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Tax-Induced Intra-Year Patterns in Bonds Yields

SHALOM J. HOCHMAN, ODED PALMON, and ALEX P. TANG*

ABSTRACT

The ratio of the yields on short-term tax-exempt and taxable bonds exhibits a sawtooth pattern that is consistent with the impacts of tax deferments from dates on which interest payments are received to dates on which the resulting tax payments are paid. The effect of the tax deferment at turns of calendar years does not differ appreciably from the effect at the turn of any other tax quarter. Investors with tax payment schedules that differ from that of the investor that is indifferent between investing in taxable and tax-exempt bonds may benefit from tax-related timing strategies for investing in these bonds. Issuers may benefit from tax-related timing strategies for scheduling interest payments.

THE IMPACT OF LONG-TERM tax deferrals on securities' pretax yields is well documented.[1] However, even when tax due dates are exogenously given, short-term tax deferrals are still possible.[2] The extent of these tax deferrals for interest income depends on the timing (within the year) of interest payments. In this study we investigate and document the effects of short-term tax deferrals on yields on short-term bonds ("the interest-timing effect").

To illustrate the potential for such effects, consider two Treasury bills that are identical in all respects except for their maturity dates. Assume that one matures in the last week of December while the other matures in the first week of the following January. Although interest on the January bill is received only one week after the date on which interest on the December bill

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[1] Following are several examples. First, before-tax yields on taxable bonds are higher than yields on otherwise identical tax-exempt bonds (tax liabilities on tax-exempt bonds may be regarded as indefinitely deferred). Second, high-dividend-paying stocks appear to have higher pretax returns than the returns on otherwise identical low-dividend-paying stocks (see, for example, Table 16–2 in Brealey and Myers (1988)). Finally, the impact of optimal-trading tax-timing options is discussed in Constantinides (1983, 1984) and Constantinides and Ingersoll (1984).

[2] Short-term tax deferrals, in the context of trade credit, are considered by Brick and Fung (1984).

is received, taxes on interest received from the January bill are due at least three months after the tax due date on the interest received from the December bill. Hence, the after-tax yields on the two bills equal each other only if the before-tax yield on the December bill exceeds the before-tax yield on the January bill.

We examine the effect of deferring tax payments on bond yields by studying monthly ratios of the yields on newly issued prime grade one-year tax-exempt bonds and on corresponding one-year taxable Treasury securities ("the yields ratio").[3] This examination enables us to focus on the impact of deferring tax payments on bond yields, because other determinants of these yields should affect both yields similarly and thus should have little effect on their ratio. Note that, while the deferment of taxes on income from tax-exempt bonds is always indefinite (and thus is uniform throughout the year), the deferment of taxes on the returns on taxable bonds should vary within the year. Thus, our conjecture is that within-the-year changes in the yields ratio should reflect changes in the deferment of taxes. This hypothesis is referred to as the "interest-timing hypothesis."

We find that the yields ratio exhibits an interesting intra-year sawtooth pattern; the yields ratio declines with time within tax quarters and increases sharply at turns of tax quarters. This sawtooth pattern is consistent with the interest-timing hypothesis, when a deferment of tax payments (for the investor that is indifferent between investing in taxable and tax-exempt bonds) is caused by deferring income across turns of tax quarters, but not within a tax quarter. The sawtooth pattern is shown to be statistically significant in the regressions that we perform. We also show that increases in the yields ratio at turns of calendar years are not significantly larger than increases at turns of tax quarters.

The organization of the paper is as follows. A derivation of the interest-timing effect is presented in Section I. The methodology and the data used to test our hypothesis are described in Section II. The results of the regressions are presented in Section III. Section IV includes a summary and concluding remarks.

