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Author(s): Charles Trzcinka

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CHARLES TRZCINKA*

ABSTRACT

This paper reports a new test of two competing theories of the relation between tax-exempt and taxable interest rates. The Miller hypothesis predicts that the tax-exempt rate is 52 percent of the taxable rate, while the institutional demand hypothesis predicts a volatile relationship. The tests in this paper employ a random intercept model to control for the risk of average interest rates. The results favor the Miller hypothesis. Marginal tax rates are found to be close to Miller's predicted 48 percent. The relationship is not influenced by relative demand or supply and the marginal tax rate appears stable over time.

IN HIS "DEBT AND TAXES" paper, Miller [12] proposed that as a result of differential personal tax rates, adjustments in the supply of corporate debt cause an equilibrium in which leverage is irrelevant for any individual firm. In this equilibrium, the tax-exempt interest rate is equal to one minus the corporate tax rate times the equivalent taxable interest rate. The hypothesis that the implied marginal tax rate on interest income equals the corporate tax rate contrasts sharply with the competing hypothesis which states that the marginal tax rate is determined by institutional demand. Fortune [5], Galper and Peterson [6], and Kimbal [10] have argued that the marginal tax rate on interest income is inversely related to the amount of participation in the tax-exempt market by commercial banks and property insurance companies. The two theories have such markedly different predictions that it seems easy to empirically discriminate between them and, in fact, researchers have found that the marginal tax rate on interest income is much lower than the corporate tax rate, thus supporting the institutional demand theory. However, these findings depend critically on the assumption that tax-exempt and taxable interest rates of comparable ratings are equivalent. We argue in this paper that bond ratings do not adequately control for the relative risk between taxable and nontaxable bonds and we show that when risk is

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properly accounted for, the resulting estimate of the marginal tax rate is very close to Miller's prediction of one minus the corporate tax rate.

Section I briefly outlines Miller's hypothesis and contrasts it with the institutional demand theory. After a presentation of preliminary evidence, we discuss the possible biases in the data due to systematic differences in risk. Section II gives the details of the econometric model employed to correct the data problems, and Section III presents the empirical results.

I. Theories of Tax-Exempt Pricing

The interest payment received from holding a bond issued by a city, state, or state agency is exempt from federal income taxes and very often from state income taxes. Thus, if two bonds are identical except for tax status, an investor will be indifferent between them if the return on the tax-exempt bond, R_m, is equal to the aftertax return on the taxable bond:

$$R_m = (1 - t_p)R_T \tag{1}$$

where t_p is the tax rate paid on the taxable return, R_T. In equilibrium, the tax rate t_p will be the marginal tax rate of the marginal buyer of municipal bonds.

The Institutional Demand Theory

According to this theory, the equilibrium marginal tax rate is responsive to both supply and demand in the municipal bond market. Proponents of this theory argue that the supply of municipals is interest-inelastic and that, therefore, the equilibrium marginal tax rate is primarily determined by demand.[1] The major purchasers of municipal bonds have been commercial banks, property insurance companies, and individuals. Since property insurance companies are a relatively minor participant in the market, the belief is that movements of commercial banks in and out of the market primarily determine the marginal tax rate. Commercial banks buy municipals to shield their income from taxes.[2] If that income is reduced, the demand by commercial banks for municipals will fall and municipal bonds must offer a higher yield to induce lower tax bracket individuals into the market, causing the marginal tax rate to fall. When the income of commercial banks rises they will purchase larger amounts of available tax-exempts, causing yields to fall and the marginal tax rate to rise. Thus, the holding of municipals by individuals is essentially a residual, depending on the actions of commercial banks. If banks (and property insurance companies) could purchase the entire supply of municipals, the marginal tax rate would be equal to the corporate tax rate. In this case, only those individuals with tax rates greater than the corporate tax rate would find municipals more profitable than taxable debt. In general, however, the supply of tax-exempts is not purchased entirely by investors paying the corporate tax rate so that, according to the institutional demand theory, the marginal tax rate varies directly with commercial bank participation in the tax-exempt bond market.

[1] See Hendershott and Koch [9], and Kimball [10].

[2] See Fortune [5] and Kimball [10].

