Do Municipal Bond Yields Forecast Tax Policy?

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During the 1995–96 Presidential primary season, the "flat tax" was a widely discussed tax reform. In July of 1995, a flat tax plan was proposed by House Majority Leader Dick Armey and Senator Richard Shelby (H.R. 2060). The Armey-Shelby flat tax was subsequently adopted as the key component of the Forbes campaign and, with modifications, as a board in the platforms of other Presidential contenders.

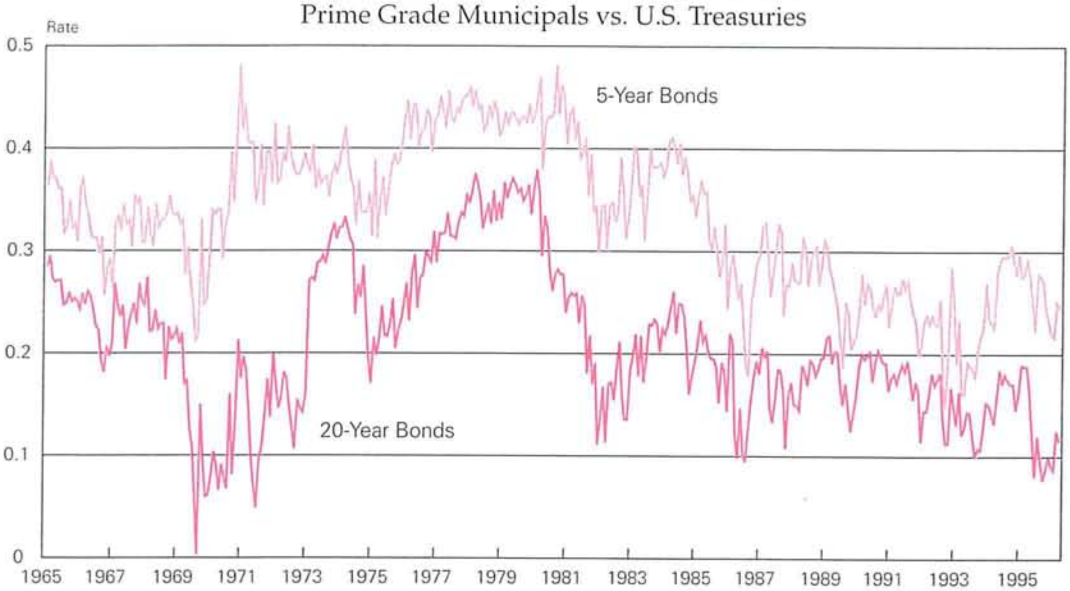
The Armey-Shelby flat tax plan proposed a single tax rate on all taxable income and a redefinition of taxable income to exclude interest and dividends. While this would have important effects on the valuation of many financial instruments, the impact on the market for municipal bonds could be profound. The exclusion of interest income from the tax base would eliminate the tax advantage that municipal bonds traditionally have enjoyed. The effect on relative interest rates is clear: The end of federal taxation of interest income should create a new security market equilibrium in which municipal bond rates would equal the rates paid on equivalent taxable securities. This entails a sharp rise in the *relative* yield on municipal bonds. However, some proponents of the flat tax argue that the general level of interest rates would fall, so that the cost of capital for municipalities might fall even though the relative yield on municipal bonds rises.

During the time of the flat tax debate, the interest rate on newly issued municipal bonds rose relative to the rate on U.S. Treasury bonds. This was frequently cited as arising from expectations that a flat tax might be implemented. For example, in the May 13, 1996 issue of its *Fixed Income Research Relative Value Report*, Lehman Brothers reported that "After spending most of 1995 in fear of a flat tax, the municipal bond market has rallied relative to taxables for the first several months of 1996."

That security prices and yields reflect anticipation of relevant future events is an axiom of financial economics. In its extreme form—the Efficient Markets Hypothesis—current asset prices reflect an optimal

Figure 1

Implicit Tax Rates on Municipal Bonds
Prime Grade Municipals vs. U.S. Treasuries



Source: Salomon Brothers and author's calculations.

forecast of the future cash flows generated by the asset. Even if one is not an efficient markets enthusiast, the partial reflection of anticipations in asset prices is widely accepted. Most of the work in this area has been done in the context of stock and commodity markets and, as we shall see, very little has been done for the municipal bond market.

Throughout this article, we will use the concept of the "implicit tax rate," also called the "breakeven tax rate" because an investor with that tax rate will be indifferent between a tax-exempt bond and a taxable bond, and the "implicit subsidy rate" because it measures the subsidy to municipal borrowing arising from tax exemption. If R_m and R denote the yields on municipal bonds and on taxable bonds with the same term to maturity and credit risk, and if s denotes the implicit tax rate, then the implicit tax rate is calculated as $s = 1 - R_m/R$.

Figure 1 shows the implicit tax rate reflected in interest rates for 5-year and for 20-year bonds. The 5-year implicit tax rate is calculated using the definition given above and Salomon Brothers 5-year Prime Grade general obligations (GOs) and 5-year U.S. Treasury bond yields; the 20-year implicit tax rate uses the Salomon Brothers data for 20-year bonds. A clear correlation can be seen between the implicit tax rates and the personal income tax rates paid by affluent investors. For example, for 5-year bonds the implicit tax rate fell after the Economic Recovery and Tax Act of 1981 (ERTA), which reduced tax rates paid by upper-income investors. It fell again after the Tax Reform Act of 1986, which further reduced the tax rates paid by the affluent and also eliminated many competing tax shelters. The same pattern is shown for 20-year bonds. Note also that the implicit tax rate fell to low levels in 1969, particularly for 20-year bonds. This was attributed at the time to a debate about including municipal interest income in the new Alternative Minimum Tax.

If the implicit tax rate has no information content, implicit tax rates at any particular time should be uncorrelated with the path of actual tax rates as they evolve after that time. At the other extreme, if the implicit tax rate has its maximum information content, it should perfectly predict future tax rates, with due allowance for statistical noise. What is the information content of implicit tax rates as predictors of future tax rates? The answer to that question will let us know how much credence to attach to tax rate debates when assessing changes in relative interest rates. It can also tell us something about the efficiency of security markets. The goal of this study is to assess the evidence bearing on this question.

The article is structured as follows. The first section briefly reviews other studies of the connection between implicit and actual tax rates. The second section addresses the question of how anticipations of future tax rates should be measured. The third section develops and estimates a model of the information content of implicit tax rates. This model allows the information content to change over time as tax policy debates wax and wane. The article ends with a brief summary.

I. Previous Research on Tax Policy and Implicit Tax Rates

Our study will examine the connection between the expected future tax rate of a representative investor and the implicit tax rate. A key question in this analysis is who should represent the representative investor. That is, whose tax rates matter? Following a brief discussion of this question, we will look at some empirical evidence on the relationship between tax policy events and bond yields.

Whose Tax Rates Matter?

It will come as some surprise to noneconomists that there has been a debate about whether implicit tax rates are affected at all by personal income tax rates. In 1977, Eugene Fama and Merton Miller independently developed models in which the implicit tax rate is determined by the corporate income tax rate. In this "new view," personal income taxes do not matter at all in the determination of municipal bond yields. If this is true, the representative investor should be a corporation facing the statutory corporate income tax rate.

Fama's explanation of the new view rests on the assumption that corporations, particularly commercial banks, are the marginal investors in municipal bonds. Because they can borrow at the corporate bond rate and deduct their interest payments, the after-tax cost of funds is $(1 - \tau_c)R$, where τ_c is the corporate tax rate and R is the taxable bond rate. If the opportunity to invest in municipal bonds is unrestricted they will hold municipal bonds when R_m exceeds $(1 - \tau_c)R$ and taxable bonds when R_m is less than $(1 - \tau_c)R$. Security market arbitrage will ensure that $R_m = (1 - \tau_c)R$ in equilibrium as banks borrow at the taxable rate and invest at the tax-exempt rate. Thus, the banking sector's demand for tax-exempts is infinitely elastic at the after-tax interest rate on taxable bonds, and banks are the marginal investors in municipal bonds. The implicit tax rate will be τ_c.

Miller's exposition of the new view sees nonfinancial corporations as the marginal suppliers of municipal debt. This might be motivated by corporate access to the municipal bond market for industrial development, real estate development, environmental, and other purposes. But Miller's story does not require direct corporate access to municipal financing. It rests on the assumption that municipal bonds and common stock are very close substitutes. Suppose that they are perfect substitutes. Investors in corporate equity (shareholders) will require a marginal pre-tax return on capital of $R_m/[(1 - \tau_c)(1 - \tau_e)]$, where τ_e is the personal income tax rate for equity income (dividends or capital gains). This is the municipal bond rate grossed up by the taxes paid at both corporate and personal levels, and it is the pre-tax return on plant and equipment required to give shareholders an after-tax return equal to the municipal bond rate. Investors in corporate debt (bondholders) will require a return on corporate capital equal to the taxable bond rate, R, so that is the marginal pre-tax cost of capital required for debt finance. The optimizing capital structure is that for which the marginal costs of capital for debt and equity are equal, hence an equilibrium exists when $R_m = [(1 - \tau_c)(1 - \tau_e)]R$. Miller also assumes that the personal income tax rate on equity income is zero, so the equilibrium yield relationship is $R_m = (1 - \tau_c)R$.[1] The implicit tax rate will, as in Fama's model, be the corporate income tax rate but the reason is that corporations are the marginal suppliers of a perfect substitute for municipal debt.