I. The Model

Let r_0 and r_b denote the before-tax annual yields on newly issued one-year tax-exempt and taxable bonds, respectively; let y denote the time interval (in years) between the date on which interest is received and the date on which

[3] Short-term bonds are more appropriate than long-term bonds for the present study because of two reasons. First, risk differentials between prime grade tax-exempt bonds and Treasury securities (which are ignored in this study in order to simplify the presentation) should be more stable between short-term bonds than between long-term bonds. Second, the impact of tax-related optimal trading (which is also ignored in the current study in order to simplify the presentation) should be less noticeable in the yields of newly issued short-term bonds than in the yields of other bonds.

taxes are due ("the tax deferment interval"); and let T denote the tax rate on interest income of the investor that is indifferent between investing in taxable and tax-exempt bonds ("the marginal investor"). Consider a one-dollar investment in the taxable bond at time $t = 0$. At time $t = 1$, the bond pays $1 + r_b$ dollars. At time $t = 1 + y$, Tr_b dollars are paid in taxes. The after-tax yields on the investments in the taxable and tax-exempt bonds (for the marginal investor) equal each other if

$$(1 + r_b)(1 + r_0)^{-1} - Tr_b(1 + r_0)^{-(1+y)} = 1.$$

Rearranging this equation, we obtain:

$$\ln[r_b/(r_b - r_0)] = (y)\ln(1 + r_0) - \ln(T). \tag{1}$$

Note that $\ln[r_b/(r_b - r_0)] \equiv -\ln[1 - (r_0/r_b)]$. Thus, in equation (1) we focus on the impact of the timing of interest payments on a monotone transformation of the yields ratio (the "transformed yields ratio"). However, the yields ratio has been explained in previous studies by combinations of other variables. Miller (1977) argues that the yields ratio should equal one minus the corporate tax rate (the "Miller hypothesis"). Trzcinka (1982), and Buser and Hess (1986) find empirical support for this hypothesis. However, the findings of Ang, Peterson, and Peterson (1985) and Fortune (1988) are not consistent with the Miller hypothesis.

Fama (1977) hypothesizes that the relative pricing of tax-exempt and taxable bonds is determined by bank arbitrage (the "Bank Arbitrage" hypothesis). Fama's hypothesis implies that, when Regulation Q is not binding, the yields ratio should equal one minus the tax rate on banks' income. Skelton (1983) finds empirical support for the Bank Arbitrage hypothesis by showing that the yields ratio is relatively high when Regulation Q is binding. Empirical support for the Bank Arbitrage hypothesis is found also by Heaton (1986). Peek and Wilcox (1986) find that the yields ratio is related to the (average) tax rate of individuals more closely than to the corporate tax rate. This finding implies that individuals (rather than institutions) are the marginal investors. Variables shown in previous studies to affect the yields ratio are included in this study as additional explanatory ("control") variables (a detailed description is provided in the next section).

II. Methodology and Data

We test the interest-timing hypothesis by estimating four regression equations, using a sample of 311 monthly observations, from January 1959 through November 1984. The purpose of estimating the first regression is to facilitate a comparison with results in previous studies. In this "Base" regression, the transformed yields ratio is regressed on variables used in previous studies:

$$\ln[r_b/(r_b - r_0)] = \beta_0 + \beta_1\ln(\mathrm{T}_p) + \beta_2\ln(\mathrm{T}_c) + \beta_3\mathrm{REG} + \beta_4\mathrm{S}, \tag{2}$$

where,

r_0 = the yield on newly-issued one-year prime grade tax-exempt municipal bonds; source: Salomon Brothers (1985);

r_b = the yield on one-year Treasury securities; source: Salomon Brothers (1985);

T_c = the effective income tax rate of corporations in the highest corporate business receipt bracket; the variable is calculated as the total income taxes paid by corporations in the top corporate business receipt bracket divided by their total taxable income; source: U.S. Treasury Department, Statistics of Income: Corporate Income Tax Returns;[4]

T_p = the effective personal tax rate of individuals in the highest income bracket; this variable is calculated as the total income taxes paid by individuals in the highest income bracket divided by their total taxable income; source: U.S. Treasury Department, Statistics of Income: Personal Income Tax Returns;[5]

REG = a variable capturing the possible impact of Regulation Q on the relative yields; REG = 1 in periods when Regulation Q is binding and REG = 0 otherwise (see Skelton (1983)); source: Federal Reserve Bulletin; and

S = the net supply of all tax-exempt bonds divided by the net supply of all bonds (see Peek and Wilcox (1986)); source: Federal Reserve Bulletin.[6]

The set of variables $\ln(T_c)$, $\ln(T_p)$, REG, and S is referred to as the set of "control variables." Note that time subscripts and error terms have been suppressed in equation (2), as in all other regression equations, to simplify the presentation.

