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Tax Effects and Transaction Costs for Short Term Market Discount Bonds

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ABSTRACT

This paper reports little evidence of tax-effects in the prices of low coupon U.S. Treasury bonds and notes around the time one capital gain holding period prior to maturity. Those departures from zero-tax pricing that are found are consistent with small transaction costs that limit an arbitrage opportunity available to dealers. No meaningful, representative tax-rate can be inferred from them. Neglecting the much larger transaction costs apparently faced by individuals, T-bills were dominated assets, and profitable opportunities for tax-trading were available, for anyone in at least a 30% tax bracket.

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This paper examines prices of short term U.S. Treasury bonds and notes for evidence of systematic departures from the prices that would be determined by arbitrage in a no-tax, perfect markets economy. Specifically, it focuses on bonds that are trading at a discount from par at the time when they are roughly one capital gains holding period away from maturity. Over the sample period 1969 to 1980, this holding period varied between six months and one year, and any increase in price (including appreciation to par) that occurred on a bond held for at least the required holding period was taxed at the favorable rates available on long term capital gains. These data allow two direct tests for the presence of tax effects. Because of the holding period restriction, a bond trading at a discount from par just before the date at which it is one holding period away from maturity had a different tax treatment than the same bond just after this date. This allows each bond to serve as its own control in a test for a tax effect. In addition, because these bonds are close to maturity, Treasury bills provide a relatively complete set of discount prices that can be used to price the before-tax stream of payments associated with each bond. McCulloch (1975), Litzenberger and Rolfo (1984a), and Jordan (1984) test for tax effects in long discount bond prices by estimating a tax parameter in a smoothed yield curve. Because the tests here focus on short bonds, they are more direct and can offer additional insight into the interpretation of the tax parameter estimated in this way. The data here are also of interest because the discrete change in the tax status of the discount bonds on the date one holding period prior to maturity can be used to test for the presence of short-sales and to indicate what role they play in the determination of the equilibrium.

Consistent with other investigations based on market discount bonds, the data considered here do indicate the presence of a statistically significant price discrepancy that can apparently be attributed to taxes; however, this discrepancy is quite small in magnitude and is bounded by the bid-ask spread in all but a few cases. In particular, it is not of the magnitude one would expect based on simple arbitrage arguments for private individuals facing moderate to high tax rates. As a result, one year Treasury bills in this sample were dominated assets on an after-tax basis for any taxpayer facing a marginal income tax rate of roughly 30% or more. Moreover, high tax bracket investors could (and apparently did) reduce their total tax liabilities by making leveraged purchases of discount bonds with funds borrowed at close to T-bill rates, generating income in the form of capital gain and comparable interest deductions against regular income. This tax arbitrage could persist in equilibrium because of an offsetting arbitrage opportunity available to dealers. In the face of these two mutually exclusive arbitrage conditions, equilibrium could exist only if private individuals were at a corner solution where no further interest deductions were allowed or if transaction costs were present. Combined with direct evidence from tax return data, the evidence here suggests by exclusion that transaction costs an order of magnitude larger than bid-ask spreads must have been present for most private individuals.

The results here are generally consistent with the finding of Litzenberger and Rolfo (1984b) that tax effects are limited to the range defined by the bid-ask spread for all bonds other than those with extreme discounts from par. Considering the entire sample of discount bonds, there is no statistically significant evidence that tax-exempt institutions could have

profited by systematically shifting out of all discount bonds in the sample and into T-bills once the cost implicit in the spread is recognized. A more selective strategy of shifting out of a small subset of the bonds with the largest discounts from par would apparently have yielded a small net-of-spread profit; equivalently, a small net-of-spread profit on these bonds was apparently available to a dealer who was able to make short sales. Evidence provided below suggests that short sales by dealers were not infeasible and did take place, so the apparent arbitrage profit that remained presumably reflects some unidentified transaction cost faced by dealers.

These results parallel those found in the study of the ex-dividend day price behavior of common stocks by Eades, Hess, and Kim (1984). In each case, arbitrage arguments for private individuals suggest a departure from equality of before-tax returns, but arbitrage for short-term traders or dealers implies that equality of before-tax returns must hold. In the data, the short-term traders and dealers generally seem to prevail over private individuals, but small departures from equality of before-tax returns are still observed. In both instances, these departures remain because of transaction costs faced by dealers and short-term traders. The results of Eades et al suggest that the "representative marginal tax rate" implied by the ratio of the fall in stock price on the ex-dividend day to the dividend is an indirect estimate of those costs and should not be interpreted as a weighted average of individual tax rates or as the tax rate of a specific clientele. The results here suggest that the same is true of any tax rate inferred the pricing of discount bonds.

2. EQUILIBRIUM WITH CAPITAL GAINS TAXES

For simplicity, consider first a stationary economy with a flat yield curve. Suppose that coupon payments on bonds and tax payments by individuals are made continuously. Let r be the return earned on Treasury bills. In the absence of any holding period restrictions, an investor paying an income tax rate i and a capital gains rate g will be indifferent between holding a T-bill paying r and a discount bond with a coupon c if and only if the before-tax yield y is such that the rate of appreciation $y-c$ satisfies

$$(1-i)r = (1-i)c + (1-g)(y-c). \tag{2.1}$$

If y is greater than this break-even value, (in particular, if y equals r), the investor will be faced with a tax arbitrage. If he buys the discount bond using funds from a collateralized loan at rate r, his before-tax return is $y-r$, but his after-tax return is $(1-g)(y-c) - (1-i)(r-c) > 0$. Neglecting any uncertainty that could force premature sales, holding period restrictions should not change the break-even rate for a discount bond that is more than one holding period away from maturity when it is offered for sale. But any discount bond sold less than one holding period away from maturity cannot be eligible for capital gains treatment. In this case, y must equal r. If y_b denotes the break-even before-tax yield just before the holding period deadline and y_a $(= r)$ is the break-even yield just after, this implies an increase

$$y_a - y_b = \frac{(i-g)}{(1-g)}\,(r-c) = \frac{(i-g)}{(1-i)}\,(y_b-c) \tag{2.2}$$

in the yield as the bond passes through the holding period deadline.

Arguments of this kind, based only on the demand side using arbitrage arguments for private individuals, are the basis for much of the discussion of discount bond pricing, but they are clearly not sufficient to determine the equilibrium in this market. In the absence of some form of uncertainty that forced unanticipated sales of bonds at dates less than one holding period from maturity, none would be supplied. Any trade in this interval increases the total tax paid by individuals in this economy. Under perfect foresight, private agents would always act to avoid the loss of a valuable tax shelter. In the presence of uncertainty that generates these forced sales, the simple price and yield relations described above may not hold.