Whatever the merits of the new view when it was first presented in the 1970s, subsequent events have weakened, if not eliminated, its validity. During the 1980s, the deductibility of interest paid to carry tax-exempt bonds was eliminated. Banks lost their incentives to invest in municipal bonds, and dominance of the municipal bond market shifted from banks to individual investors, primarily through mutual funds. This ended the foundation on which Fama's version of the new view rested. At the same time, changes in

[1] A zero personal income tax rate is not farfetched. Dividend-paying stocks tend to be held by tax-exempt financial institutions, and low-dividend stocks are affected by the capital gains tax rate. The effective capital gains tax rate can be quite low because realization can be deferred as long as the shareholder wishes.

Table 1
Events Expected to Affect Implicit Tax Rates

Predicted Sign	Regression Results: Estimated Impact on Implicit Tax Rate 5-yr	10-yr	20-yr	Date	Event
+	c	c	c	Jan67	President Johnson proposes tax surcharge
+	c	c	x	May–Jun68	One-year surtax passes and is signed
–	c	c	c	Mar69	Several members of House Ways and Means propose changing taxation of municipal interest
–	c,s	c,s	c,s	Jul69	House Ways and Means passes minimum tax proposal including municipal interest in tax base
+	c	c	x	Sep69	Senate Finance Committee members oppose including tax-exempt income in minimum tax
+	x	x	x	Dec69	Surtax extended to 1970
+	c,s	c	c	Jan70	President Nixon proposes revenue-sharing plan
+	c,s	c,s	c,s	Nov–Dec70	Proposed revenue-sharing plan expanded
+	c	c	x	Mar72	House approves revenue-sharing
–	c	c,s	c,s	July74	House Ways and Means passes bill reducing top personal income tax rate to 50%
–	x	c	c,s	Nov–Dec74	New York City financial crisis
+	c	x	c	Jan78	President Carter proposes upper-income tax rate increase
–	c	c	c	Jun78	Proposition 13 passes in California
–	x	x	c	Jun80	Candidate Reagan proposes large cuts in income tax rates
–	x	x	c	Nov80	Reagan elected President
–	c	c	c	Dec80	IRS rules commercial banks cannot deduct interest paid for carrying municipal securities
–	c	c	c	Jan81	President Reagan proposes tax cut
–	c	c	c	Aug81	Economic Recovery Tax Act passes
–	x	x	x	Aug82	Tax Equity and Fiscal Responsibility Act allows deduction of only 85% of interest paid to carry municipal bonds
–	c	c	c,s	Apr83	Social Security Act amendment exposes municipal interest to taxation
–	x	x	x	Mar–May83	Washington Public Power Supply default
–	c	c	c	Aug84	Deficit Reduction Act reduces bank interest deduction for carrying municipals to 80%

the tax code eliminated the foundations for Miller's version of the new view. For example, after 1986 (and until 1993) the maximum personal income tax rate was less than the corporate income tax rate, so personal income taxation would become relevant.

The early empirical evidence for the new view appeared to be favorable. In a widely cited paper, Trczinka (1982) found that the implicit tax rate was very close to the corporate income tax rate during the 1970s. However, later evidence has led to a rejection of the Fama-Miller view. Fortune (1988) showed that Trczinka's results were unique to the 1970s, and that during the 1980s the movements in the implicit tax rate were consistent with changes in personal income tax rates. This shift is, of course, consistent with the tax code changes during the 1980s, which weakened the new view's foundations. In addition, as Figure 1 shows, the implicit tax rate fell sharply in 1981, when ERTA reduced marginal tax rates of the affluent but did not change the corporate tax rate. This event occurred before the tax code changes that eliminated the new view's validity, suggesting evidence against that view even in its prime.

Thus, we adopt the position that the representative investor is an individual for whom the personal income tax is the tax-related force driving his portfolio decisions. Our results will support that choice.

Event Studies

Event studies also indicated the importance of personal income taxes. These event studies were the first to show that the implicit tax rate did reflect information about future tax rates. Poterba (1986,

Table 1 continued

Events Expected to Affect Implicit Tax Rates

Predicted Sign	Regression Results: Estimated Impact on Implicit Tax Rate 5-yr	10-yr	20-yr	Date	Event
–	**c**	**c**	**c,s**	Nov84	Reagan reelected, Treasury I tax proposal announced
–	**c**	**c**	**c**	Dec85	House Ways and Means passes bill incorporating major tax reforms including reducing tax rates and tax shelters
–	**x**	**x**	**c**	Mar86	Senate Finance Committee considers including municipal interest in alternative minimum tax
–	**c,s**	**c,s**	**c,s**	May86	Senate Finance Committee passes revised version of the Dec '85 House bill
–	**x**	**x**	**x**	Sep86	Tax Reform Act passed
–	**x**	**c**	**x**	Apr88	In *South Carolina vs. Baker*, Supreme Court rejects constitutional foundation for tax exemption
–	**x**	**x**	**c**	Nov90	President Bush signs Revenue Reconciliation Act, eliminates "bubble" tax rate, sets cap on capital gains tax rate
+	**c**	**x**	**x**	Aug93	President Clinton's Omnibus Budget Reconciliation Act passed, increases tax rates for higher-income groups, treats market discounts as ordinary income
–	**c**	**c**	**x**	July–Dec95	Armey-Shelby Flat Tax (HR 2060) Introduced and debated
–	**c**	**x**	**x**	Jan–Feb96	Several Presidential primary candidates endorse flat tax
Summary	5-yr	10-yr	20-yr	Total	
Number **c**	22	21	21	64 (66.7%)	
Number **c** and **s**	4	4	7	15 (15.6%)	
Number **x**	10	11	11	32 (33.3%)	
Number **x** and **s**	0	0	0	0	

The regression equation was an MA(1) with the change in the implicit tax rate as the dependent variable.
c denotes regression coefficient has the predicted sign.
s denotes regression coefficient is statistically significant (5%, one-tail).
x denotes regression coefficient has incorrect sign.

1989) investigated the movements in implicit tax rates during important tax policy events. In his first paper, Poterba included 22 tax policy events and seven credit risk events in the 1962–82 period. In his second paper, he focused on 13 tax policy events between 1968 and 1988. Rather than report his results, we have used the same methods on an updated list of 32 events in the 1967–96 period.

An updated list of relevant events is shown in Table 1. A multiple regression was estimated in which the implicit tax rate was regressed on dummy variables for specific tax policy events.[2] This was done for implicit tax rates on 5-year, 10-year and 20-year bonds. The interest rates used were the Salomon Brothers monthly series for Prime Grade GOs and U.S. Treasury bonds. The first column of the table reports the predicted sign of the coefficient on the event. The next three columns summarize the regression results (c indicates a correct sign, x indicates an incorrect sign and s indicates statistical significance). The remaining two columns show the date and a brief description of the event. There are 96 event coefficients (32 tax policy events times 3 bond maturities).

Of the 96 event effects estimated, two-thirds of the coefficients have the correct sign, giving the appearance that tax policy events affect the implicit tax rate. However, only 16 percent of the coefficients have both the correct sign and statistical significance, weakening

[2] A dummy variable is a variable designed to reflect the existence of a condition. It is defined as one during the period the condition exists, and zero otherwise. Each tax policy event was reflected by a dummy variable having a value of one during the month(s) of that event, and zero otherwise.

the conclusion that tax policy events are embedded in implicit tax rates. Only four tax policy events showed statistically significant *and* correct signs for two or more of the regressions. These events were the July 1969 passage of a House Ways and Means Committee bill including municipal interest in the proposed minimum tax, the late 1970 expansion of the revenue-sharing plan proposed by President Nixon, the July 1974 House Ways and Means passage of a bill reducing the top personal income tax rate to 50 percent, and the May 1986 Senate Finance Committee passage of the House version of the Tax Reform Act.

Event studies were the first to show that the implicit tax rate did reflect information about future tax rates, but an updated event study provides little comfort for those who believe that implicit tax rates carry abundant information about future tax policy.

During much of the period the municipal bond market was segmented, with commercial banks dominating the market for shorter maturities and individuals dominating the longer-term market. This segmentation might explain why the results for the 5-year implicit tax rate differed from the 10- and 20-year results. Thus, while the July 1974 House Ways and Means bill reducing top personal income tax rates did depress implicit tax rates at all maturities, the effect was statistically significant only for the 10- and 20-year terms, where high-income individuals were the primary investors. The 1983 Social Security Act Amendments, which exposed municipal interest received by high-income Social Security beneficiaries to taxation, affected all three implicit tax rates in the correct direction, but only the 20-year effect was significant. However, other events that should have affected the short end where banks invested did not have the expected effects. For example, the 1982 Tax Equity and Fiscal Responsibility Act (TEFRA) and the 1984 Deficit Reduction Act both reduced bank incentives to hold municipal bonds. TEFRA showed incorrect signs in all three cases, while the milder DRA showed the correct sign in all three cases.