The second regression tests the interest-timing hypothesis jointly with the hypothesis that deferring income across turns of tax quarters (but not within a tax quarter) defers tax payments for the marginal investor. In addition to the set of control variables, the explanatory variables in this "Quarterly Deferment" regression equation include a product of an instrumental variable for $\ln(1 + r_0)$, denoted by $\hat{r}_0$, and an estimate for the tax deferment interval (see equation (1)). Formally, this "Quarterly Deferment" regression equation is:

$$\ln[r_b/(r_b - r_0)] = \beta_0 + \beta_1 \ln(T_p) + \beta_2 \ln(T_c) + \beta_3 \mathrm{REG} + \beta_4 \mathrm{S} + \hat{r}_0[\beta_5 \mathrm{MEQ} + \beta_6 \mathrm{D1} + \beta_7 \mathrm{D2} + \beta_8 \mathrm{D3} + \beta_9]. \quad (3)$$

[4] If tax deductions depend on income, the effective marginal tax rate may be approximated by the average tax rate better than by the statutory marginal rate. The results obtained when the top statutory corporate income tax rate is used are not qualitatively different from those obtained using the effective rate.

[5] Assuming that investors choose between holding tax-exempt and taxable bonds based on tax considerations only, tax-exempt bonds should be held by investors in the top tax bracket. See also the previous footnote for the discussion regarding using effective vs. statutory rates.

[6] The data used to generate this variable are available on a quarterly basis only. The monthly values of this variable are set equal to the respective quarterly figure.

The tax deferment interval (i.e., the variable y in equation (1)) is quantified in this regression by the set of "timing variables." This set includes a variable denoted by MEQ, and three dummy variables (denoted by D1, D2, and D3). The variable MEQ represents the number of months remaining until the end of the tax quarter, and the three dummy variables indicate whether a month is in the first, second, or third tax quarter, respectively. Note that, according to the U.S. Tax Code, the calendar year is partitioned into four *unequal* quarters for the purpose of paying estimated taxes. The first quarter includes the months of January, February, and March; the second quarter includes the months of April and May; and the third quarter includes the months of June, July, and August.[7] Thus, the variable MEQ is constructed as follows:

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MEQ	2	1	0	1	0	2	1	0	3	2	1	0

Each of the three dummy variables represents the difference between the tax deferment intervals associated with months within its tax quarter and the tax deferment intervals associated with the corresponding months (i.e., months with the same MEQ) in the fourth tax quarter. The coefficient β_9 represents the impact on the dependent variable of the tax deferment interval for the month of December. The three dummy variables are used because the number of months remaining until the end of the tax quarter may not be sufficient to characterize tax deferment intervals for the various months. Although taxpayers pay estimated taxes quarterly, the formal basis for the tax assessment may be annual income. Thus, the tax deferment interval may vary across quarters even if the time to the end of the tax quarter (measured by MEQ) is held fixed. For example, taxes on interest received in March are paid at the same time as taxes on income received in January or February. Hence, the tax deferment interval for interest received in March is one month shorter than for interest received in February, and two months shorter than for interest received in January. However, the tax deferment interval may not be identical for interest received in March, May, August, and December (the last months in the four tax quarters).

Because the tax deferment interval in equation (1) is multiplied by $\ln(1 + r_0)$, and because the regression's error terms are likely to be correlated with r_0, the set of timing variables is multiplied by the instrumental variable $\hat{r}_0$. The values of this instrumental variable are the fitted values of a regression in which $\ln(1 + r_0)$ is explained by the control and timing variables.

Recall that according to the interest-timing hypothesis the dependent variable should decline with time within a tax quarter. In other words, the coefficient of the product of MEQ and $\hat{r}_0$ is predicted to be positive.