A more serious objection is that these price relations imply a pure before-tax arbitrage opportunity for a dealer who can short sell the discount bond. The increase in the yield described in equation 2.2 corresponds to a discrete drop in the price of the bond as it passes through the deadline one holding period before maturity. If a dealer arranges a sale of the security at the before-deadline price and covers his commitment by buying the security at the after-deadline price, he captures the price difference. The dealer cannot accomplish this by arranging a simple contract promising future delivery because any bond purchased under such a contract would not be eligible for capital gains treatment; the holding period for the purchaser would be determined by the delivery date, not the contract date. But he can accomplish it with a short sale. He can "borrow" the bond from someone who holds it before the deadline, sell it to someone else at the before deadline price and then close his position with the lender of the bond by buying an identical bond after the deadline and giving it to the lender. The tax

treatment of short sales is crucial to this transaction. The holding period of the lender is taken to be unaffected when he lends his bond, i.e. sells it to the dealer in return for an identical bond to be delivered in the future. [Prentice Hall Federal Income Tax, 32,287 (100)]

As a result of this treatment of short sales, the number of individuals claiming ownership of a particular bond for purposes of establishing a holding period can in principle be larger than the total number of bonds outstanding. Anyone who can can arrange a short sale can in effect issue new versions of the discount bond. If the discount bond pays a lower before-tax return than T-bills, this person can borrow at the discount bond rate and invest at the T-bill rate. Under the price relations in equations 2.1 and 2.2 as suggested from the demand side, this would be especially profitable over any short interval containing the deadline date because the before-tax return on the bond, and hence borrowing costs, would be negative; but the logic applies equally well over any interval prior to this date if the before-tax discount bond return is less than the T-bill return. In the absence of any transaction costs for dealers, this arbitrage would imply that the before-tax return on a discount bond could not differ from the return on a comparable government bond that was not eligible for capital gains treatment. Discount bonds should never trade at a premium.

Viewed from the perspective of a private individual and of a dealer who can arrange a short sale, the tax code generates two arbitrage conditions that are mutually exclusive. In the absence of trading frictions, equilibrium could obtain under only at some corner solution where one of the arbitrage opportunities is not feasible. Because the arbitrage for the dealer is in

before-tax terms but the abitrage for the individual is in after-tax terms, only the individual can be constrained by a corner determined by the tax code. In an equilibrium without trading frictions, private investors would take the maximum allowable interest deductions and the before-tax return on short term discount bonds would be the same as that on T-bills. Every private investor would exploit the opportunity to borrow at the T-bill rate and invest in capital gains eligible bonds. This would not affect before-tax income, but because of the capital gains exclusion, it would reduce tax liability as long as the interest from borrowing could be deducted against other income. Over this sample period, this would imply that all investors had interest deductions equal to total investment income plus the maximum amount, which varied between $25,000 and $10,000, deductible against other income. In particular, no one would have paid tax at regular income tax rates on investment income from equities or other fixed income investments. The total number of actual discount bonds outstanding would not limit the amount of income that could be sheltered in this way because dealers would use short sales (in effect) to issue new bonds until the before-tax returns on the bonds and T-bills were equalized.

Even a casual examination of the I.R.S. Statistics of Income indicates that this is not an adequate description of the data. As described in the next section, it is not true that all dividend income is sheltered by interest deductions. Transaction costs are not literally zero and apparently cannot be neglected in this context. Fixed costs associated with access to capital markets can act to preclude small investors from exploiting this kind of tax shelter. Marginal costs like bid-ask spreads imply that even large private

investors may stop exploiting the tax shelter potential of the discount bonds at rates that superficially appear to offer tax savings. If only private individuals faced important transaction costs, the before-tax returns on the discount bonds and the T-bills would still be equalized. Private investors in various tax brackets would exploit the tax shelter opportunities until either the limitation on the deductibility of investment interest became binding or transaction costs made the shelter unprofitable on an after-tax basis. If dealers and tax-exempt traders also face non-negligible transaction costs, the equilibrium return on the discount bond could be less than the T-bill rate by an amount determined by those costs. If these costs pertain exclusively to short-sales (for example, if short-sales are infeasible) and the difference in returns is large enough to compensate for the cost of trading implied by bid-ask spreads, tax-exempt institutions should exchange their holdings of the discount bonds for T-bills. Then the equilibrium would be one with segmented tax-clienteles as described by Schaefer (1982).

The simplest test for the presence of a tax effect is to regress changes in the yields of discount bonds on the yield-coupon spread as suggested by equation 2.2. Results of this kind are reported in the next section, but this is not the most powerful test for a tax effect and it offers no direct evidence about the size of any tax effect relative to the costs implicit in the bid-ask spread. As an alternative to comparing the yield of the bond before and after the deadline date, the next section also compares the price of a bond on a given date with the price of an appropriately chosen T-bill portfolio. Once the due date for tax payments is specified, it is straightforward to calculate the stream of after-tax payments associated with

the purchase of a given bond on a given date for a taxpayer facing tax rates i and g. Since the bonds are roughly one year or less from maturity, it is then possible to construct a portfolio of T-bills with the same after-tax stream of payments and compare the bid and ask prices for the T-bill portfolio with the bid and ask prices of the bond.

To illustrate the calculation of the T-bill portfolios, consider a bond with coupon rate c and a maturity prior to 1977 so the holding period was six months. Let day 0 be the observation date six months plus one week prior to maturity, let day 1 be the date of the coupon payment six months prior to maturity and let day 2 be the maturity date. Let A denote the accumulated interest for this bond on day 0, and let P_b denote the price actually paid for the bond on day 0. (P_b is the flat price reported in the newspaper plus the accumulated interest A.) Let P_1 and P_2 denote the prices on day 0 of (one dollar face value) T-bills maturing respectively on dates 1 and 2. To a taxpayer who makes tax payments when income is received and who faces an income tax rate i and a capital gains tax rate $g = i/2$, the bond produces a net-of-tax payment from the government of

$$x_1(i) = \frac{c}{2} - i\left(\frac{c}{2}-A\right) \tag{2.3}$$

on date 1 and

$$x_2(i) = 100 - \frac{i}{2}(100-P_b+A) + \frac{c}{2}(1-i) \tag{2.4}$$

on date 2.[1] Each T-bill results in an after-tax payment on date $j=1,2$ of

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[1] Strictly speaking, the amount A would be deductable immediately upon purchase of the bond and the entire amount $c/2$ would be treated as interest income when it is received. Allowing for this would make a negligible difference in the estimates which follow. In any case, the basis for establishing capital gain on the bond is the flat price P_b-A.