Some events that should be important for implicit tax rates are not. For example, President Reagan's January 1981 tax cut proposal and passage of the Economic Recovery Tax Act in August of 1981 show correct signs, but neither of these effects is statistically significant. Both the South Carolina vs. Baker decision in April 1988, and President Clinton's signing of the 1993 Omnibus Budget Reconciliation Act in August of 1993, show incorrect signs in two of the three cases. Of particular interest, the introduction and debate of the Armey-Shelby flat tax bill showed correct signs in two of the three regressions, but neither was statistically significant, and the 1996 Presidential primary debates over the flat tax showed correct signs in only one of the three cases, again with no statistical significance.[3] Thus, Lehman Brothers' attribution of high municipal bond yields, and low implicit tax rates, to flat tax debates is not supported.

The general failure of this event study to support the view that implicit tax rates contain a great deal of information about tax policy is somewhat unsettling, though event studies do have a number of well-known problems. The selection of an "important event" is in the eye of the beholder, and the timing of economic events is notoriously hard to identify because the real question is not when did legislation pass, or when was it proposed, but when did expectations about future tax rates change. Furthermore, the best event study can only tell whether there was a correlation between the timing of an event and related market activity or prices; it says nothing about the magnitude of the event's impact, or about the dynamics surrounding that impact. Even so, our update of Poterba's event study provides little comfort for those who believe that implicit tax rates carry abundant information about future tax policy.

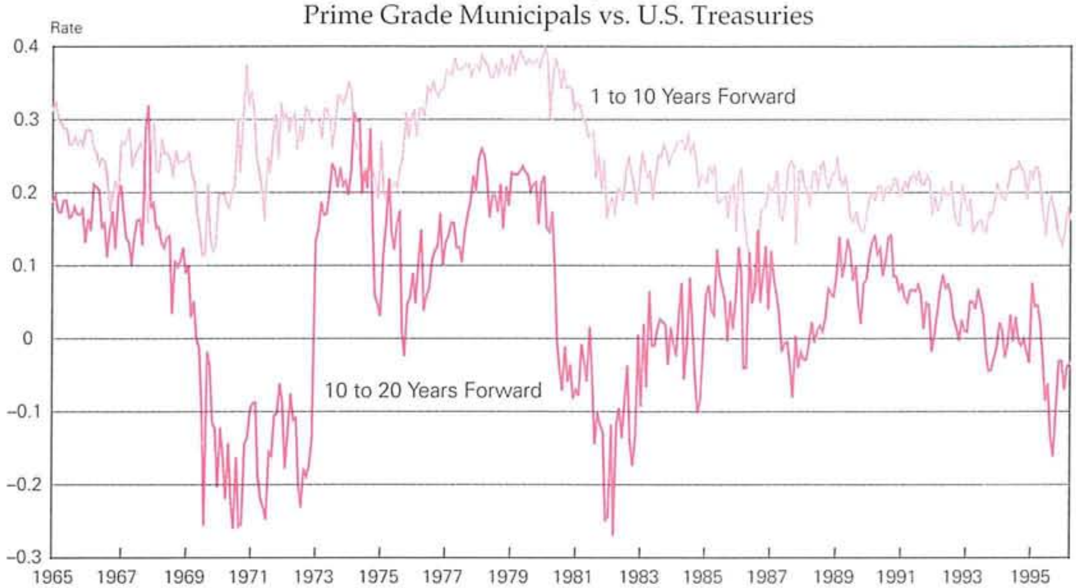
II. Measuring Expected Future Tax Rates

In order to examine the connection between implicit tax rates and expectations of future tax rates, we must have some measure of expectations. In this section we consider two approaches to deriving measures of expected future tax rates. We first assess the

[3] We date the flat tax debate in two events: the period in 1995 following introduction of H.R. 2060 (July–December) and the period of the Presidential primary debate over the flat tax (January–February 1996).

Figure 2

Forward Ex Ante Implicit Tax Rates
Prime Grade Municipals vs. U.S. Treasuries



Source: Salomon Brothers and author's calculations.

tax rates implicit in the yield curves for taxable and tax-exempt bonds. The result, called the *ex ante implicit tax rate*, has been used by Fortune (1991) in an analysis of the determinants of municipal bond yields and, more recently, by Park (1995) in an examination of the relationship between federal financial conditions and expected tax rates. Rejecting this measure of expected future tax rates, we develop an alternative approach by determining the future tax rates that investors actually pay, using the discounted value of these as a measure of expected future tax rates. The result, called the *ex post tax rate*, measures the value of taxes actually avoided over the life of a municipal bond.

The Ex Ante Implicit Tax Rate

Among the earliest studies of ex ante implicit tax rates is Kochin and Parks (1988), which used the yield curves for municipal and U.S. Treasury bonds to calculate the ex ante tax rates implicit in the yield curves for taxable and tax-exempt bonds. If $s_{t,t+k}$ is the spot implicit tax rate at time t on bonds maturing at time $t + k$, $s_{t,t+m}$ is the spot implicit tax rate at time t on bonds maturing at a more distant time, $t + m$, and $T_{k,m}$ is the ex ante implicit tax rate at time t for the interval $t + k$ to $t + m$, then, Kochin and Parks show, the ex ante implicit tax rate is a weighted average of the two spot implicit tax rates. Specifically,

$$T_{k,m} = w_t s_{t,t+m} + (1 - w_t) s_{t,t+k},$$

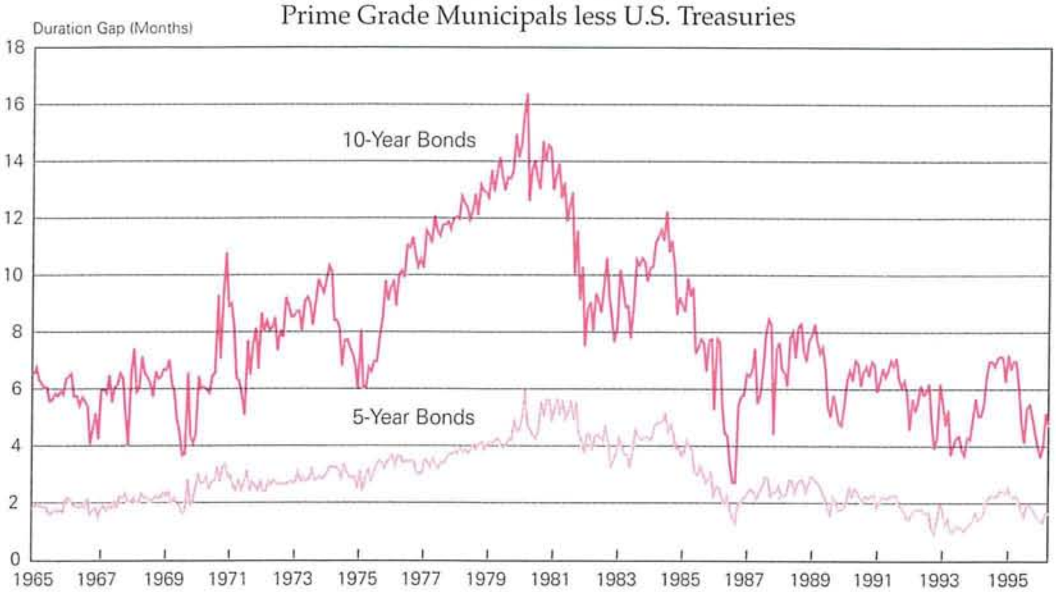
$$\text{where} \quad w_t = \sum_{i=1}^{m} (1 + R_i)^{-i} / \sum_{i=k+1}^{m} (1 + R_i)^{-i}. \qquad (1)$$

Figure 2 shows the ex ante implicit tax rates for two future intervals, 1 to 10 years into the future, and 10 to 20 years into the future.[4] The 1- to 10-year ex ante implicit tax rate appears to conform roughly with expectations: It is always positive and it ranges between 0.2 and 0.4. It also shows a tendency to peak just before major tax rate reductions (the 1981 ERTA and the 1986 TRA). However, the 10- to 20-year ex ante implicit tax rate makes no sense. It is negative for extended periods, and it seems too low in the 1980s.

[4] The Kochin-Parks calculation of the weight, w_t, requires information on the zero-coupon yield curve, showing the interest rate on single payments through the life of the longest bond. Because these data are not available, we use the yield curve for coupon-bearing municipal bonds.

Figure 3

Difference in Duration
Prime Grade Municipals less U.S. Treasuries



Source: Salomon Brothers and author's calculations.

This pattern is the same as that found by Kochin and Parks.