An alternative formulation of the interest-timing hypothesis is that the

[7] For further details see U.S. Income Tax Code Sections 6154, 6654, and 6655.

effective tax rate on interest income depends on the tax deferment interval.[8] For a given statutory tax rate, the effective rate should be lower the longer is the deferment interval. Because we use tax rates as explanatory variables, the unobservable effective tax rates cannot be directly incorporated in our framework. Thus, we test this version of the hypothesis by estimating a regression equation that is identical to the Base regression, except that the coefficient of the personal tax rate variable is allowed to vary within each tax quarter in a manner consistent with the interest-timing hypothesis.[9] This is done by adding to the set of explanatory variables of the Base regression a variable which is the product of the variable MEQ and the natural logarithm of the variable T_p. This variable is denoted by MEQln(T_p). Formally, this "Variable Effective Tax Rate" regression equation is:

$$\ln[r_b/(r_b - r_0)] = \beta_0 + \beta_1 \ln(T_p) + \beta_2 \ln(T_c) + \beta_3 \mathrm{REG} + \beta_4 S + \beta_5 \mathrm{MEQ}\ln(T_p), \tag{4}$$

which is equivalent to:

$$\ln[r_b/(r_b - r_0)] = \beta_0 + [\beta_1 + \beta_5 \mathrm{MEQ}]\ln(T_p) + \beta_2 \ln(T_c) + \beta_3 \mathrm{REG} + \beta_4 \mathrm{S}. \tag{4'}$$

In this specification, β_1 is the coefficient of $\ln(T_p)$ in the last month of each quarter, $\beta_1 + \beta_5$ is the coefficient in the month preceding the last month of the tax quarter, $\beta_1 + 2\beta_5$ is the coefficient in the preceding month (if in the same tax quarter), and so on.

The findings of Park and Reinganum (1986), Chang and Pinegar (1986), and Jordan and Jordan (1991) motivate the estimation of an "Annual vs. Quarterly" regression. Park and Reinganum find that the yield curve for Treasury bills resembles an increasing step function with steps occurring at turns of calendar months. They also find that steps at turns of calendar years are larger than other steps. As Park and Reinganum note, their findings contradict the interest-timing hypothesis. Chang and Pinegar find abnormally high returns on long-term low-grade corporate bonds during the month of January. Jordan and Jordan find abnormally high returns on an index of corporate and utility bonds at the turn-of-the-year (compared to the turn-of-the-month), and during the non-turn-of-the-month days in the month of January (when compared to non-turn-of-the-month days in other months).[10]

The dependent variable in the Annual vs. Quarterly regression is the first (time) difference of the original dependent variable. The control variables are also the first differences of the respective original control variables.[11] The

[8] We thank an anonymous referee for directing our attention to this alternative representation.

[9] When the coefficients of the corporate and personal tax rates are allowed to vary within each tax quarter, collinearity (the simple correlation is 0.98) mitigates the statistical inferences.

[10] Note that we study the *yields ratio*, and thus our dependent variables are different than the dependent variables in these studies.

[11] In another specification the control variables have not been differenced. The resulting coefficients of the timing variables in the two specifications are similar to one another.

timing variables are two dummy variables indicating the turn of a tax quarter (TOQ) and the turn of the calendar year (TOY). The TOQ variable equals one when the dependent variable is the difference between the observations of April/March, June/May, September/August, and January/December (of the previous year), and zero otherwise. The TOY variable equals one when the dependent variable is the difference between the observations of January/December, and zero otherwise. These timing variables are multiplied by a lagged $\hat{r}_0$.[12] That is, the regression equation is:

$$\begin{aligned}\{1 - L\}\{\ln[r_b/(r_b - r_0)]\} = {} & \beta_0 + \beta_1\{1 - L\}\{\ln(\mathrm{T}_p)\} \\ & + \beta_2\{1 - L\}\{\ln(\mathrm{T}_c)\} + \beta_3\{1 - L\}\{\mathrm{REG}\} \\ & + \beta_4\{1 - L\}\{\mathrm{S}\} \\ & + \{L\}\{\hat{r}_0\}[\beta_5\mathrm{TOQ} + \beta_6\mathrm{TOY} + \beta_7],\end{aligned} \tag{5}$$

where $\{L\}\{x\}$ is the value of the variable x, lagged one period, and $\{1 - L\}\{x\}$ is the current value minus the lagged value of the variable x.