The Miller Hypothesis

The preceding analysis assumes that the taxable interest rate is determined independently of the tax-exempt market. However, Miller [12] has suggested that the supply of taxable debt will be responsive to the relative yields on taxable and tax-exempt bonds. He argues that to analyze the tax advantages of deductible corporate interest, it is important to include the personal tax implications of additional corporate debt. If personal taxes on income from bonds are positive, then there is a gain from corporate leverage only if the corporate income tax rate is greater than the marginal tax rate on income from bonds. If the corporate tax rate is less, then there is a loss. Miller argues that in a world with progressive income taxes and a fixed corporate tax rate, firms will supply corporate debt to the point where the tax advantages of corporate debt are fully utilized; then, the tax rate of the marginal bond holder will be equal to the corporate tax rates that condition (1) becomes:

$$R_m = (1 - t_c)R_T \tag{2}$$

where t_c is the corporate tax rate.[3]

According to Fama [4] and Haley, Higgins, and Howard [7], commercial banks have an incentive to reinforce this relationship. The tax laws allow commercial banks to engage in tax arbitrage, transforming taxable income into nontaxable income by borrowing to invest in tax-exempt securities. The aftertax return on tax exempt bonds is R_m while the aftertax cost of borrowing is $(1 - t_c)R_T$ and thus, tax arbitrage will be profitable if $R_m > (1 - t_c)R_T$. When this occurs, the increased demand for tax exempts will tend to drive tax-exempt interest rates down to the point where arbitrage is no longer profitable. The reverse is true when tax arbitrage is unprofitable and, therefore, banks have an incentive to preserve condition (2).

According to Moore [13], tax arbitrage with tax-exempt bonds is not confined to commercial banks. While the tax laws ostensibly prohibit the deduction of interest when the proceeds of borrowing are used to buy tax-exempts, the difficulties of enforcing this section has led the IRS to allow corporations to deduct interest and hold tax-exempts if the borrowing is not in excess of business needs. Moore observes that "corporations have been quite successful in identifying business needs despite the presence of large quantities of tax exempt securities."[4] He goes on to argue that the law is enforced only in the "most flagrant" cases. Thus, in addition to adjusting the supply of corporate debt in response to changes in the yield ratio, firms have the incentive to demand tax exempts if $R_m > (1 - t_c)R_T$, causing a fall in R_m until (2) holds.[5]

[3] The current corporate tax rate is actually 46 percent but the tax rate for almost all of the sample period was 48 percent. Consequently, for the purpose of clarity, the latter tax rate is used in the discussion.

[4] Moore [13], p. 1448.

[5] Tax arbitrage may be constrained by the chance that the IRS will disallow it if a substantial portion of the bank's income is generated by this action. Additional constraints are that tax rates may change and regulators may reduce tax arbitrage by commercial banks. Finally, if ordinary firms act to preserve Equation (2), they are not, in fact, major buyers or issuers of tax-exempts.

Table I

Ratios of Tax-Exempt to Taxable Interest Rates[a]

Ratio	Mean	Std. Dev.	Min.	Max.	N
30 Yr. Prime / Long Aaa Utility	.6881	.0392	.6154	.7962	117
20 Yr. Prime / Long Aaa Utility	.6568	.0362	.5949	.7643	117
10 Yr. Prime / 10 Yr. Aaa Utility	.5838	.0225	.5455	.6375	45
30 Yr. Good / Long Aa Utility	.6888	.0420	.6070	.7921	117
20 Yr. Good / Long Aa Utility	.6585	.0385	.5871	.7640	117
10 Yr. Good / 10 Yr. Aa Utility	.6022	.0327	.5427	.6824	81
30 Yr. Medium / Long A Utility	.7012	.0461	.6146	.8245	117
20 Yr. Medium / Long A Utility	.6699	.0423	.5951	.8000	117
10 Yr. Medium / 10 Yr. A Utility	.6232	.0389	.5463	.7143	103

[a] The data are from Salomon Brothers' *Analytic Record of Yields and Yield Spreads.* All interest rates are monthly averages of the yields on newly issued bonds. Each interest rate series ends in September 1979.

Preliminary Evidence

The two theories have such markedly different conclusions that it seems an easy task to distinguish between them. The data in Table I are ratios of monthly averages of the yields on newly issued utility (taxable) and municipal (tax-exempt) bonds.[6] The Miller hypothesis predicts that these ratios should be equal to $(1 - t_c)$ or 52 percent, but it is apparent that they are never close to this number and exhibit considerable volatility. Ratios similar to those reported in this table have been cited by DeAngelo and Masulis [3] and Hendershot and Koch [9] as evidence against the Miller hypothesis.