The negative ex ante implicit tax rates in the distant future present a serious problem for the interpretation of relative yields as driven by tax rate expectations. Clearly, investors in 20-year municipal bonds do not expect negative future tax rates 10 to 20 years out. Furthermore, the observation of negative ex ante implicit tax rates should elicit arbitrage behavior that eliminates the phenomenon. For example, investors with high tax rates can earn riskless profits by buying long-term municipal bonds, receiving the high municipal bond yields, and selling Treasury bonds with an equal duration. This would reduce municipal bond yields and raise Treasury bond yields, restoring the positive ex ante implicit tax rate. However, Figure 2 shows that negative ex ante implicit tax rates last for extended periods, suggesting that this arbitrage does not function, or that there is some other explanation for the negative implicit tax rates.

A more plausible interpretation of Figure 2 is that the bond yields from which the ex ante tax rates are constructed are contaminated by factors other than tax-rate expectations, and that this contamination becomes more serious as we look further into the future. These "contaminants" all can be capsulized in a generic "risk premium" that investors attach to municipal bonds. This risk premium is the extra return required to compensate for all nontax differences between municipal and Treasury bonds.

Several candidates come to mind. The first is duration. Municipal bonds and U.S. Treasury bonds with the same term to maturity necessarily differ in their durations and, therefore, in the interest rate risk their holders experience. The reason is that the coupons on newly issued municipal bonds are less than the coupons on Treasury bonds with the same maturity. This shifts the distribution of cash payments further into the future for municipal bonds than for Treasury bonds, making the duration longer for municipals. Figure 3 shows, for 5-year and 10-year terms, the difference between the durations of Prime Grade GOs and U.S. Treasury bonds. The duration of municipal bonds is always greater than the duration of Treasury bonds because tax exemption shifts the stream of cash payments further into the future: Both bonds receive the face value (say, $1000) at maturity, but municipals pay a lower coupon. Figure 3 also shows that the duration gap widens when interest rates are high and narrows when they are low: When interest rates rise, the duration of Treasury bonds falls relative to the duration of municipal bonds. Thus, we would expect that the ex ante implicit tax rates are a biased estimate of future tax rates because of duration differences in the instruments, and that this bias increases with interest rates. If a positive relationship exists between duration and yields required by investors, this bias will induce higher municipal bond yields for more distant maturities and contribute to the very low, sometimes negative, implicit tax rates on 20-year municipal bonds shown in Figure 2.

A second contaminant is callability. U.S. Treasury bonds do not carry call features, but many municipal bonds allow the issuer to call the bond at its discretion after some period of time. Because the call option held by the issuer has value, the municipal bond buyer, who is the option's writer, pays a lower price for a callable bond than for an equivalent non-callable bond. This shows up as a higher interest rate on the municipal bond and, therefore, as a lower implicit tax rate. Again, the effect is to make the implicit tax rate a downward-biased measure of expected future tax rates. The effect of callability is largely confined to municipal bonds with over 10 years to maturity. Cook (1982) reports that in a sample of 860 municipal bonds issued in 1977–78, less than 1 percent of 5-year bonds were callable, and only about 10 percent of 10-year bonds could be called before maturity. In contrast, 88 percent of 15-year bonds and 98 percent of 20-year bonds had call features.

The "risk premium" that investors attach to municipal bonds is the extra return required to compensate investors for such nontax differences between municipal and Treasury bonds as duration, callability, and credit risk.

The value of the call feature is not constant, so the bias in implicit tax rates is not constant. Two important determinants of the call's value are the volatility of interest rates and the time to first call. Because the call's value increases with volatility, the bias will be greater at times of high interest rate volatility. Because the call's value decreases as the time to first call gets closer, the bias will be smaller for bonds with a short time to first call. It is, perhaps, not coincidental that the negative implicit tax rates for 20-year bonds shown in Figure 2 were in periods of considerable financial market volatility, the early 1970s and the early 1980s.

The call option problem can be addressed in several ways. One is to explicitly measure the value of the call option using one of the many models available for valuing options on bonds. This would lead one to calculate option-adjusted spreads, and to use these interest rates in computing both spot and ex ante implicit tax rates. A second and simpler approach, which we follow, is to eliminate from our analysis bonds with more than 10 years to maturity, on the grounds that these are the ones most tainted by callability.

Yet a third contaminant of ex ante tax rates is credit risk. The probability of a U.S. Treasury default is negligibly low, although recent fiddling with debt limits might suggest some caution. Municipal bonds are another matter. Most tax-exempt bond defaults have been confined to revenue bonds, such as the Washington Public Power Supply default in 1983. Very few general obligation bonds have defaulted, but the possibility always remains that even Prime Grade GOs can default. Because this is more likely to occur in the distant future, default risk prospects will be most prominent for terms beyond five years. Indeed, default risk is one of the reasons often given for the decline in the implicit tax rate as bond maturity gets more distant (Figure 1).

A recent paper by Chalmers (1995) suggests that default risk does not explain the inverse relationship between the implicit tax rate and time to maturity revealed in Figure 1. Chalmers examines advance refunding (defeasance) of municipal bonds. An advance refunding involves determining the portfolio of U.S. Treasury securities required to match the cash payments to be made on outstanding municipal bonds, then issuing a new municipal bond in an amount equal to the cost of this portfolio. Because the proceeds are invested in an irrevocable escrow of the requisite U.S. Treasury bonds, from which the income and principal are used to make the payments on the refunded issue, the defeased municipal bond has no default risk. The incentive to do this is, of course, the reduction in debt service achieved by taking advantage of the higher yield on Treasury securities and substituting a new, lower-coupon municipal bond for the old bond.

Chalmers found that the inverse relationship between maturity and implicit tax rate held for defeased bonds as well as for the bonds used in the Salomon Brothers Prime Grade GO series. Furthermore, the rate of decline was about the same for both series. Because defeased bonds have no default risk and no call risk (the call option is typically extinguished at defeasance), Chalmers' results suggest that the relationship between implicit tax rates and maturity derives from factors other than default risk and callability. One possibility is that it reflects the uncertainty about future tax rates.

We reject ex ante implicit tax rates as measures of expected future taxes because they appear to be a poor measure.

We reject ex ante implicit tax rates as measures of expected future taxes because they appear to be a poor measure. We have seen that the ex ante implicit tax rates constructed from the Salomon Brothers bond yield data are not determined by tax rate anticipations alone, but are also affected by duration, callability, default risk, and market risk differentials (though Chalmers' work suggests these effects might be less severe than previously thought).

Ex Post Tax Rates

An alternative measure of expected future tax rates can be constructed from actual future tax rates. This entails a minor truncation: Ex post tax rates cannot be calculated for periods in which actual future tax rates are not known. For example, because we have data up through 1995, our series for the ex post tax rate on 5-year bonds cannot be extended beyond 1990; the tax rate on 10-year bonds cannot be calculated after the end of 1985.

Suppose that we have data on a representative investor's actual tax rates after time t. Let τ_{t+i} represent the investor's tax rate in period $t + i$. Noting that coupons are typically paid semiannually, we can construct the time series for tax rates paid at each future semiannual period. This series is denoted as $\tau_{t+6}, \tau_{t+12}, \tau_{t+18}, \ldots, \tau_{t+6n}$, with t being the spot date and n being the number of semiannual periods to maturity. The average ex post tax rate (T_t) can then be constructed from known statutory tax rates over the period to maturity. We use the following definition, in which the actual semiannual ex post tax rates are discounted to the present using the weights derived in Box 1.

$$T_t = \sum_{i=1}^{N/12} w_i \tau_{t+6i},$$

$$\text{where} \quad w_i = R_m(1 + R_m)^{-i}/[1 - (1 + R_m)^{-N}]. \quad (2)$$

No single ex post tax rate applies to all time horizons and all investors. The ex post tax rate will be different for each bond maturity because the horizon over which future tax rates are considered changes. It will also vary across investors, because an investor's income path determines his tax rates. Finally, it will vary over time, as statutory tax rate schedules change.

We have constructed the ex post tax rate for several representative investors over our sample period (1965–95). Because our focus is on the implicit tax rates derived from municipal bonds, we have focused on high-income individuals who will invest in these securities. Our analysis is based on federal income tax rates, excluding state income taxes which might be relevant if a state's municipal bonds were sold entirely within the issuing state.[5]

Figure 4 shows the actual tax rates paid by three representative investors: those who pay the maximum federal personal income tax rate, and those who earn real taxable incomes (1980 dollars) of $100,000 and $50,000. The figure shows that prior to the 1986 Tax Reform Act a pronounced difference existed in marginal tax rates, reflecting the progressivity of the tax code. The maximum tax rate was 70 percent prior to 1982, about 10 to 20 percentage points more than the marginal tax rate associated with $100,000 of real taxable income. The Economic Recovery Tax Act of 1981 greatly reduced the differentials, and the 1986 Tax Reform Act reduced them even more. A reemergence of tax rate differentials began in 1993, with

[5] Most states include tax-exempt interest in the state's definition of taxable income only if the interest is paid by an out-of-state issuer. This gives an extra tax advantage to in-state investors. However, whether this affects the yield on a state's municipal bonds depends on whether out-of-state investors buy those bonds. If they do, the state income tax plays no role in the pricing of the municipal bonds because the marginal investors are out-of-state. Only when the marginal investors are in-state will the state's income tax rate affect the yield on municipal bonds.