The coefficient β_7 in equation (5) should represent the impact of turns of months within the tax quarter on the original (i.e., undifferenced) dependent variable. Thus, this coefficient should be negative according to the interest-timing hypothesis. The coefficient of the $\{L\}\{\hat{r}_0\}$TOQ variable represents the impact of turns of tax quarters on the original dependent variable, above and beyond the impact of turns of months within the tax quarter. Thus, if deferring income across turns of tax quarters defers tax payments for the marginal investor, this coefficient should be positive according to the interest-timing hypothesis. Similarly, the coefficient of the $\{L\}\{\hat{r}_0\}$TOY variable represents the impact of turns of calendar years, above and beyond the impact of turns of tax quarters. Thus, this coefficient should be positive if deferring income across turns of calendar years defers tax payments above and beyond the deferment generated by deferring income across turns of tax quarters.

III. Empirical Results

The intra-year pattern of the yields ratio is illustrated in Figure 1, where averages of the yields ratios for each calendar month are plotted.[13] As shown in Figure 1, the yields ratio declines with time within tax quarters and increases sharply at turns of tax quarters.[14] Estimates of the four regressions

[12] Note that the timing variables differ slightly from the first-order time differences of the original timing variables. In an alternative specification, the timing variables are the exact first-order time differences of the timing variables in the Quarterly Deferment regression equation. The estimates of this unreported specification are similar to those of the Annual vs. Quarterly regression.

[13] The averages in Figure 1 are of the yields ratios from January 1959 through December 1983.

[14] Note that the average of the yield ratios in September is lower than a value that would be consistent with the interest-timing hypothesis. The explanation of this phenomenon is left for future research.

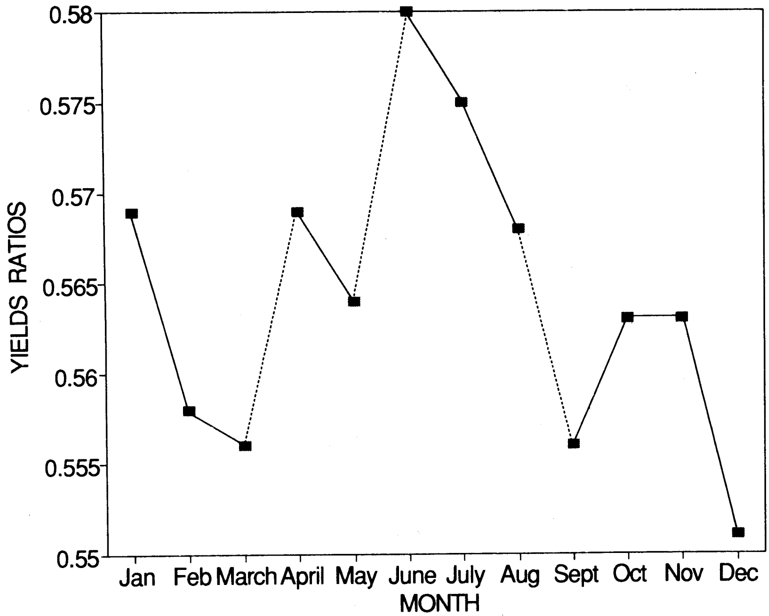

Figure 1. Intra-year pattern of yields ratio. The yields ratio for each calendar month is calculated as the ratio of the yield on newly-issued one-year prime grade tax-exempt municipal bonds and the yield on one-year Treasury securities (Source: Salomon Brothers (1985)). Plotted are the averages of the yields ratios for each month for the period January 1959 through December 1983. *Solid lines* connect months within a tax quarter, and *dotted lines* connect months in successive tax quarters.

are reported in Tables I and II. An examination of the autocorrelations and partial autocorrelations of the residuals indicates that the error terms exhibit an autoregressive, but not a moving-average, pattern. Thus, we use SAS's AUTOREG procedure with 11 lags to obtain Yule-Walker estimates.[15] Several Box-Pierce Q-statistics are constructed; none of them indicates a misspecification of the ARIMA parameters (Box-Pierce Q-statistics with 14 degrees of freedom are reported in Tables I and II for all the regressions). This procedure is used to estimate all the regressions.

