20	2.93	−3.94	−0.06	3.47	0.64	1.82	0.46
	(−3.54)	(3.12)	(−2.89)	(−0.89)	(1.84)			

[a] Each model covers a different maturity segment on the term structure of relative yield spreads. For example, 1–2 covers the segment from one to two years.

[b] The number in parentheses is a t-value under the null hypothesis that the corresponding parameter is zero.

[c] "0.00" represents a number that is less than 0.005.

marginal differences in the tax-timing option values, are negative as predicted by the theory, and significant at the 0.05 level for contingent maturity segments of 1–2, 2–5, and 5–10 years. The $\hat{\beta}_4$'s, which measure the effect of the expected rate of inflation, are significant at the 0.05 level for only the 2–5 year maturity segment.

Test results for the four hypotheses for the models listed in Panel A of Table 3 are presented in Panel A of Table 4. Based on the Wald statistics for H_0^1, the implicit tax rates differ significantly at the 0.05 level for the maturity segments of 2–5 and 5–10 years. Based on the Wald statistics for H_0^2, the default risk premia differ significantly at the 0.05 level for all maturity segments of the term structure of relative yield spreads. Based on the Wald statistics for H_0^3, the marginal differences of option values differ significantly at the 0.05 level for the maturity segments of 1–2, 2–5 and 5–10

Table 2. *The results for the linear restrictions for the models in the corresponding panels of Table 1*

Model[a]	Wald test statistics[b] H_0^1	H_0^2	H_0^3	H_0^4
Panel A: 1954:2–1987:12 (406 observations)				
1–2	0.01	20.30***	20.26***	0.92
1–5	5.55**	17.57***	48.05***	2.21
1–10	25.24***	5.76**	62.13***	2.34
1–20	27.90***	6.5**	92.44***	3.62
1–30	28.17***	7.85***	90.91***	4.59
Panel B: 1954:2–1979:9 (308 observations)				
1–2	0.40	17.12***	15.48***	0.34
1–5	0.00	22.69***	34.69***	1.38
1–10	5.95**	8.94***	58.29***	2.34
1–20	6.99***	7.84***	68.77***	2.42
1–30	6.54**	8.58***	71.44***	2.60
Panel C: 1979:10–1982:9 (36 observations)				
1–2	13.59***	2.49	0.29	2.60
1–5	3.44*	0.42	1.81	0.17
1–10	7.06***	1.76	5.11**	0.72
1–20	5.55**	0.14	10.88***	0.32
1–30	12.49***	1.15	19.44***	0.24
Panel D: 1982:10–1987:12 (63 observations)				
1–2	1.53	11.22***	1.43	0.11
1–5	0.83	4.69**	7.93***	2.28
1–10	4.51**	0.76	0.23	0.04
1–20	14.70***	0.54	1.05	2.04
1–30	12.52***	2.66**	0.80	3.39*

[a] Each model covers a specific maturity segment on the term structure of relative yield spreads.

[b] Each Wald statistic has a χ^2 distribution with one degree of freedom.

*Significant at the 0.10 level.

**Significant at the 0.05 level.

***Significant at the 0.01 level.

years. Based on the Wald statistics for H_0^4, the impact of the expected rate of inflation is significant at the 0.05 level for only the maturity segment of 2–5 years.

The above analysis indicates that the theoretical model appears to be supported by the statistical evidence. The sign and magnitude of the parameter estimates are as predicated by the theoretical conjectures; that is, the decreasing term structure of relative yield spreads is affected by the implicit tax rate, default risk premium, tax-timing option, and expected rate of inflation.

While the whole sample period is used for the above analysis, it is also recognized that the term structure of interest rates is affected by the changes in monetary regimes. For example, during the period of 1979:10–1982:9, the Federal Reserve increased its emphasis on control of bank reserves and money supply (M1) and reduced its emphasis on short-term interest rates. Many empirical studies conclude that the changes in the Federal Reserve System's monetary policy in the period did have an impact on the term structure of interest rates (see, for example, Huizinga and Mishkin, 1984; and Clarida and Friedman, 1984). During this period, the inflation rate was reduced significantly (i.e., from around 11–12% to 4–5%), short-term interest rates rose to very high levels, and the variability of interest rates was greater than ever before.