$1 - i(1-P_j)$ so the price of an after-tax dollar on date j implicit in the T-bill price is

$$Q_j(i) = \frac{P_j}{1-i(1-P_j)} . \tag{2.5}$$

The price $P_p(i)$ for the portfolio of T-bills that generates the same after-tax stream of payments as the bond for an individual facing an income tax rate i is then

$$P_p(i) = Q_1(i)x_1(i) + Q_2(i)x_2(i). \tag{2.6}$$

(This expression has an obvious extension for bonds with more or less than one coupon payment left before maturity.) For the special case of $i = 0$, this allows a comparison of a bond and a T-bill portfolio offering the same before-tax stream of payments, and this comparison will be meaningful both before and after the holding period deadline date. The comparison for an individual with $i > 0$ is obviously meaningful only on days before the deadline date. Using bid or ask prices for the component T-bills gives bid and ask prices for the portfolio. These can be compared directly with the bid and ask prices for the bond.

If the ask price for the T-bill portfolio is higher than the ask price for the bond, the bond is a better initial purchase for an individual with these tax rates who wishes to acquire additional securities; if in addition the bid price for the T-bill portfolio is higher than the ask price of the bond, this individual can profitably exchange any holdings of the specified T-bills for the bond. To the extent that selling T-bills at the bid price is equivalent to borrowing at the T-bill rate, this is the condition necessary for the individual to fully exploit the tax shelter potential of the discount bonds in the absence of other transaction costs. Symmetrically, for an

institution or dealer, it is possible to compare the price of the bond to the price of the T-bill portfolio offering the same before-tax stream of payments. (By the construction above, this will not be the same T-bill portfolio as the one for the private investor. For a given bond, the portfolio of T-bills offering the same after-tax stream of payments as the bond depends on the tax rates of the holder.) Suppose that the dealer must also bear the costs implicit in the bid-ask spread either directly or indirectly. If the bid price at which he can sell the bond to another dealer is higher than the ask price at which he can acquire the portfolio and if no other transaction costs are present, the dealer can profitably exploit his arbitrage opportunity, borrowing at the bond rate and investing at the T-bill rate.

The arbitrage opportunity for the dealer or institution is intentionally evaluated in before-tax terms. For a non-taxable institution this is appropriate; for a dealer it is best viewed as a plausible simplifying assumption. Generally, since any expenses connected with the short sale are deductable directly against income for the dealer, a before-tax arbitrage opportunity is also an after-tax arbitrage opportunity. What this neglects is the timing of income and deductions. Implicitly, the calculations here assume that the dealer is on an accrual basis for tax purposes, recognizing income and deductions from the arbitrage in equal proportions during each tax period. Dealers on a cash basis would actually receive proportionally more income from the T-bills early on, with much of the deduction deferred until he closes his short position in the discount bond. This by itself would make the arbitrage opportunity slightly less attractive for the dealer; but in fact, over this sample period, dealers had wide lattitude to shift the timing of income and

deductions by making leveraged purchases of T-bills maturing in a subsequent tax period. This generates interest deductions in the current period, but the offsetting income from the T-bills is not recognized until the subsequent period. Exploited to the limit, dealers could defer all tax liabilities indefinitely, so the choice of $i = 0$ may actually be a reasonable approximation to the actual tax rate faced by dealers.[2]

Given a specific tax rate i and the formula for the price $P_p(i)$ of the T-bill portfolio that generates the same after-tax stream of payments for an individual facing the tax rate i, it is simple to test whether $P_p(i)$ differs significantly from P_b in some sample of bonds. By considering appropriate bid and ask prices and values of i, this offers one test for the presence of a systematic, net-of-spread arbitrage opportunity in the sample as a whole. A more powerful test with a slightly different interpretation is to regress the premium $P_b - P_p(i)$ on the yield-coupon spread, again for a fixed value of i. Finally, for comparison with the reported "representative" tax rates from estimates of smoothed yield curves, it is possible to estimate a non-linear regression that chooses the value of i to minimize the difference $P_b - P_p(i)$ over the sample as a whole. Equation 2.6 for P_b involves the value P_b on the right side because it appears in the calculation of the after-tax payment on date 2. If we set the right hand side of 2.6 equal to

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[2]This opportunity has been substantially limited by provisions of the Deficit Reduction Act of 1984. Dealers must now treat T-bills like original issue discount bonds, accruing a portion of the appreciation to par as income in each tax period. Whether this will raise the effective tax rate on dealers or simply force them to revise their tax avoidance strategies is not clear. Individuals are not subject to this mandatory accrual, but cannot deduct any interest on loans used to finance the purchase of T-bills until the income from the T-bill is realized.

P_b and solve for P_b, the result is

$$P_b = \frac{1}{1-(i/2)Q_2(i)} [Q_1(i)x_1(i) + Q_2(i)\tilde{x}_2(i)] \tag{2.7}$$

where

$$\tilde{x}_2(i) = 100 + (100+A)(1-\frac{i}{2}) + \frac{c}{2}(1-i).$$

The terms on the right side of 2.7 now depend only on the observable attributes of the bond (i.e. coupon and maturity date), the T-bill prices and the parameter i. Once the presence of a disturbance term in 2.7 has been justified, this can be used to estimate a value of the parameter i. That justification is put off until the next section, but it is important to emphasize that this estimate is offered only for comparison with other estimated values of i and that the interpretation of the estimate in this context is not clear.

3. DATA AND RESULTS

The raw data are prices and yields for U.S. Treasury bonds and notes collected from selected reporting dealers by the Federal Reserve Bank of New York and published in the Wall Street Journal. Observations were taken from the years 1969 through 1980. To ensure a relatively homogenous sample, two kinds of securities with special features were excluded from consideration: bonds redeemable at par in payment of estate taxes ("flower bonds") and the 1.5% 5-year Treasury notes offered solely in exchange for 2.75% Treasury bonds due 1975-1980. The 1.5% notes were typically outstanding in small amounts, e.g. $20 million versus several hundred million for other issues. To increase the power of the tests and to avoid the issues associated with the

tax treatment of premium bonds, only bonds with a "large enough" discount from par were included in the sample. Specifically, the coupon rate on each candidate bond was compared to the yield on the bond with the next latest maturity date. If the difference y-c was less than 1%, the bond was excluded. Because this procedure depends on neither the price nor the yield of the candidate bond, it should not introduce any sample selection bias. To ensure independent observations, multiple observations on the same date were avoided; from any set of bonds with the same maturity date, only the bond with the lowest coupon was included. Subject to these exclusions, every bond that passed through the date one holding period prior to maturity during the years 1969 to 1980 inclusive was included in the sample. For tax years ending prior to 1977, the holding period was 6 months; for tax years ending in 1977, it was 9 months; for the rest of the period it was one year. The sample selection criteria resulted in a set of 57 bonds, 14 with maturities before 1975, 43 with maturities after 1977. Since none matured in 1977, the holding period was either 6 months or one year and we can ignore any difficulties associated with the transition period.