Box 1: The Implicit Tax Rate and Ex Ante Implicit Tax Rates in an Efficient Market

Consider a newly issued N-period taxable bond with a coupon rate equal to the required interest rate, therefore priced at par. Let R be the yield to maturity (also the coupon rate) on the taxable bond, and R_m be the yield to maturity (and coupon rate) on an N-period tax-exempt bond. Also, let τ^*_{t+i} be the tax rate presently anticipated to apply in period $t + i$, and θ_{t+i} be the marginal risk premium required on income from a taxable bond in period $t + i$, required to make that income equivalent to income from tax-exempt bonds with the same term. The expected tax rate is conditional on the information available at the present time, denoted as Ω_t. Thus, $\tau^*_{t+i} = E(\tau_{t+i} | \Omega_t)$.

The sequence of marginal risk premia $\{\theta_1, \theta_2, \ldots, \theta_N\}$ is, of course, unobservable. The "risk premia" arise for any reason that causes investors to attach different values to an expected stream of after-tax income from taxable bonds and an equal expected stream of income from tax-exempt bonds. For example, differences in call features, in duration, in underlying collateral, and in the general quality of the bonds can be captured in the "risk premium". Note that a negative value of θ_i means that taxable bonds have a nonpecuniary disadvantage relative to tax-exempt bonds, so that equalization of risk-adjusted yields requires a deduction of θ_i from the actual yield on taxable bonds. Thus, the marginal risk premium θ_i can be treated as analogous to a rate of tax on taxable bond income.

The following equation describes the relationship between taxable and tax-exempt N-period bonds if both are newly issued at par:

$$1 = \sum_{i=1}^{N} \{R[1 - (\tau^*_i - \theta_i)](1 + R_m)^{-i}\} + (1 + R_m)^{-N} \quad \text{(B1.1)}$$

Note that θ_i is treated as the addition to the taxable bond yield required to make taxable and tax-exempt bonds equivalent on a risk-adjusted basis. Equation (B1.1) can be used to derive

$$s = \sum_{i=1}^{N} (\tau^*_i - \theta_i) w_i, \quad \text{where}$$

$$w_i = R_m(1 + R_m)^{-i}/[1 - (1 + R_m)^{-N}] \quad \text{(B1.2)}$$

The left-hand side of (B1.2) is the implicit tax rate, defined as $s = 1 - R_m/R$. The right-hand side is a weighted average of the expected future marginal tax rate less the average marginal risk premium on municipal bonds.

Let π_t denote the properly discounted average marginal risk premium. For any investor who holds both tax-exempt and taxable securities, the following relationship holds.

$$s_t = E_t - \pi_t \quad \text{where}$$

$$E_t = \sum_{i=1}^{N} w_i E(\tau_{t+i} | \Omega_t), \qquad \pi_t = \sum_{i=1}^{N} w_i \theta_i, \qquad \text{and}$$

$$w_i = R_m(1 + R_m)^{-i}/[1 - (1 + R_m)^{-N}] \quad \text{(B1.3)}$$

Thus, the spot implicit tax rate is the expected average future marginal tax rate less the average future marginal risk premium. A slight rewriting of (B1.3) tells us that the expected average marginal tax rate must be equal to the *risk-adjusted* implicit tax rate, defined as the implicit tax rate plus the average marginal risk premium on municipal bonds. Thus, in an efficient market the expected future tax rate is the spot implicit tax rate plus a risk premium.

$$E_t = s_t + \pi_t \quad \text{(B1.4)}$$

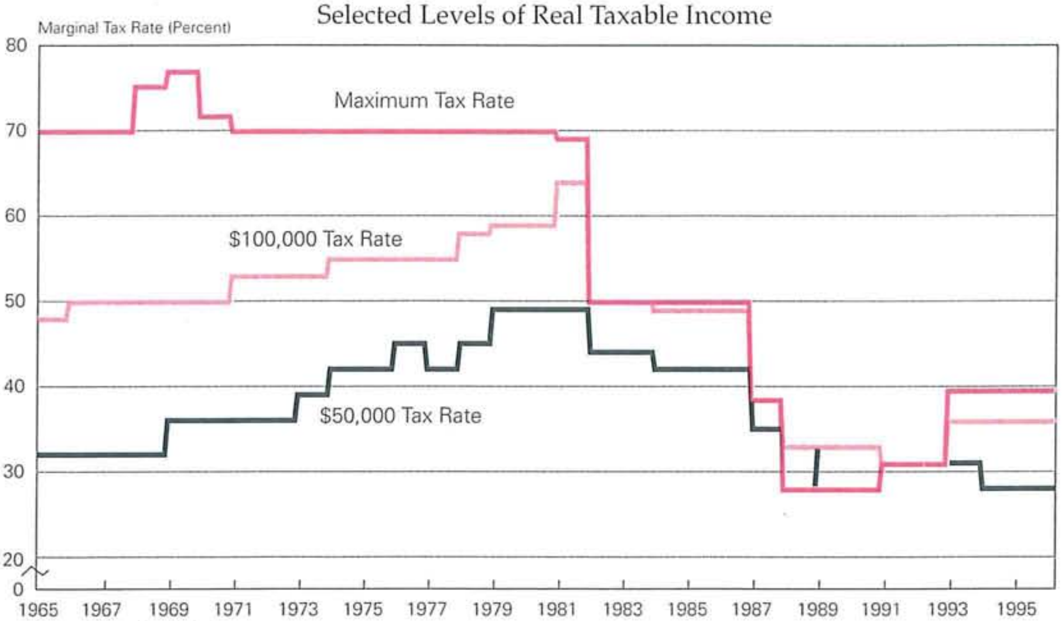
President Clinton's Omnibus Budget Reconciliation Act.[6] Note that while the maximum tax rate declined over the 1965–86 period, the marginal tax rates for lower income levels rose. This reflected, in part, the bracket effect of inflation, as rising prices pushed taxpayers into higher income tax brackets even though their real taxable income remained constant. The indexing of tax brackets has mitigated this effect.

[6] This Act also contained a provision to treat market discounts on municipal bonds as ordinary income. Prior to this, market discounts were taxed at the capital gains rate.

Figure 4

Personal Income Tax Rates

Selected Levels of Real Taxable Income



Source: Author's calculations.

III. Implicit Tax Rates as Forecasts of Future Tax Rates

A well-known property of optimal forecasts is that the actual value of a variable being forecasted is equal to the value forecast plus a forecast error. Thus, if $E_{t,t-i}$ is the expected or forecasted value of a variable at time t, the forecast being made at time t-i, and if A_t is the realized or actual value of that variable at time t, then the following relationship must hold.

$$A_t = E_{t,t-i} + \varepsilon_t \qquad (3)$$

where the term ε_t is the forecast error. A further property of an optimal forecast is that the forecast error will have a zero mean, and it will be uncorrelated with the forecast value, $E_{t,t-i}$. If the mean forecast error is nonzero, the forecaster is neglecting some systematic information. If the forecast error is correlated with the forecast, relevant information in the form of missing variables is also being neglected. In either case, the forecast will not be optimal.

An example illustrating the use of the relationship between an optimal forecast and the realized value of the variable is Shiller's 1981 study of the efficiency of the U.S. stock market. If, as Efficient Markets Theory suggests, the spot price of a common stock contains all the relevant information about future stock returns, the spot price will be an optimal forecast of the present value of future dividends. Shiller constructed a time series for the realized, or ex post, value of a share of stock using actual dividends paid in the future. Thus, his measure of A_t is the present value of actual dividends paid. Noting that one of the implications of optimal forecasting is that the variance of the realized outcomes must be less than the variance of the forecast, Shiller compared the variance of his series for the "true" value of the S&P 500 (the present value of dividends) with the variance of the spot S&P 500 index. He found that the variance of the spot price exceeded the variance of the present value of dividends. His result can be interpreted in three ways. Either the stock price is not a present value of future dividends, or the market develops inefficient estimates of the true price, or some assumption underlying the analysis is incorrect. Shiller concluded that the U.S. stock market is inefficient.

The Model

Our analysis follows this optimal forecasting approach. It does not suffer from some of the shortcomings of Shiller's study. The bonds we use in constructing ex post tax rates have a finite life, not the perpetual life of common stock. As a result, we can know the path of a representative investor's tax rates throughout the life of the instrument, and we do not need to make assumptions about future values. Also, the coupons on both municipal and Treasury bonds are known at the time the bonds are issued, and they do not adjust according to the (perhaps complicated) dynamics involved in corporate dividend decisions.

However, the tests appropriate for this study cannot be as simple as Shiller's variance bounds test. In an efficient market, the optimal forecast of the average future tax rate over the life of a bond is the *risk-adjusted* implicit tax rate. In the notation of Box 1, the risk-adjusted implicit tax rate is $s_t + \pi_t$, where s_t is the spot implicit tax rate and π_t is the risk premium on municipal bonds. Now, if T_t is the ex post tax rate, then optimal forecasting means that $T_t = (s_t + \pi_t) + \varepsilon_t$. Unfortunately, the risk premium is not observable, and it is likely to be correlated with the implicit tax rate and difficult to disentangle from the forecast error. Thus, a simple comparison of the variance of the observed implicit tax rate with the variance of the ex post implicit tax rate will tell us nothing about the information content of the implicit tax rate.