Three subperiods (1954:2–1979:9, 1979:10–1982:9 and 1982:10–1987:12) are chosen to correspond to these monetary regimes. The regression results for Equation 7 for various cumulative segments of the term structure for each of these subperiods are presented in Panels B, C and D of Table 1. Test results for the four hypotheses for each of these three subperiods are presented in Panels B, C and D of Table 2. The regression results for Equation 7 for various contingent segments of the term structure for each of the three subperiods (1954:2–1979:9, 1979:10–1982:9 and 1982:10–1987:12) are presented in Panels B, C and D of Table 3. Test results for the four hypotheses for each of the subperiods are presented in Panels B, C and D of Table 4.

Although minor variations exist in the estimated values of the parameters across the subperiods, the model represents the equilibrium condition reasonably well. The model is able to capture the movements in the term structure of relative yield spreads, and relate it to several major determinants: the implicit tax rate, default risk premium, tax-timing option value, and expected rate of inflation. During the subperiod of 1979:10–1982:9, the default risk premia behaved differently from the theory prediction. The risk premia of the tax-exempt bonds are lower (higher) with longer (shorter) maturity in the late 1970s and early 1980s. This might be caused by the turbulence in the short end of the term structure because of a regime change.

IV. CONCLUDING REMARKS

In this paper, a theoretical model for determining relative yield spreads between taxable and tax-exempt bonds was developed and estimated. Six major empirical findings based on various cumulative and contingent maturity segments for the period 1954:2–1978:12, and three subperiods therein, are as follows: First, the decreasing term structure of relative yield spreads is determined by not only the implicit tax rate imposed on the marginal investor, but also by the differences in default risk premia, the tax-timing option values, and the expected rate of inflation. Secondly, the implicit tax rate decreases as term to maturity increases, possibly due to maturity-specific market segmentation. Thirdly, the default risk premia play a significant role in the determination of the decreasing term structure of relative yield spreads. Generally, the default risk premia associated with longer-term tax-exempt bonds are higher than those associated with shorter-term tax-exempt bonds. A notable exception is the subperiod 1979:10–1982:9, when the US monetary regime changed significantly to policy targeting the money supply from targeting short-term interest rates. During this subperiod of very volatile interest rates, less

Table 3. *The regression results for various contingent segments of the term structure of relative yield spreads based on Equation 7 for the whole period and three subperiods*

Models[a]	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	DW	R^2
Panel A: 1954:2–1987:12 (406 observations)								
1–2	0.00[b]	0.52	− 0.62	− 0.05	− 0.39	0.56	2.08	0.41
	(0.10)[c]	(8.02)	(− 7.53)	(− 4.50)	(− 0.96)			
2–5	− 0.03	0.72	− 0.88	− 0.05	0.86	0.70	2.22	0.65
	(− 3.36)	(13.53)	(− 10.82)	(− 4.83)	(2.23)			
5–10	− 0.03	1.50	− 1.72	− 0.02	− 0.17	0.86	2.31	0.68
	(− 2.17)	(10.10)	(− 9.11)	(− 1.96)	(− 0.52)			
10–20	− 0.04	3.14	− 3.41	− 0.02	0.20	0.93	2.14	0.85
	(− 1.89)	(12.58)	(− 12.5)	(− 1.78)	(0.66)			
20–30	− 0.00	3.36	3.59	0.00	0.29	0.83	2.26	0.54
	(− 0.17)	(13.94)	(− 14.08)	(0.49)	(1.26)			
Panel B: 1954:2–1979:9 (308 observations)								
1–2	0.00	0.54	− 0.65	− 0.06	− 0.29	0.59	2.07	0.44
	(0.63)	(7.52)	(− 6.98)	(− 3.93)	(− 0.59)			
2–5	− 0.00	0.78	− 1.04	− 0.05	0.70	0.72	2.15	0.75
	(− 0.19)	(14.59)	(− 11.76)	(− 4.31)	(1.63)			
5–10	− 0.01	1.64	− 2.01	− 0.03	− 0.06	0.91	2.08	0.78
	(− 0.37)	(12.13)	(− 10.52)	(− 3.73)	(− 0.20)			
10–20	− 0.03	3.11	− 3.42	− 0.00	− 0.10	0.94	2.03	0.87
	(− 0.86)	(12.42)	(− 12.17)	(− 0.40)	(− 0.27)			
20–30	0.00	3.19	− 3.43	0.00	0.18	0.84	2.27	0.49
	(0.21)	(12.27)	(− 12.32)	(0.53)	(0.66)			
Panel C: 1979:10–1982:9 (36 observations)								
1–2	− 0.04	4.32	− 4.11	− 0.01	− 0.59	0.43	2.05	0.83
	(− 3.68)	(9.45)	(− 8.21)	(− 0.54)	(− 1.61)			
2–5	− 0.09	1.81	− 1.18	− 0.02	− 0.64	0.73	2.24	0.68
	(− 2.67)	(1.57)	(− 0.89)	(− 1.02)	(− 0.84)			
5–10	− 0.26	− 3.77	6.11	− 0.03	1.19	− 0.04	2.31	0.68
	(− 15.70)	(− 3.13)	(4.50)	(− 1.95)	(1.94)			
10–20	− 0.02	5.00	− 5.72	− 0.02	0.37	0.63	2.05	0.63
	(− 0.48)	(2.37)	(− 2.68)	(− 1.19)	(0.59)			
20–30	− 0.00	9.45	− 9.72	0.01	0.17	0.50	1.81	0.50
	(− 0.15)	(6.23)	(− 6.22)	(0.60)	(0.53)			
Panel D: 1982:10–1987:12 (63 observations)								
1–2	0.02	2.96	− 3.43	− 0.05	− 0.36	0.20	1.91	0.26
	(1.24)	(3.12)	(− 3.32)	(− 1.19)	(− 0.33)			
2–5	− 0.07	2.33	− 2.39	− 0.05	0.92	0.24	1.98	0.11
	(− 3.94)	(1.63)	(− 1.52)	(− 1.10)	(0.73)			
5–10	− 0.06	4.28	− 4.52	0.15	− 2.74	0.09	1.96	0.28
	(− 3.08)	(2.57)	(− 2.43)	(3.26)	(− 2.34)			
10–20	− 0.03	9.44	− 10.15	− 0.13	2.00	0.74	1.79	0.74
	(− 1.06)	(6.69)	(− 6.29)	(− 4.76)	(2.53)			
20–30	− 0.00	7.64	− 7.80	0.02	1.26	0.40	2.08	0.80
	(− 0.21)	(8.00)	(− 8.66)	(1.18)	(2.83)			