The arguments based solely on the demand from taxable private individuals suggests that little or no trading of the discount bonds should be observed in the interval less than one holding period from maturity. Relying on the presumption that bid-ask spreads reflect the level of trading activity to some extent, the spread for the discount bonds was examined at dates ranging from two weeks before to two weeks after the holding period deadline. Using any test and any conventional level of significance, one can reject the hypothesis that the spread changes as the bond moves through the deadline. In almost all

cases, the spread was $.125 (1/8'th) per $100 face value both before and after the deadline. This is also the value for the spread for virtually all other bonds with the same term to maturity, so there is no evidence from the spreads either that trading diminishes after the holding period deadline or that the discount bonds are more thinly traded than other bonds. In a sense, the evidence here is too strong. The spreads are so consistent across time and across bonds as to suggest that the reported numbers do not reflect the true spread available to large customers. In any case, the true prices for even the best customers should lie within the quoted range, and any unobserved increase in the spread relative to other bonds or as the bond passes through the capital gains deadline should be bounded by the value $.125.

The behavior of the spread is indicative of a general feature of the reported prices (and yields) for the bonds. They are not actual transaction prices for either purchases or sales. Rather, they represent an estimate by some trader of where the market is at a particular time each day. Moreover, in the comparisons with the T-bills, this time need not necessarily correspond to the time of day when T-bill prices are reported. Also additional errors arise because typically there is no T-bill maturing on the exact day when a coupon payment is made or a bond matures. The actual T-bill prices used in the pricing of the T-bill portfolios are derived from the prices of T-bills with nearby maturities using logarithmic interpolation. This assumes in effect that the implicit daily forward rates are constant over the intervals between actual maturity dates. For the bonds one or two weeks plus a year to maturity, T-bill prices for the payments at maturity were derived by extrapolation, holding constant the forward rate implicit in the two longest

outstanding T-bills.[3] For any of the equations above involving bond or bill prices or yields only on the left side, the induced errors can be treated as conventional disturbances in a regression equation, with the qualification that there are a priori reasons to expect that such errors may not be homoskedastic over the sample as a whole. In any equation where these appear as right side variables, care must be taken to avoid estimates that are inconsistent.

Table 1 reports a direct test of the change in yield predicted from the demand by private individuals in equation 2.2. The change in the yield of the discount bond over an interval containing the holding period deadline date was regressed on a constant and the yield-coupon spread observed two weeks before the deadline. To correct for changes in yield caused by changes in the general level of interest rates, the yield change over the specified interval was calculated not only in absolute terms, but also as the change relative to the change in a T-bill with a comparable maturity. Since any change in the T-bill yield must be unrelated to any change in the bond yield caused by the change in its tax status, this reduces the noise in the data without biasing the results. The change was measured over a two week interval and a four week interval containing the deadline date. Because the independent variable includes the yield of the bond as observed before the deadline date, ordinary

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[3]One noticeable systematic effect induced by the extrapolation is that the bid-ask for the extrapolated T-bill prices is implausibly small. This is caused by the fact that the bid-ask spread on the most recently issued one year bill is smaller than on the next oldest bill. Extrapolating bid and ask prices separately, this leads to spreads on the T-bill portfolios which are too small by roughly $.02 to $.03 per $100 of bills. Anywhere where this could affect the inferences drawn, a correction for this effect is made which leads to a conservative inference.

least squares estimates may not be consistent; if the yield prior to the deadline date is reported with error, this induces correlated errors in the measured change in the yield and the yield-coupon differential. To correct for this, the difference between the yield on the bond with the next latest maturity and the coupon for the bond under consideration was used as an instrumental variable for the yield-coupon spread. Since some evidence of heteroskedasticity was found, the standard errors for the instrumental variables estimates are also estimated using the heteroskedastic-consistent procedure from White (1980). The table also reports the value of the tax rate i implied by the estimate of the slope coefficient. For $g = i/2$, equation 2.2 implies that $i = \frac{2b}{(1+b)}$.

Contrary to the prediction from the demand side that the yield should increase in proportion to the yield-coupon spread when the bond loses eligibility for capital gains treatment, the results in Table 1 show no significant evidence of a yield change related to the spread. The slope coefficients in the regression are all insignificantly different from zero and have the wrong sign in two out of four cases. Over the four week interval, there is some evidence of a general increase in rates as indicated by the constant term in the regression on the absolute yield changes, but this is common to T-bills as well, as is indicated by the absence of this effect when the change in the bond yield is measured relative to the change in the T-bill yield. This intercept simply captures the fact that interest rates in general were increasing on average over the sample period. The implied value of the tax rate i as reported in the last column can be interpreted as the rate above which an individual would not be indifferent between buying the bond

before and after the deadline date; it is a convenient measure of the magnitude of the observed coefficient, but should not be taken seriously as a representative tax bracket. Even for the coefficients with the correct sign, this implied rate is no more than 6%. The simple analysis on which equation 2.2 is based neglects uncertainty and variation in the yield curve, but it seems highly unlikely that private individuals in even moderate tax brackets would be indifferent between buying bonds before and after the deadline date. The results here are more supportive of the prices based on the short-sale opportunities available to dealers than of arguments based on the demands of private individuals.

Using the data on bond yields alone, there is no evidence of a significant price or yield change over the two and four week intervals examined here, but this does not offer any direct evidence about the pricing of the discount bonds relative to other securities. In particular, it does not rule out the possibility that the bonds trade at a premium both before and after the deadline date. Table 2 reports the results of the direct comparison of bond prices with prices for the T-bill portfolios. Specifically, it reports an estimate of the median difference between the bond price P_b and the price for the portfolio of T-bills, $P_p(i)$, for various tax rates i. As before, the capital gains tax rate g is assumed for simplicity to be equal to one-half the income tax rate i. This over-estimates the effective capital gains tax rate over part of the sample. A more careful treatment would strengthen the results reported below about the desirability of the discount bonds for private individuals. As indicated in the derivation of equations 2.6 and 2.7, tax payments are assumed to be due when taxable income is

realized, either when coupons are received or at maturity when any capital gain is realized. This will be approximately true for any individual making quarterly estimated tax payments. For comparison, calculations were also made under the assumption that no tax payments were due until the maturity date of the bond in question. This has only a small effect, making the discount bonds slightly more attractive for private individuals. All of the assumptions about taxes have no effect on the comparison of a bond with a portfolio offering the same before-tax stream of payments.