An alternative approach is to directly model the expected future tax rate. Our model is outlined in Box 2. The result is a regression model of the following form.

$$T_t - \tau_t = \alpha_0 + \alpha_1(s_t - \tau_t) + \alpha_2(1/R_t) + \varepsilon_t,$$

$$\text{where} \quad \varepsilon_t \sim N(0, \sigma^2), \qquad E(\varepsilon_t\, \varepsilon_{t-s}) = 0 \qquad (4)$$

in which the excess of the ex post tax rate over the current tax rate $(T_t - \tau_t)$ is a linear function of the excess of the spot implicit tax rate over the current tax rate $(s_t - \tau_t)$ and of the reciprocal of the yield on taxable bonds. The parameter α_1, called the "information parameter," measures the information content of the implicit tax rate: $\alpha_1 = 0$ if there is no content, $\alpha_1 = 1$ when the implicit tax rate is an optimal forecast. The parameter α_2 measures the risk premium on municipal bonds: It will be positive when tax-exempt bonds expose the investor to more risk than do taxable bonds of equal maturity.

The risk premium on municipal bonds has several sources. Some elements of the risk premium are embedded in the nature of the instruments and of the markets for them. For example, duration differences, default risk differences, and segmentation of the municipal bond market will give rise to risks faced by all investors. Other sources of the risk premium are specific to the investors. For example, in a progressive tax system the more affluent investors will receive a higher average after-tax rate of return, even though they might earn no unusual after-tax return at the margin. This extra average after-tax return is a sort of investor's surplus, or windfall, which will appear as a component of the risk premium because it represents an excess of the actual tax rate over the implicit tax rate.[7]

The risk premium on tax-exempt bonds should be directly related to the investor's tax rate, because high-tax-rate investors will receive a greater windfall on their intramarginal investments in tax-exempt bonds.

If the information parameter and risk premium are constant, our model can be estimated using ordinary least squares. However, both parameters are likely to vary over time. The information parameter should vary because, as Box 2 shows, it is interpreted as reflecting the confidence attached to the implicit tax rate as a predictor of tax policy. That confidence should vary as tax rate policy proposals are proposed, considered, and eventually adopted or rejected. The risk premium will also vary as investors change their assessments of the relative risks of taxable and tax-exempt bonds, and as tax code changes alter the investor's surpluses.

The Data

Our data for bond yields are taken from the Salomon Brothers series for Prime Grade GOs and U.S. Treasury bonds. We have estimated our model

[7] The investor's surplus on municipal bonds arises from the progressivity of the tax code. High-income investors are the most eager purchasers of municipal bonds, but the absorption of the total supply of bonds requires that some lower-income "marginal" investors enter the market. This means that high-income investors receive an after-tax return greater than the amount required to make them hold the bonds they chose to purchase.

Box 2: A Model for Predicting the Ex Post Tax Rate

Following Trczinka (1982) and Fortune (1988), we assume that, for each investor, portfolio equilibrium is described by the following linear relationship between the yields on municipal and Treasury bonds with equal terms to maturity.

$$R_m = \lambda_{0i} + \lambda_{1i} R \qquad \text{(B2.1)}$$

The parameter λ_{0i} is the marginal risk premium required by the *ith* investor to hold his chosen quantity of municipal bonds, and the parameter λ_{1i} is the investor's after-tax return on a dollar of taxable income, that is, $\lambda_{1i} = (1 - \tau_i^*)$, where τ_i^* is the expected marginal income tax rate over the investment horizon. This relationship holds for every investor in municipal bonds since, at the margin, the excess of the after-tax return on municipals over the after-tax return on taxable bonds must be just enough to compensate for the risk associated with holding municipal bonds.

Equation (B2.1) can be used derive the *risk-adjusted* implicit tax rate embedded in relative yields.

$$\tau_i^* = s + \lambda_{0i}/R \qquad \text{(B2.2)}$$

where $s = 1 - R_m/R$ is the observed implicit tax rate, common to all investors.

We assume that the ex post tax rate is a weighted average of several "information variables" that are relevant to forecasting future tax rates. For simplicity, we assume two information variables: the risk-adjusted implicit tax rate, τ_i^*, and the spot (current) tax rate. Denoting an investor's ex post tax rate as T_{it}, his current tax rate as τ_{it}, and the forecast error as ε_{it}, our basic model is

$$T_{it} = \alpha_1 \tau_i^* + (1 - \alpha_1)\tau_{it} + \varepsilon_{it} \qquad \text{(B2.3)}$$

The parameter α_1 is the "information parameter," measuring the information content of the risk-adjusted implicit tax rate. This is the key parameter in our analysis. Substituting (B2.2) into (B2.3) results in the following model whose parameters can be estimated.

$$T_{it} - \tau_{it} = \alpha_1(s_t - \tau_{it}) + \alpha_{2i}(1/R_t) + \varepsilon_{it} \qquad \text{(B2.4)}$$

in which α_1 is the information parameter, assumed the same for all investors, and $\alpha_{2i} = \alpha_1\lambda_{0i}$ measures the influence of the risk premium for a specific investor.

Our model assumes that the expected value of the ex post tax rate is a weighted average of the risk-adjusted implicit tax rate and of the current tax rate. The use of a mixed forecast is justified as follows. Let y be a random variable, and (x_1, x_2) be two orthogonal forecasts of y. Then $f_1 = y - x_1$ and $f_2 = y - x_2$ are the forecast errors. Assume that they are joint normally distributed, and consider a forecast of y that is a weighted average of the two information variables, x_1 and x_2. The composite forecast error is $z = y - [\beta x_1 + (1 - \beta)x_2]$, which can be written as $z = \beta f_1 + (1 - \beta)f_2$. The variance of the composite forecast error is

$$\sigma_z^2 = \beta^2\sigma_1^2 + (1 - \beta)^2\sigma_2^2.$$

If investors choose the β that minimizes the mean-squared error, that is, minimizes σ_z^2, the optimal value of β is $\beta = \sigma_2^2/(\sigma_2^2 + J_1^2)$. Thus, the optimal weight on an information variable will be greater, the smaller the total variance explained by that variable, that is, the more "precise" are forecasts using that variable. The value of α_1 in (B2.3) is equivalent to this β.

for 1-year, 5-year, and 10-year terms. Longer terms are excluded because, as we have shown above, the yields are influenced by factors difficult to control for, and the implicit tax rates at long maturities display strange behavior.

Data for the ex post tax rate were calculated using the marginal tax rates in each year for investors having nominal taxable income equivalent to a specific real income level in 1980 dollars. Four marginal tax rate series were constructed: the maximum tax rate, and tax rates for real income levels of $100,000, $75,000, and $50,000.[8] The annual tax rate was assigned to each month in the year, and the ex post tax rate for each of these representative investors was then calculated using equation (2). These calculations assume that interest is paid semiannually, so the tax rate

[8] Between 1987 and 1990 there was a "bubble" in the tax rate schedule: the tax rate schedule was 15 percent, 28 percent, 33 percent, and 28 percent. Thus, the highest tax rate was 33 percent, but this was not the tax rate paid by those at the highest income levels; that tax rate was 28 percent. Our "maximum" tax rate is 28 percent during this period.

is derived as a weighted average of future tax rates at six-month intervals. Because our bond yield and tax rate data are available monthly for the period 1965 to 1995, the regressions for 10-year, 5-year, and 1-year bonds use the sample periods 1965 to 1985, 1965 to 1990, and 1965 to 1994, respectively.

Our basic model explains the excess ex post tax rate as a function of the excess implicit tax rate and the reciprocal of the Treasury bond yield. The latter serves as a variable capturing the risk premium on municipal bonds. We have added a dummy variable for the Tax Reform Act of 1986, defined as zero before 1986:12 and one thereafter. This dummy variable is excluded from the 10-year bond regressions because the dummy variable is always zero during the sample period for those regressions. The reason for this dummy variable is that the Tax Reform Act dramatically altered the structure of tax rates, as well as the incentives of important financial institutions (particularly commercial banks) to hold municipal bonds.

The information content of implicit tax rates increases dramatically at times of important legislative debates, and has increased over time as tax rate changes have become more frequent.

We first estimate a constant-coefficients form of our model, in which it is assumed that the parameters do not change over time. We then estimate the model with time-varying coefficients. To estimate the time-varying parameter version of the model, we assume that each of the parameters is a random walk, with the parameter changes arising from random shocks that are normally distributed with zero mean, constant variances, and zero covariances. Thus, the *ith* parameter evolves over time according to the model

$$\alpha_{it} = \alpha_{i,t-1} + u_{it} \quad u_{it} \sim N(0,\ \delta_i^2) \quad i = 1,2,3,4 \qquad (5)$$

Equations (4) and (5) form a state-space model, in which equation (4) is the measurement equation and equation (5) describes the transition equations. The parameters α_{it} are the state variables. The only parameters to estimate in this model are the transition variances, δ_i^2. These are estimated using the method of maximum likelihood. After maximum likelihood estimation of the four δ_i^2, a Kalman Filter is used to construct the paths of the state variables.[9]

The Results

Table 2 reports the results of estimating the constant-coefficient version of the model.[10] As noted above, the information parameter should be positive and no greater than one. In addition, the risk premium on tax-exempt bonds should be directly related to the investor's tax rate, because high-tax-rate investors will receive a greater windfall on their intramarginal investments in tax-exempt bonds. Table 2 supports these expectations. In all 12 regressions the information parameter (α_1, the coefficient for the excess implicit tax rate) is positive and statistically significant. It is roughly the same magnitude, about 0.10, for nearly all terms. This indicates that the implicit tax rate contains statistically significant information about future tax rates, but that the bulk, roughly 90 percent, of the relevant information is in the current tax rate. In short, implicit tax rates have some value in forecasting future tax rates, but not much.