The estimated coefficients of the Base regression are reported in the first column of Table I. All the coefficients of the control variables have the expected signs, however, none of them is significantly different from zero. The t-statistics of the personal tax rate and supply coefficients are larger (in absolute value) than the t-statistics of the corporate tax rate and the Regulation Q coefficients. Thus, our results resemble those of Peek and Wilcox (1986) and Fortune (1988) more than those of other previous studies. The results obtained by previous studies are not directly comparable to our

[15] The number of lags is chosen according to Akaike's Information Criterion. Using F tests would have resulted in choosing the same number of lags.

results. Trzcinka (1982) uses a similar specification, but explains the yields ratio of bonds with considerably longer maturities. Trzcinka's results are not comparable with ours because, as reported by Peek and Wilcox, the impacts of the explanatory variables on the dependent variable vary across maturities. Quantitative comparisons with other studies (e.g., Buser and Hess (1986)) are not possible because the specifications that they employ are different than ours. Note also that when the variable ln(T) is used (as in our specification), its coefficient is expected to be negative (see equation (1)). In contrast, when the variable ln(1 − T) is used (as in Peek and Wilcox), its coefficient is expected to be positive.[16]

The estimates of equation (3) are reported in the second column of Table I. The coefficient of the product of $\hat{r}_0$ and the MEQ variable is positive, and is significantly different from zero at the 1% significance level. (The coefficients of the products of a timing variable and the variable $\hat{r}_0$ in the Quarterly Deferment regression are referred to as the coefficients of the timing variables hereafter). This result implies that the longer the time remaining until the end of the tax quarter, the closer to one another the yields on taxable and tax-exempt bonds. Recall that the prediction of the interest-timing hypothesis is that the excess of the yield on taxable bonds over the yield on tax-exempt bonds should be negatively related to the length of the deferment interval. Thus, assuming that deferring income across turns of tax quarters (but not within a tax quarter) defers tax payments for the marginal investor, our result is consistent with the prediction of the interest-timing hypothesis. Furthermore, using an F-test, the hypothesis that the coefficients of all the timing variables equal zero is rejected at the 1% significance level (with $F(5,290) = 3.42$). Note that, the coefficient of the dummy variable D3 is significantly positive. This may suggest that the tax deferment interval does not depend solely on the time remaining until the end of the tax quarter.[17]

The stability of the coefficients of the regression is tested by splitting the sample into two equal-length samples. A test that the coefficients of the corresponding timing variables in the two split samples equal each other is conducted by calculating the F-statistic for the set of restrictions. The value

[16] Note also that Peek and Wilcox include a lagged dependent variable as one of the explanatory variables, while we employ SAS's AUTOREG procedure. These differences may explain the minor differences between the reported results.

[17] The dependent variable and the tax explanatory variables in the Base and Quarterly Deferment regressions (i.e., regression equations (2) and (3)) differ from the regressions that are reported in previous studies. Thus, we have estimated two corresponding regression equations which differ from the reported equations in four respects. First, the dependent variable is $\ln(r_0/r_b)$. Second, the variables $\ln(1 - T_p)$ and $\ln(1 - T_c)$ replace the variables $\ln(T_p)$ and $\ln(T_c)$. Third, the timing variables in the Quarterly Deferment regression are not multiplied by $\hat{r}_0$. Fourth, because the timing variables are not multiplied by $\hat{r}_0$, the coefficient β_9 is not included. The estimates of these alternative regression equations are similar to those that are reported and are available from the authors upon request. Note also that excluding the timing variables does not bias the coefficients of the control variables. This may be expected because the correlation between the timing variables and the control variables is low (the correlation matrix is available from the authors upon request).

Table I

Estimation Results for the Base Equation, Quarterly Deferment Equation, and Variable Effective Tax Rate Equation

The dependent variable is the transformed yields ratio, $\ln[r_b/(r_b - r_0)]$, where r_b and r_0 are the yields on one-year Treasury securities and tax-exempt municipal bonds, respectively. The explanatory variables are: T_p, the personal tax rate; T_c, the corporate tax rate; REG, a dummy variable which equals one in periods when Regulation Q is binding and zero otherwise; S, the net supply of tax-exempt bonds divided by the net supply of all bonds; MEQ, the number of months remaining until the end of a tax quarter; $\hat{r}_0$, an instrumental variable consisting of the fitted values of a regression in which $\ln(1 + r_0)$ is explained by the variables $\ln(T_p)$, $\ln(T_c)$, REG, S, MEQ, D1, D2, and D3; $\hat{r}_0$MEQ, the product of the variable $\hat{r}_0$ and the variable MEQ; $\hat{r}_0$Di (i = 1, 2, 3), the products of the variable $\hat{r}_0$ and the three dummy variables: D1 equals one for January, February, and March, and zero otherwise, D2 equals one for April, and May, and zero otherwise, D3 equals one for June, July, and August, and zero otherwise; and MEQln(T_p), the product of MEQ and $\ln(T_p)$. The AUTOREG procedure is used to obtain the estimates.