The first line of Table 2 reports the results of a comparison of bond prices with prices for T-bill portfolios generating the same before-tax stream of payments. As one would expect from the simple intuition based on the demand for the bonds on the part of private investors, there is some evidence of a premium in the price of the bond, but it is very small. Over the sample as a whole, the mid-point of the bid and ask prices for a $100 face value bond was roughly $.11 higher than the mid-point of the bid and ask prices for the corresponding T-bill portfolio. This premium is small enough that anyone who faced the costs implicit in bid-ask spreads would just barely be able to break even on a before-tax basis by selling any holdings of the bonds and buying T-bills; the second line in the table reports estimates of the difference between the bid price for the bond and the ask price for the bill portfolio that are essntially zero (and certainly not different from zero in any statistically significant sense.)[4] Over the sample as a whole, there is

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[4]To the extent that the bid-ask spread on the bill portfolio is underestimated, correcting the estimates can only reinforce the conclusion that spread for the bond and the bill portfolio overlap so no net-of-spread arbitrage opportunity is present.

no evidence of systematic, unexploited, net of bid-ask spread profit opportunities for dealers who can short sell discount bonds or for institutions holding discount bonds. As indicated below, this does not rule out the possibility of such opportunities for some sub-set of bonds with the largest discounts from par. If the positive difference between the mid-points of the bond and bill prices does reflect an incipient premium due to the treatment of capital gains, the persistence of this difference at least two weeks beyond the holding period deadline suggests that dealers are indeed short selling bonds across the deadline and are closing their positions with purchases shortly thereafter. The only other obvious explanation for why anyone would be willing to pay more for the bonds after the deadline date is that private investors simply misrepresent actual delivery dates on purchases of the discount bonds so they can claim capital gains treatment; however, it seems unlikely that individuals would cheat in such an easily verifiable fashion to achieve capital gains treatment when it is legally available on comparably priced bonds of slightly longer term to maturity.

Lines three and four report the comparison relevant for an individual facing a marginal income tax rate of 30%. Despite the evidence that the discount bonds are slightly overpriced on a before-tax basis, the favorable treatment of the capital gains makes the bonds more attractive for this individual on an after-tax basis. Systematically over the sample period, this investor could have saved about $.20 per $100 of newly purchased bonds; even if he had to sell existing holdings of T-bills, he could have saved about $.12 per $100. As reported on lines five and six of the table, these figures increase to $.66 and $.59 respectively for someone in the 70% tax

bracket.[5] In this case, the difference is roughly 10 times the spread on T-bills and 5 times the spread on the bonds. This kind of estimate of the average difference over the sample as a whole is not particularly large in an absolute sense, but does offer statistically significant evidence of an opportunity that persisted over an 11 year interval. As indicated below, a trading scheme based on this opportunity and restricted to bonds with the largest yield-coupon differentials would have been considerably more profitable on an after-tax basis.

Any estimate of the median premium $P_b - P_p(i)$ over the sample as a whole will mask any variation in the premium across bonds with different discounts from par. Figure 1 gives a scatter plot of the premium for $i = 0$; Figure 2 gives the same scatter plot for $i = .70$. In both cases, the prices are observed on the date one week before the holding period deadline date and the mid-points of the bid and ask prices for both bonds and bills were used to calculate the premia. An examination of Figure 1 shows that while the median premium was not large enough to overcome the cost implicit in the bid-ask spread, the premium for bonds with the largest yield-coupon spreads should have been large enough. The scatter of points gives some evidence of the size of possible errors in the measured prices and individual observations should not be taken seriously as representing arbitrage opportunities, but there is an apparent positive relation between the premium and the size of the yield-coupon spread.

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[5] If it is assumed that all of the underestimate of the spread between the bid and ask prices for the T-bill portfolio is due to an over estimate of portfolio bid price, these numbers should be reduced in magnitude by roughly $.03. In all cases, they are still significantly different from zero.

The presence of this relation is confirmed by the regression results reported in Table 3. The premium in the bond price relative to the T-bill portfolio offering the same before-tax stream of income was regressed against the yield-coupon spread on the four dates one or two weeks either side of the deadline date. Since the yield-coupon spread is measured on the date two weeks before the deadline, the same instrumental variable as in Table 1 was used to get a consistent estimate for the regression coefficients on that date. All the reported standard errors are corrected for heteroskedasticity. As suggested by an inspection of the scatter plot, the coefficient for the date one week before the deadline is positive and significant at the usual levels. Nonetheless, the implied unexploited profit opportunities are relatively small. Even for a bond with a yield-coupon difference of 8% (close to the sample maximum), the estimate of the premium on the date one week before the deadline is roughly \$0.50 on a \$100 face value bond. The slope coefficients for the dates two weeks before, one week before and one week after the deadline are significant and have the pattern one would expect if dealers are short selling across the deadline. As measured by the slope coefficient, the premia on the bonds diminish after the deadline, with no significant coefficient observed by two weeks after the deadline.[6] Apparently, there are costs in addition to bid-ask spreads that cause dealers to forego the opportunity to short sell even the large coupon bonds one week

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[6] In this respect, the regression results differ from those reported for the median change. In Table 2, the results suggest the existence of a premium on both days 3 and 4. Judging from the slope coefficient alone, Table 3 suggests that there is no premium on date 4. Because the regression results will depend much more heavily on the behavior of the few observations with the largest yield-coupon differentials, there is no necessary reason why the two measures should agree in a particular sample.

before the deadline and to wait for three weeks or more to close the short position.

Compared to the relatively small unexploited opportunities available to dealers, the premia exhibited in Figure 2 for 70% tax bracket individuals are quite large. Using the regression estimates for this date, again one week before the deadline, the estimated premium on a $100 face value bond with an 8% yield-coupon difference is -$2.16. On the date two weeks before the deadline, the opportunities are even more pronounced, the estimate in this case being -$2.34. These magnitudes are not only large relative to the costs implicit in the bid-ask spread, they are large in absolute terms. Since most of the bonds in the sample (especially those with large yield-coupon spreads) are observed roughly one year before maturity, these values can be readily converted into rates of return. For an investor in the 70% tax bracket, a bond with a discount of this magnitude has an after-tax return that is more than 200 basis points higher than the return on a one year T-bill.

One possible interpretation of this kind of dominance is that individuals sort themselves into clienteles according to tax bracket, investing only in undominated assets. Dominated assets can persist because short sales are assumed to be impossible, but no other transaction costs are relevant for the determination of equilibrium. (See for example, Schaefer (1982).) This interpretation is not compelling for these data. There is no reason to believe that dealers are incapable of short sales and the evidence above suggests that short sales do in fact take place. In addition, the tax arbitrage available to individuals on the bonds in this sample does not require true short sales. All that is necessary is the ability to make

leveraged purchases of the discount bonds at rates close to T-bill rates, and there is direct evidence that this did take place. In December 1979, a column in the Wall Street Journal reported that several large security dealers were offering an unpublicized arrangement with taxable individuals, selling them discount bonds financed by loans at essentially the cost of the funds to the dealer, i.e. the RP rate.[7] This arrangement alone would not constitute a true arbitrage because borrowing on a short-term basis leaves the holder exposed to some interest rate risk, but this could easily be hedged in the financial futures market. This article is also of interest because it uses the 6 and 7/8'ths of March 31, 1981 to illustrate this opportunity. This bond had the largest yield-coupon difference for this sample, almost 8.5%. (It is the observation on the extreme right in both Figures 1 and 2.) Almost three months after this column was published, when the observations used here were taken, this bond was still underpriced relative to T-bills by almost $2.50 per $100 face value for a 70% tax bracket individual.