Note that for all grades, the average ratios fall as term to maturity decreases. In fact, for *each month* the thirty-year ratios are always larger than the twenty-year ratios and the twenty-year ratios are almost always larger than the ten-year ratios. For prime grade bonds, twenty-year ratios are always larger than ten-year; for good grade, the twenty-year ratios are larger in 78 out of 81 months; and for medium grade, in 98 out of 103 months.[7] This tendency occurs because the term structure for municipals is always rising when ratings are used to control for risk. Proponents of the institutional demand theory usually explain this phenomenon in terms of the preferences of commercial banks. According to Van Horne [16], banks are interested primarily in shorter maturities because their deposit liabili-

[6] Municipal yield averages are classified as "prime", "good", and "medium" by Salomon Brothers instead of Moody's "Aaa", "Aa", "A".

[7] The ranking across maturity is also observed when municipals are compared to U.S. Government yields, see Hendershott and Koch [9], Table 1-1.

ties are short-term while their assets are typically longer term. The result is a greater relative demand for short-term securities than for long-term securities and, consequently, an upward sloping yield curve. Ratios of yields on short-term tax-exempts to yields on taxables will be close to 52 percent because this segment of the market is dominated by investors (commercial banks) with a 48 percent tax rate. Longer-term yields must be higher to induce investors with lower tax rates into the market, thus raising the tax-exempt/taxable ratio above 52 percent.

These arguments implicitly assume that municipalities have a preference for long-term debt. Were this not so, municipalities would simply issue more short-term debt and less long-term, thus eliminating the premium on long-term debt. The assumption that state and local governments have this maturity preference is based on the fact that most of the proceeds from tax-exempts are used to finance capital expenditures and the argument that municipalities seek to finance long-term projects with long-term debt. Yet, Hendershott and Koch [9] argue that sources of municipal funds are "fungible" (i.e., substitutable) with respect to the proceeds from federal grants; it is not unreasonable to suppose that this fungibility carries over to short and long term debt. Furthermore, they argue that state and local governments create agencies to bypass interest rate ceilings and it is possible that such agencies may be able to circumvent any regulation prohibiting the substitution between short and long term debt.

Thus the arguments explaining the term-structure of the ratios in terms of institutional tastes are not convincing and ignore the logic of the Miller hypothesis. Even if municipal preferences for long-term debt resulted in a consistently rising municipal term structure, corporations would find that the tax advantage of short-term corporate debt was less than that of long-term corporate debt. Firms would have an incentive to increase the supply of long-term debt, increasing the yield and raising the marginal tax rate. Thus, even if preferred habitats in the municipal bond market resulted in a rising term structure, a more general equilibrium analysis predicts that the ratio, R_m/R_T, will be equal to one minus the corporate tax rate.

Municipal Bond Risk and Ratings

Time series plots of the ratios of tax-exempt to taxable interest rates suggest why they diverge from the value predicted by Miller's analysis. As shown in Figure 1, the ratios are somewhat lower and less volatile after January 1972 which is the date of the State and Local Federal Assistance Act (Revenue Sharing Act) of 1972.[8] Yawitz [17] has argued that the act reduced, at least temporarily, the risk-premiums of tax-exempts suggesting that the change shown in Figure 1 is the result of changes in risk. Yet by matching interest rates of similar ratings, risk is presumably held constant. If the rating of a bond captured its risk whatever

[8] The data are the same as for Table I. Statistics for subperiods are as follows:

	30 year		20 year	
	mean	(std. dev.)	mean	std. dev.
Jan. 1970–Dec. 1971	.727	(0.34)	.692	(.037)
Jan. 1972–Sept. 1979	.678	(0.31)	.648	(.030)