In all but one of the regressions, the effect of the risk premium on municipal bonds, captured by the coefficient α_2, is positive, as expected.[11] Also, as expected, the size of α_2 is generally related to the investor's taxable income level: It is highest for the maximum tax-rate investor and, in most cases, it declines as taxable income (and tax rates) fall. This is consistent with our knowledge that higher-tax-rate investors receive a larger average after-tax return from investment in municipal bonds. The coefficient on the 1986 Tax Reform Act dummy is positive in all cases, and typically is significant. Thus, after the Tax Reform Act there was an increase in expected future taxes

[9] The time-varying parameter estimation assumes the following initial conditions. The unconditional mean of the four parameters (zero) sets the starting value of the parameters. The initial covariance matrix of the parameters is taken as a diffuse prior; specifically, the value 1,000 is assigned to each initial variance.

[10] Ordinary least squares showed very high serial correlation. To correct for this we used Hannan's method of correction with spectral analysis. The Q statistics reported in Table 2 show that this eliminated serial correlation over a 36-lag period for the 1-year bonds, and for the 5-year bonds with a maximum tax rate. The correction failed for the other regressions.

[11] Box 2 shows that the size of the risk premium is $\lambda_0 = \alpha_2/\alpha_1$. Because α_1 is roughly 0.10, λ_0 is roughly 10 times the value of α_2.

Table 2
Linear Regression Model
Constant Coefficients

$$T_t - \tau_t = \alpha_0 + \alpha_1(s_t - \tau_t) + \alpha_2(1/R_t) + \alpha_3 TRA86 + \eta_t$$

Coeff/ t-stat	1-Year 1965:1 to 1994:12 Income Level				5-Year 1965:1 to 1990:12 Income Level				10-Year 1965:1 to 1985:12 Income Level			
	Max	\$100K	\$75K	\$50K	Max	\$100K	\$75K	\$50K	Max	\$100K	\$75K	\$50K
α_0	−.0047	−.0074	−.0046	−.0020	−.0104	−.0050	−.0043	−.0027	−.0200	−.0067	−.0110	−.0012
$t_{\alpha 0}$	−1.05	−2.88	−1.14	−.39	−2.97	−1.55	−1.57	−.77	−3.70	−1.42	−2.65	−.31
α_1	.0968	.0876	.0368	.0732	.1383	.1275	.0574	.1255	.1053	.1058	.0638	.0577
$t_{\alpha 1}$	5.22	6.49	4.51	5.89	5.69	6.19	5.11	6.72	3.40	4.42	3.51	3.41
α_2	.1205	.0524	.0148	−.0050	.2540	.0819	.0150	.0396	.1505	.0889	.1183	.0475
$t_{\alpha 2}$	2.24	1.41	.70	−.17	3.81	1.70	.55	1.00	1.73	1.40	2.75	1.08
α_3	.0072	.0582	.0065	.0050	.0694	.0490	.0209	.0160	n.a.	n.a.	n.a.	n.a.
$t_{\alpha 3}$	.74	7.06	1.59	1.02	6.17	5.86	4.27	2.38				
DW	1.96	1.89	1.82	1.71	1.99	1.61	1.66	1.32	1.66	1.59	.82	1.43
Q_{36}	11.10 (99%)	50.66 (5%)	25.64 (90%)	35.47 (49%)	29.84 (76%)	90.76 (0%)	168.90 (0%)	179.20 (0%)	97.09 (0%)	167.3 (0%)	1063.0 (0%)	219.24 (0%)

Hannan-Efficient estimation was used. This is a transformation of variables by spectral analysis to correct for serial correlation. The statistic Q_{36} tests for any serial correlation over a 36-month period. The significance level is in parentheses: a significance level of s% means a (1-s)% chance that the observed Q is due to chance.
n.a. not applicable

relative to the information contained in the risk-adjusted implicit tax rate.

Table 3 reports the results of estimating the model in a state-space form, in which the coefficients are time-varying parameters following a random walk. In this model, the parameters, designated δ_i, are the standard errors of the shocks in the transition equations. These are, of course, nonnegative. A very small value of δ_i means that the associated coefficient, α_i, moves very little over time; a large δ_i means that α_i varies considerably over time.

Our primary interest is in the value of δ_1, which measures the standard deviation of shocks in the information parameter. Shocks to the information parameter are statistically significant for all but one of the 5-year and 10-year cases; the one exception is at the low (\$50,000) taxable income level, for which the model is least valid. For three out of the four 1-year cases, δ_1 is not statistically significant. This result is plausible, because one would expect that 1-year tax rate forecasts would be dominated by the current tax rate, and that the weight on the 1-year implicit tax rate would not vary much over time.

A Kalman Filter was used to construct the path of the information parameter implied by the estimates in Table 3. The Kalman Filter is a method of optimal updating of state-variable values as new observations of data emerge. The key equation in a Kalman Filter describes the updating of a state variable as a new observation on the dependent variable arrives. In our notation, the updating equation is $\alpha_t = \alpha_{t,t-1} + g_t \varepsilon_t$, where ε_t is the current forecast error and g_t is the Kalman Gain, which measures how much the parameter forecast adjusts when a forecast error occurs. The Kalman Gain is inversely related to the variance of the forecast error—when the forecast is very uncertain, the new information is given very little weight in the updating formula. This parameter updating equation says that the optimal current value of a parameter at time t is the value that was forecast at the previous period, $\alpha_{t,t-1}$, plus an adjustment related to the forecast error based on the previous period's information.

Figures 5a and 5b report the paths of the information parameter implied by the Kalman Filter for investors paying the maximum personal income tax rate, and for investors with \$100,000 of real taxable income, respectively. These are the taxable income

Table 3

Maximum Likelihood Estimation of Transition Equation Standard Errors

State-Space Model Using Kalman Filter

$$T_t - \tau_t = \alpha_{0t} + \alpha_{1t}(s_t - \tau_t) + \alpha_{2t}(1/R_t) + \alpha_{3t}TRA86t_t + \varepsilon_t$$

$$\alpha_{it} = \alpha_{i,t-1} + u_{it}\ (i = 0,1,2,3) \qquad u_t \sim N(0, \Delta^2) \qquad \varepsilon_t \sim N(0, \sigma^2)$$

Coeff/	One-Year 1965:1 to 1994:12 Income Level				Five-Year 1965:1 to 1990:12 Income Level				Ten-Year 1965:1 to 1985:12 Income Level			
t-stat	Max	$100K	$75K	$50K	Max	$100K	$75K	$50K	Max	$100K	$75K	$50K
δ_0	.0025	.0042	.0010	.0000+	.0526	.0042	.0297	.0010	.0018	.0166	.0003	.0101
$t_{\delta 0}$	.59	.23	6.43	.02	14.33	37.27	12.91	.48	4.61	7.27	.13	3.17
δ_1	.0745	.0546	.0190	.0022	.0810	.1018	.0355	.1060	.0590	.1134	.1423	.0120
$t_{\delta 1}$	18.70	1.30	.34	.88	8.47	13.38	20.02	9.42	8.59	6.42	13.32	.33
δ_2	.0000+	.0000+	.0000+	.0000+	.0000+	.0000+	.0000+	.0001	.0000+	.0002	.0000+	.0001
$t_{\delta 2}$	.03	.02	.00+	.00+	.23	.16	1.66	.34	.01	1.17	.11	.61
δ_3	.0037	.0025	.0004	.0000+	.0999	.1301	.0355	.0005	na	na	na	na
$t_{\delta 3}$	.42	.32	.05	.00+	1.11	1.24	2.04	.03				
σ	.2948	.2340	.1441	.1942	.1050	.1630	.0362	.2113	.2796	.1097	.1089	.1917

The parameters δ_0, δ_1, δ_2 and δ_3 are the standard errors of the transition equation steps, defined as square roots of the diagonal elements in Δ. All off-diagonal elements are assumed to be zero. The parameter σ is the standard deviation of the measurement equation.

levels for which the model should be the most valid.[12] The information parameter paths show that little weight was attached to implicit tax rates in the 1970s. This was a period of few major tax rate changes, so investors placed most of the weight (about 90 percent) on the current tax rate when forming forecasts of future tax rates.