In principle, it is possible that the price observed for this bond and others is consistent with the absence of other transaction costs for private individuals because every taxpayer had already taken the maximum possible interest deductions. In fact, this is clearly not the case. In the Statistics of Income report on private individuals (Internal Revenue Service (1982)), the IRS publishes summary information on income tax returns with adjusted gross income plus tax preferences (made up largely of the capital gains exclusion) of more than $200,000. A priori, high income, high bracket individuals would seem most likely to take advantage of the tax arbitrage.

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[7] Your Money Matters, December 31, 1981, page 20.

For the tax year 1980, this group consisted of roughly 158,000 returns with total taxable income of $41 billion and total tax payments of $22 billion. Given the tax rates applicable for that year, this much tax could be due only if a substantial fraction of this group was paying tax at the maximum rate of 70%. It is true that some 17,000 out of the total of 158,000 had investment interest deductions exceeding investment income by an average of over $17,500 per return. These individuals may have been using the tax arbitrage described here (or some other comparable set of transactions) to shelter substantial amounts of investment income, but for the group as a whole, dividend and interest income alone were over $14 billion and investment interest totaled only $2.4 billion. Unambiguously, a substantial amount of unsheltered investment income was received by large wealthy investers and taxed at very high rates.

Finally, for comparison with other studies that have estimated a specific tax rate i by choosing the value that gives the best fit to the data, Table 4 reports non-linear least squares estimates of the parameter i in equation 2.7. If it were clear that the underlying parameter had some kind of structural interpretation, one might be concerned by the use of T-bill prices as right side explanatory variables because those prices are potentially observed with error. Here it is probably best not to assign any structural interpretation and to view this simply as an exercise in curve fitting. Additionally, the standard errors for the parameter estimates are not corrected for possible heteroskedasticity, but the corrections to the least squares regressions were generally small. As always, the capital gains tax rate g is assumed to be one-half the income tax rate i. As should be clear

from the simple calculation in eq. 2.2, the likelihood function for these data will be quite flat along a locus of i and g values. Essentially only the difference $i-g$ can be precisely estimated. The estimate of i ranges from a high of 21% on the date one week prior to the deadline dated and a low of about 10% both two weeks before and after the deadline. These figures are comparable with other reported estimates. Litzenberger and Rolfo (1984a), report that subject to the constraint that $g=i/2$, the best "smoothed" estimate of bond prices implicit in the yield curve for a sample of bond prices observed in January 1980 is achieved at a value of $i=.20$. Jordan (1984) uses a similar approach for 40 different dates between 1979 and 1980 and reports estimates for i ranging from .00 to .40 with a median of .10.

4. Discussion

In terms of the question posed at the beginning of this paper, there is some evidence of a tax effect in the pricing of short term to maturity U.S. government securities, but the most interesting finding is the small size of this effect. As one would expect from the tax treatment of discount bonds, the difference between the price for a bond and a T-bill portfolio offering the same stream of before-tax payments is positively related to the yield-coupon difference (or discount from par) on the bond. Neglecting any transaction costs other than bid-ask spreads, this relation implies the existence of a small unexploited profit opportunity for dealers on the bonds with extreme discounts from par. But the small size of the slope coefficient implies much larger (after-tax) profit opportunities for high tax bracket

individuals. Previous studies that have found similar evidence of dominance relations have interpreted these as evidence of the existence of clienteles for specific assets that persist because of sharp limitations on the ability of agents to short-sell securities, but the results here are not consistent with this interpretation. Dealers do seem to engage in short sales. At least some individuals seem to be able to make leveraged purchases of discount bonds. Rather, the results suggest the presence of transaction costs other than bid-ask spreads of as much as 0.5% for dealers and between 2% and 2.5% for those individuals who are not constrained by the limitation on the deductability of investment interest. In general, the results offer at best weak evidence the existence of segmented tax-clienteles. Tax-exempt investors could not have profited by exchanging discount bonds for T-bills except possibly in the case of the bonds with the larget discounts from par. To support even this conclusion, it must be argued that tax-exempt investors selling bonds are not affected by the transaction costs faced by dealers and private individuals. (It is possible that the costs for the dealers pertain only to arranging short-sales.)

This evidence suggests first that estimates of marginal tax rates inferred from data on discount bonds are in fact indirect estimates of the transaction costs facing dealers. As indicated in the introduction, this conclusion is consistent with the evidence provided by Eades, Hess and Kim (1984) in their examination of the ex-dividend day price behavior following taxable distributions on common stocks. Despite the presence of an arbitrage opportunity for short-term traders, the price change differed from that expected in a world with no taxes because of transaction costs faced by those

traders. If this interpretation is correct and the magnitude of the tax effect in each case is determined by costs faced by short-term traders and dealers, the "representative" tax rates implied by these data should not be treated as structural parameters that explain the demand for securities by taxable investors. In particular, models using a representative private agent with the estimated tax rate are likely to have misleading implications about the nature of equilibrium. For example, if transaction costs are largely fixed costs, they should affect investments in inverse proportion to the anticipated holding period. For short term securities, they can dominate tax considerations for private individuals. For problems like capital structure decisions by firms, where the time horizons for private investors may be much longer, transaction costs may be less important and tax considerations more important than the analysis here suggests.

These results have special relevance for estimates of private tax rates inferred from T-bill data using an after-tax Fisher equation. (See for example Peck (1982).) Under either a clientele interpretation or a transaction cost interpretation, private individuals cannot be the "marginal investors" in the Treasury bill market. Under the clientele interpretation, T-bills are a dominated asset for private individuals; under a generalized version of a model with transaction costs, private individuals will hold T-bills instead of discount bonds only in the presence of differential transaction costs that are substantially higher for the bonds than the bills; but the lack of access to other securities means that they cannot be the marginal investors in this market.

More generally, these results are relevant to the whole class of intertemporal asset pricing theories.[8] In one sense they may be partially reassuring because much of the empirical difficulty with these models appears to arise from the inclusion of T-bills into the portfolio of assets. These theories seem to be better at explaining cross-sectional variation in returns on equities alone or even on equities and long bonds. (See for example the results and discussion in Dunn and Singleton (1984).) If T-bills are dominated for private individuals, perhaps they should be excluded from the investment portfolio for purposes of estimating consumption based asset pricing models. (Private individuals do hold T-bills, but they also hold passbook savings accounts.)

This optimistic view must be tempered by the evidence that transaction costs as large as 2.5% may be important for even the wealthiest investors. These costs are of the same order of magnitude as the variation in the returns the intertemporal models seek to explain and may be quite important in models that are driven by monthly or even quarterly movements in aggregate consumption. Additionally, the results here confirm once again how difficult it will be to introduce the complexity of the U.S. tax code into any simple aggregate asset pricing theory.