Regression Equation	Base (2)	Quarterly Deferment (3)	Variable Effective Tax Rate (4)
Intercept	0.559	0.588	0.573
	(2.23)*	(2.35)*	(2.28)*
$\ln(T_p)$	−0.228	−0.172	−0.212
	(−1.40)	(−1.01)	(−1.29)
$\ln(T_c)$	−0.153	−0.117	−0.136
	(−0.53)	(−0.40)	(−0.47)
REG	0.015	0.007	0.015
	(0.87)	(0.37)	(0.85)
S	0.376	0.494	0.386
	(1.27)	(1.66)	(1.30)
$\hat{r}_0$MEQ		0.280	
		(2.74)**	
$\hat{r}_0$D1		0.156	
		(0.51)	

of the F-statistic is 1.52, indicating that the null hypothesis that these corresponding coefficients equal each other cannot be rejected.

The estimates of equation (4) are reported in the third column of Table I. The estimate of β_5 is −0.0112, meaning that the coefficient of $\ln(T_p)$ increases from one month to the next within each tax quarter by 0.0112 (because MEQ declines with time within each tax quarter). Recall that these monthly changes in the coefficients have been estimated in lieu of the monthly changes in the unobservable effective tax rates. When only the coefficient β is allowed to change in the product $\beta \ln(T_p)$, the change in the

Table I—*Continued*

Regression Equation	Base (2)	Quarterly Deferment (3)	Variable Effective Tax Rate (4)
$\hat{r}_0$D2		0.805	
		(1.94)	
$\hat{r}_0$D3		1.135	
		(3.69)**	
$\hat{r}_0$		−0.137	
		(−0.13)	
MEQln(T_p)			−0.011
			(−1.46)
R^2	0.68	0.71	0.69
F-statisitc		3.42**	1.85
B-P Q-statistic	14.80	12.10	14.30

The t-statistics are in parentheses; F-statistics are for the significance of all timing variables; Box-Pierce Q-statistics have 14 degrees of freedom.

* Denotes significance at the 5% level.

** Denotes significance at the 1% level.

impact on the dependent variable is $\Delta\beta\ln(T_p)$. When, instead, only the tax rate is allowed to change, the change is $\beta\Delta[\ln(T_p)] \approx [\beta/(T_p)]\Delta(T_p)$. Thus, the change in the monthly effective tax rates that is equivalent in its effect on the dependent variable to the monthly change in the coefficient may be solved by setting $\Delta(\beta)\ln(T_p) = [\beta/T_p]\Delta(T_p)$. Because $-\beta_5$ is the estimated monthly change in the coefficient (i.e., $\Delta\beta$), the equivalent change in T_p is $-\beta_5(T_p)\ln(T_p)/\beta_1$. Substituting the sample's average of T_p for T_p in this expression, the estimated monthly increase in the effective tax rate is 1.6 percentage points.

The estimates of the "Annual vs. Quarterly" regression are reported in Table II. The coefficient β_7 in equation (5) is negative, indicating that the transformed yields ratio declines with time within a tax quarter. This result is consistent with the prediction of the interest-timing hypothesis. The coefficient of the $\{L\}\{\hat{r}_0\}$TOQ variable is significantly larger than zero, whereas the coefficient of the $\{L\}\{\hat{r}_0\}$TOY variable is positive but is not significantly different from zero. This reflects the increase in the yields ratio at turns of tax quarters, and indicates that there is no evidence for a significant additional increase at calendar year turns. Recall that the coefficient of D1 in the "Quarterly Deferment" regression is smaller than the coefficient of D2, which is, in turn, smaller than the coefficient of D3. Thus, the estimates of the "Annual vs. Quarterly" and "Quarterly Deferment" regression equations indicate that the tax deferment interval for the marginal investor does not depend *exclusively* on the time interval from the date on which interest is received until the end of the calendar year.