[a] Each model covers a different maturity segment on the term structure of relative yield spreads. For example, 1–2 covers the segment from one to two years.

[b] '0.00' represents a number that is less than 0.005.

[c] The number in parentheses is a t-value under the null hypothesis that the corresponding parameter is zero.

differences in default risk premia are observed across the maturities. Fourthly, the marginal differences between the tax-timing option values for taxable and tax-exempt bonds also play a role in the determination of the decreasing term structure of relative yield spreads. Fifthly, changes in the expected rate of inflation play a role in the determination of the decreasing term structure of relative yield spreads. However, the impact varies in both direction and magnitude. Finally, the results are relatively robust for the three subperiods examined herein.

Table 4. *The results for the linear restrictions for the models in the corresponding panels of Table 3*

	Wald Test Statistics[b]			
Model[a]	H_0^1	H_0^2	H_0^3	H_0^4
Panel A: 1954:2–1987:12 (406 observations)				
1–2	0.01	20.30***	20.26***	0.92
2–5	13.21***	17.20***	23.35***	4.99**
5–10	4.71**	9.66***	3.84**	0.27
10–20	3.57*	8.20***	3.18*	0.43
20–30	0.03	27.82***	0.24	1.60
Panel B: 1954:2–1979:9 (308 observations)				
1–2	0.40	17.12***	15.48***	0.34
2–5	0.38	31.50***	18.57***	2.65
5–10	0.13	17.09***	13.90**	0.38
10–20	0.74	7.14***	0.16	0.75
20–30	0.04	17.13***	0.28	0.44
Panel C: 1979:10–1982:9 (36 observations)				
1–2	13.59***	2.49	0.29	2.60
2–5	7.11***	2.46	1.03	0.71
5–10	246.40***	105.11***	3.78*	3.74*
10–20	0.23	2.26	1.42	0.34
20–30	0.02	2.75*	0.36	0.28
Panel D: 1982:10–1987:12 (63 observations)				
1–2	1.53	11.22***	1.43	0.11
2–5	15.53***	0.11	1.21	0.53
5–10	9.46***	1.06	10.64***	0.46
10–20	1.13	6.07**	22.63***	6.41**
20–30	0.44	2.81*	1.40	8.03***

[a] Each model covers a specific maturity segment on the term structure of relative yield spreads.

[b] Each Wald statistic has a χ^2 distribution with one degree of freedom.

*Significant at the 0.10 level.

**Significant at the 0.05 level.

***Significant at the 0.01 level.

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