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[8]One area for which these results are no longer relevant is personal tax planning. In the Deficit Reduction Act of 1984, Congress changed the tax treatment of market discount bonds. For any bond issued after the summer of 1984, appreciation to par will not be treated as a capital gain if the bond is purchased at a discount. For outstanding bonds trading at a discount, the excess of the interest paid on loans used to finance the purchase of the bonds over the coupon income from the bond cannot be deducted until the sale of the bond. At that time any accumulated interest deductions cause an equal amount of the gain on the bond to be treated as regular income. This removes both the ability to take deductions and defer income and the ability to convert other investment income into capital gain.

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Table 1

Regression of yield change on yield-coupon spread around the capital gains holding period deadline.

Interval	NOBS	Dependent Variable	OLS a	OLS b	IV a	IV b	Value for i
-1 week to +1 week	57	Absolute Change	.06 (.16)	-.01 (.05)	.01 (.17)	.01 (.07)	2%
		Relative Change	-.07 (.07)	.03 (.02)	-.09 (.07)	.03 (.03)	6%
-2 weeks to +2 weeks	48	Absolute Change	.55 (.24)	-.15 (.08)	.50 (.19)	-.13 (.08)	0%
		Relative Change	.10 (.07)	-.01 (.02)	.10 (.06)	-.01 (.02)	0%

Ordinary least squares and instrumental variables estimates for the regression (yield change) = a + b(yield-coupon spread)+ϵ, with standard errors in parentheses. Standard errors for the instrumental variables estimates are corrected for possible heteroskedasticity. The yield change is measured over an interval measured in weeks relative to the deadline. It is calculated in absolute terms and as the change relative to the change in yield of a T-bill with a comparable maturity. Because some of the four week intervals overlapped, there are fewer independent observations for the second set of regressions. The estimate of the implied "representative" income tax rate i is based on the estimate of the coefficient b and is derived from equation 2.2 in the text and the assumption that the capital gains tax rate $g = i/2$.

Table 2

Difference between bond price and T-bill portfolio price for selected tax rates.

Tax Rate	Prices used	Observation date relative to deadline			
		-2 weeks	-1 week	+1 week	+2 weeks
0%	Mid-point of spreads	$.12 (.08, .17)	.11 (.07, .16)	.12 (.09, .16)	.09 (.07, .13)
	Bond bid minus bill ask	.04 (-.01, .09)	.01 (-.04, .07)	.02 (-.01, .06)	.00 (-.03, .03)
30%	Mid-point of spreads	-.20 (-.25, -.16)	-.20 (-.25, -.16)		
	Bond ask minus bill bid	-.12 (-.16, -.08)	-.11 (-.16, -.06)		
70%	Mid point of spreads	-.66 (-.78, -.59)	-.66 (-.81, -.56)		
	Bond ask minus bill bid	-.59 (-.71, -.49)	-.56 (-.70, -.47)		

The units are dollars per $100 of face value. The price difference is estimated from a sample of size 57 using the non-parametric Hodges-Lehman estimator. A 95% confidence interval based on the order statistics of the sample is given in parentheses. For details concerning this estimator, see Hollander and Wolfe (1973)

Table 3

Regression of bond premium on yield-coupon spread

Tax rate	Parameter	Observation date relative to deadline			
		-2 weeks	-1 week	+1 week	+2 weeks
i=0	a	.034	-.009	.026	.073
		(.036)	(.059)	(.048)	(.032)
	b	.034	.058	.046	.013
		(.011)	(.018)	(.022)	(.012)
	$\hat{\sigma}$	.158	.267	.157	.135
i=.7	a	.015	-.039		
		(..029)	(.044)		
	b	-.295	-.266		
		(.007)	(.018)		
	$\hat{\sigma}$	.139	.180		

Estimates of the equation $P_b - P_p(i) = a + b(y-c) + \epsilon$, where P_b is the bond price and $P_p(i)$ is the price of the T-bill portfolio that gives the same stream of after-tax payments for someone facing a marginal income tax rate i. Standard errors for the coefficient estimates, all corrected for possible heteroskedasticity, are given in parentheses. Prices for bonds and T-bills are given in dollars per $100 face value of securities, and are measured as the midpoint of the bid-ask spread. The yield y and the coupon rate c are measured in percentage points. $\hat{\sigma}$ is the estimated standard error of the regression. The slope coeffcient for the date 2 weeks before the deadline is estimated using an instrumental variable, as noted in the text.

Table 4

Non-linear regression estimates of the parameter i from eq. 2.7

Parameter	Observation date relative to deadline			
	-2 weeks	-1 week	+1 week	+2 weeks
a	.011	-.108	-.014	.00
	(.026)	(.059)	(.036)	(.028)
i	.107	.212	.142	.096
	(.036)	(.037)	(.025)	(.021)
$\hat{\sigma}$	.148	.242	.152	.121

Non-linear least squares estimate of the equation $P_b=a+f(i)+\epsilon$, where the expression $f(i)$ is as given in equation 2.7. Approximate asymptotic standard errors, with no correction for possible heteroskedasticity, are given in parentheses. Both the bond price P_b and the T-bill prices included in the expression $f(i)$ are measured as mid-points of the bid-ask spread. Since the non-linear expression $f(i)$ depends on the observed values of the T-bill prices, errors in those prices may affect the estimate of i.