Table II

Estimation Results for the Annual vs. Quarterly Equation

The dependent variable, $\{1 - L\}\{\ln[r_b/(r_b - r_0)]\}$, is the difference between the current value and the lagged value of the transformed yields ratio, where r_b and r_0 are the yields on one-year Treasury securities and tax-exempt municipal bonds, respectively. The explanatory variables are constructed from current and lagged values of the following variables: T_p, the personal tax rate; T_c, the corporate tax rate; REG, a dummy variable which equals one in periods when Regulation Q is binding and zero otherwise; S, the net supply of tax-exempt bonds divided by the net supply of all bonds; TOQ, a dummy variable equaling one when the dependent variable is the difference between the observations of April/March, June/May, September/August, and January/December (of the previous year), and zero otherwise; TOY, a dummy variable equaling one when the dependent variable is the difference between the observation of January/December, and zero otherwise; and $\hat{r}_0$, an instrumental variable consisting of the fitted values of a regression in which $\ln(1 + r_0)$ is explained by the variables $\ln(T_p)$, $\ln(T_c)$, REG, S, TOQ and TOY. The AUTOREG procedure is used to obtain the estimates.

Regression Equation	Annual vs. Quarterly (5)
Intercept	−0.002
	(−0.45)
$\{1 - L\}\{\ln(T_p)\}$	0.133
	(0.50)
$\{1 - L\}\{\ln(T_c)\}$	0.120
	(0.35)
$\{1 - L\}\{\text{REG}\}$	0.012
	(0.69)
$\{1 - L\}\{\text{S}\}$	0.046
	(0.16)
$\{L\}\{\hat{r}_0\}[\text{TOQ}]$	0.929
	(2.94)**
$\{L\}\{\hat{r}_0\}[\text{TOY}]$	0.177
	(0.45)
$\{L\}\{\hat{r}_0\}$	−0.247
	(−1.47)
R^2	0.30
F-statistic	2.84
B-P Q-statistic	15.50

The t-statistics are in parentheses; F-statistic is for the significance of all timing variables; Box-Pierce Q-statistic has 14 degrees of freedom.

** Denotes significance at the 1% level.

IV. Summary and Concluding Remarks

The ratio of the yields on tax-exempt and taxable short-term bonds is high at the beginning of a tax quarter and declines gradually during the quarter. This sawtooth pattern is consistent with a pattern induced by deferments of tax payments, for the investor that is indifferent between investing in tax-exempt and taxable bonds, from dates on which interest payments are received to dates on which taxes are due. Also, it seems that the tax deferments for this "marginal investor" vary across tax quarters. However, for this marginal investor, deferring income across turns of calendar years does not generate tax deferments above and beyond those generated when income is deferred across turns of tax quarters.

Our results suggest that infra-marginal investors may employ holding strategies that take advantage of the intra-year pattern in the yields ratio. Note that investors are infra-marginal when they differ from the marginal investor either in their tax rates or in their schedule of tax payments. For example, a tax-exempt investor should find taxable bonds that pay interest at the end of a tax quarter more attractive than taxable bonds that pay interest at the beginning of a tax quarter. The order of magnitude of the difference in the yields between the two strategies (i.e., purchasing taxable bonds at the end vs. at the beginning of a tax quarter) may be inferred from the estimates of the Quarterly Deferment regression by assuming that the yield on tax-exempt bonds is fixed throughout the year. Under this assumption, the difference in the yields between the two strategies is approximately ten basis points. Another example relates to investors who are subject to the *same* tax rates as the marginal investor but have a different schedule of tax payments. Consider an investor for whom the tax deferment interval depends exclusively on the time interval from the date on which an interest payment is received until the end of the calendar year. This investor may opt to invest in taxable bonds at the beginning of a calendar year and in tax-exempt bonds at the end of a calendar year.

Issuers of bonds may also benefit from employing tax-related timing strategies if the dates that are associated with tax deferments for them differ from the dates that are associated with tax deferments for their marginal investor. For example, issuers of tax-exempt bonds may benefit from scheduling interest payments at the ends of the tax periods of their marginal investor. Issuers of taxable bonds may benefit from scheduling interest payments on dates that are at the beginnings of the tax periods of their marginal investor and at the ends of their own tax periods.

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