Beginning in the early 1980s, the information parameter rose dramatically. Two major tax rate restructurings occurred in the 1980s, the Economic Recovery Tax Act of 1981 and the Tax Reform Act of 1986. In both cases the maximum personal income tax rate fell sharply, as did the maximum tax rate at the $100,000 real taxable income level. Figure 5a shows a dramatic jump in the information parameter, from 0.10 to about 0.50. The same pattern is seen in Figure 5b, though the rise in the information parameter began before the passage of ERTA in 1981.

The passage and implementation of the 1986 Tax Reform Act was followed by only small effects on the information parameter. It remained at a high level, indicating the continuation of the high information content in the risk-adjusted implicit tax rate, up to 1990, then (according to the 1-year bond data) began a slow decline, returning to its 1970s level by 1995.

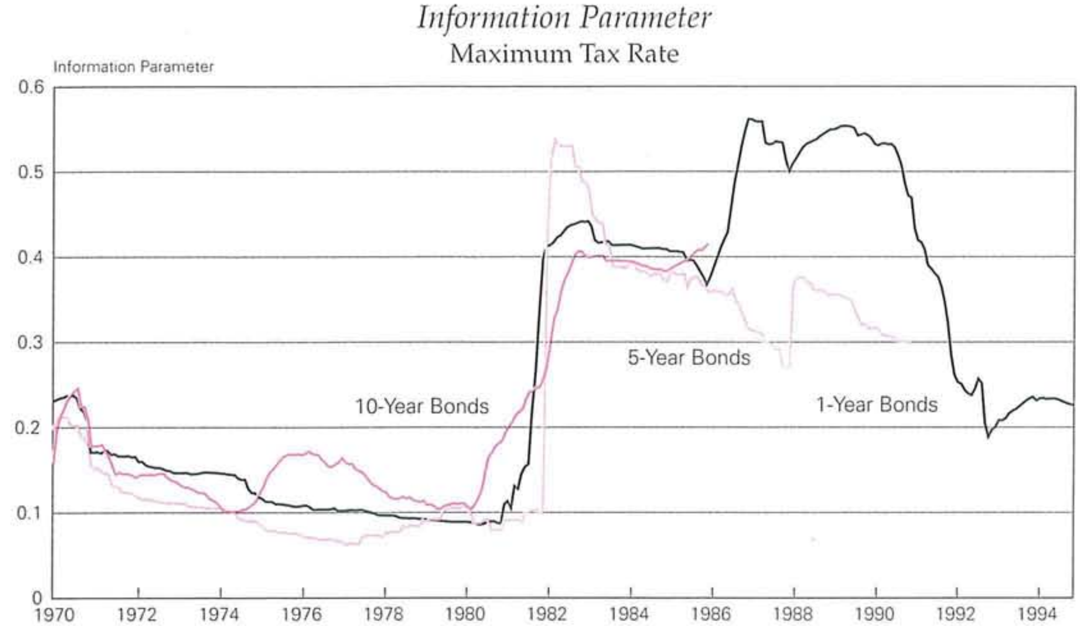
[12] The results are more mixed for investors with $75,000 and $50,000 of taxable income, who would be less likely to conform to our model.

IV. Summary and Conclusions

The implicit tax rate, derived from yields on Prime Grade general obligations and U.S. Treasury bonds with the same term to maturity, should contain information relevant to the prediction of future tax rates. This study addresses the information content about future tax rates that is embedded in the implicit tax rate. Several specific questions are raised. Does the flat tax debate of 1995–96 explain the high municipal bonds yields (low implicit tax rates) of that period? Is the implicit tax rate determined by the corporate income tax rates, as proposed by Fama and Miller, or by personal income tax rates, as is more commonly thought? Has the information content of the implicit tax rate varied over time?

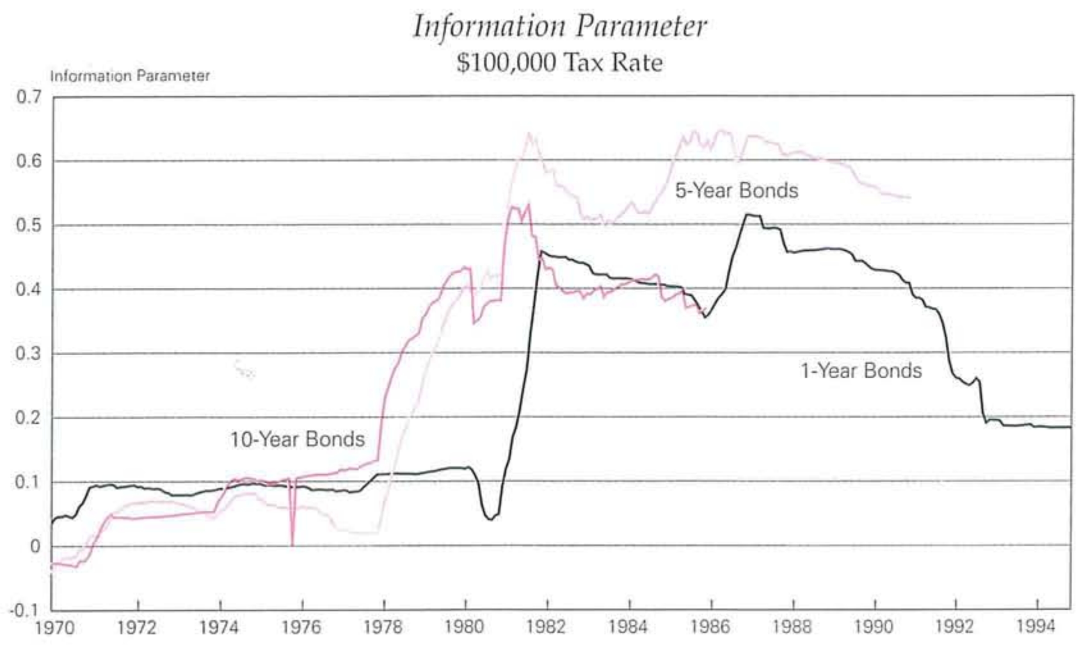
The first section assesses the previous literature on the relationship between tax policy and relative bond yields. Poterba's event studies of the 1980s are updated, and we find only a weak relationship between implicit tax rates and the proposal, debate, and passage or failure of tax policy legislation that should affect relative bond yields. This section also briefly

Figure 5a



Source: Author's calculations.

Figure 5b



Source: Author's calculations.

discusses the Fama-Miller hypothesis that only corporate income tax rates affect the relative yield on municipal bonds.

The second section discusses two possible ways of measuring expected future tax rates. The first, the ex ante implicit tax rate, is rejected because previous evidence shows that it can behave in strange ways, especially at long maturities. The second, called the ex post tax rate, represents the actual tax rate that will be paid over the life of a bond by a representative investor.

We find that the implicit tax rate is a statistically significant predictor of personal income tax rates, and that the information content rose during the period of personal income tax rate variability in the 1980s.

The third section develops an econometric model of implicit tax rates in which the risk-adjusted implicit tax rate is used as a forecast of the ex post tax rate. The key parameter in this model, called the information parameter, measures the change in the expected future tax rate resulting from a change in the risk-adjusted implicit tax rate. This model is estimated for 1-year, 5-year, and 10-year bonds, over a sample period beginning in January 1965. The model is first estimated as a constant-coefficients regression. Then it is estimated as a state-space model in which the coefficients are the state variables. The latter allows us to use a Kalman Filter to derive the path of the information parameter.

With respect to the narrow question of the flat tax debate as a source of high municipal bond yields (or low implicit tax rates) in 1995–96, the answer appears to be in the negative. Our event analysis shows no statistically significant increase in implicit tax rates during either the July–December 1995 introduction and discussion of H.R. 2060, or the January–February 1996 Presidential primary debate. Unfortunately, the only ex post tax rate series that can be used to test the importance of the flat tax debate (the one-year-ahead series) ends in December of 1994, so our state-space model does not tell us anything about the implicit tax rate debate.

With respect to the broader question of the information content of implicit tax rates, our results are clear. Not only do implicit tax rates contain relevant information, but the information content has changed over time. During the period of tax code stasis in the 1970s, investors appear to have placed a small weight (about 10 pecent) on the implicit tax rate as a predictor of future tax rates, with the primary weight, about 90 percent, put on the current tax rate. During the 1980s, when tax reform was much debated and several significant changes were made in the income tax code, investors recognized the increased probability of tax rate changes by increasing the weight placed on implicit tax rates and reducing their reliance on current tax rates as predictors of tax policy. Thus far, relatively minor changes in tax rates have been made during the 1990s, with the greatest changes being at upper income levels. The weight placed on implicit tax rates has declined back toward its 1970s level. Thus, we find that implicit tax rates are an important predictor around the time of major tax rate changes that are perceived as highly probable. At other times, such as the flat tax debates of 1995–96, implicit tax rates appeared to carry little information about future tax rates.

With respect to the question of whose tax rates matter, our results do not support the Fama-Miller hypothesis. If that hypothesis were valid, we would expect that the implicit tax rate would have information content for predicting corporate income tax rates, not personal income tax rates. We find that the implicit tax rate is a statistically significant predictor of personal income tax rates, and that the information content rose during the period of personal income tax rate variability in the 1980s.

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