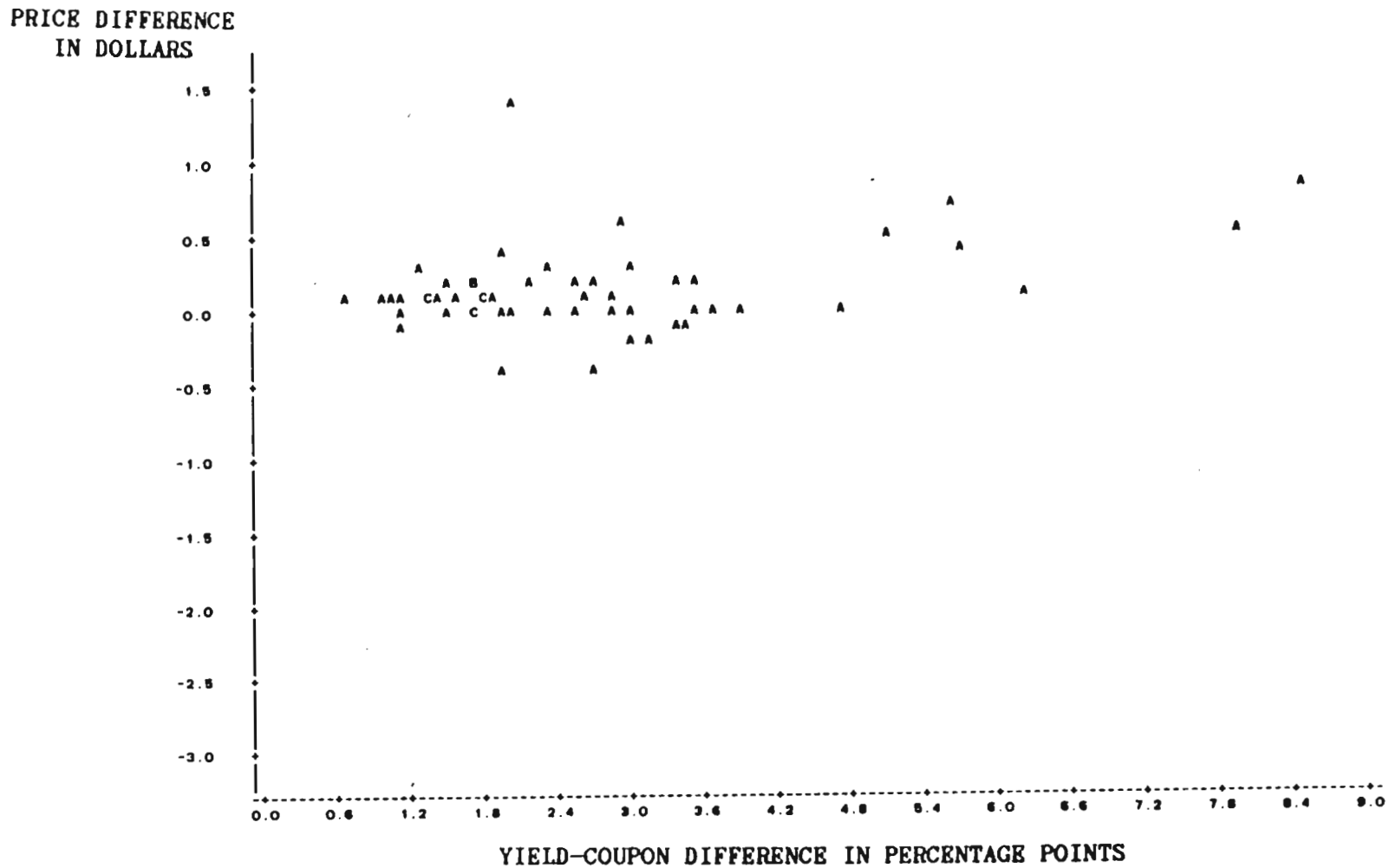

Fig. 1. $P_b - P_p(0.0)$, the difference between the price on a bond and the price on the T-bill portfolio offering the same before-tax stream of payments plotted as a function of the yield-coupon spread. Both bond and T-bill prices are measured as mid-points of the bid-ask spread. A=1 observation, B=2 observations, etc.

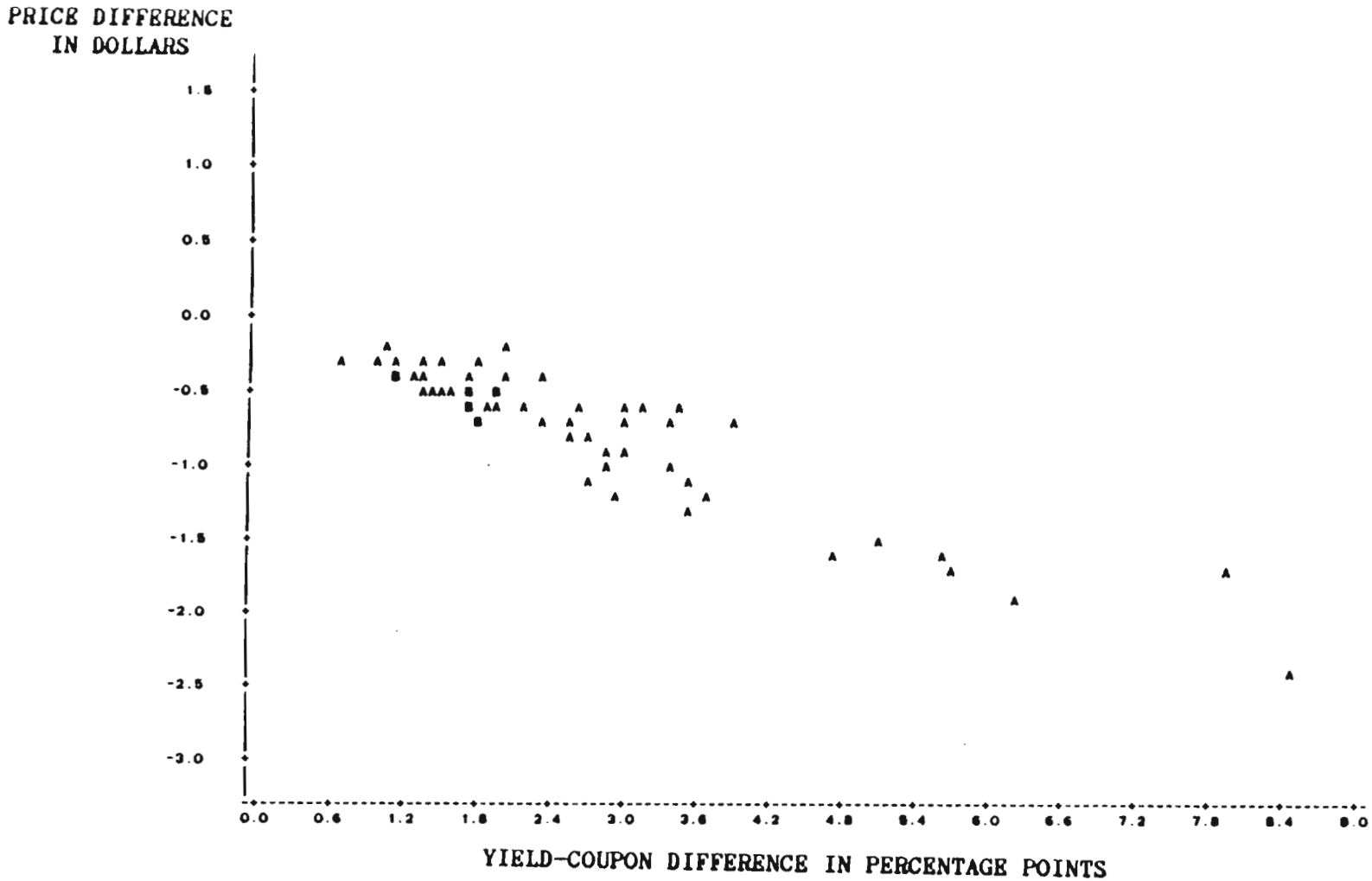

Fig. 2 $P_b - P_p(.70)$, the difference between the price on a bond and the price on the portfolio of T-bills offering the same stream of after-tax income to an individual in the 70% tax bracket, plotted as a function of the yield-coupon spread on the same scale as Figure 1. Both bond and T-bill prices are measured as midpoints of the bid-ask spread. A=1 observation, B=2 observations, etc.

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