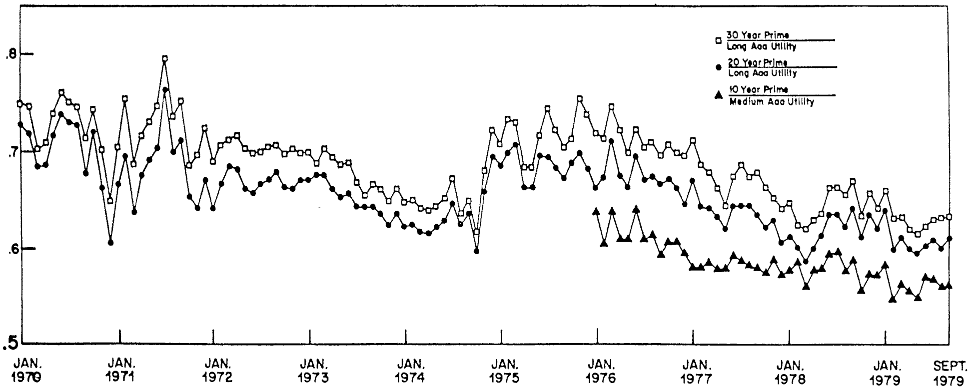

Figure 1

the type of bond, the effects of the revenue sharing act would not be observed in the data. Instead, municipalities rated *Aa* would have their ratings boosted to *Aaa* and so on. The fact that no wholesale revamping of ratings occurred is an indication that ratings agencies do not attempt to make ratings comparable between corporate and municipal bonds. Thus, it is likely that equivalent ratings for corporate and municipal bonds do not imply equivalent risks as perceived by investors.[9]

Furthermore, there are reasons to believe that municipals are, on average, more risky than corporates of the same rating, thus providing an alternative explanation of why the ratios are always higher than predicted by Miller. Van Horne [16] argues that ratings agencies focus primarily on the probability of default and make little attempt to adjust for other factors influencing risk. This means that municipals are likely to be more risky than corporates of the same rating. First, as Hempel [8] has observed, in bankruptcy proceedings, municipal assets cannot be seized as easily as corporate assets because they may be physically impossible to seize (e.g., a sewer system) or they may be legally protected (e.g., a school). Second, according to Zimmerman [19], municipalities have more incentives than corporations to raise information costs. He argues that municipalities are responsive to voters and voters have an incentive to constrain but not monitor the actions of a municipality. This incentive causes voters to demand municipal financial statements which are less useful to bondholders than corporate accounting statements. Finally, Fama [4] argues that the profit maximizing incentives of firms make their actions relatively more predictable than the actions of a state or local government which are subject to a less predictable political process. Therefore, the focus by ratings agencies on probability of default means that the rating will not incorporate certain risks which are specific to municipal bonds, and we expect that municipals will have higher average interest rates than corporate bonds of the same rating. To correct this bias in the ratings, Equation (1) should be written:

$$R_m - \lambda = (1 - t_p)R_T \tag{3}$$

[9] The use by Salomon Brothers' of prime, good, and medium for tax-exempts instead of the Aaa, Aa, and A used for corporate explicitly reinforces this point.

where λ is a differential risk premium which exists because ratings primarily measure default risk.[10]

II. Measurement Model and the Specific Hypothesis

Equation (3) cannot be estimated by standard regression techniques because there is little reason to believe that λ is constant. It is likely that the differential risk premium will change over the business cycle as do other risk premiums defined in terms of ratings.[11] Furthermore, exogenous shocks to the market, such as the revenue-sharing act, may also change the risk premiums. Thus, to capture the variation in an empirically testable model, it is assumed that for a given rating and maturity

$$R_{mt} = \lambda_t + \beta R_t, \qquad t = 1, \cdots, N \tag{4}$$

where R_{mt} and R_t are the municipal and taxable yields at time t, λ_t is the differential risk premium at time t, and β is one minus the marginal tax rate or 52 percent if the Miller hypothesis is correct. Since λ_t is theoretically the extra return necessary to compensate investors for bearing risks not measured by ratings, it should follow a random walk in an efficient market.[12] To test empirically whether λ_t follows a random walk, the procedures of Cooley and Prescott [2] are adopted. It is assumed that

$$\lambda_t = \lambda_t^P + U_t, \qquad t = 1, \cdots, N \tag{5}$$

$$\lambda_t^P = \lambda_{t-1}^P + V_t, \qquad t = 1, \cdots, N \tag{6}$$

where P denotes the permanent component of the parameter. The random variables U_t and V_t are assumed to be identically and independently distributed normal variates with mean values of zero and variances given by:

$$\mathrm{Var}(U_t) = (1 - \gamma)\sigma^2 \quad \text{and} \quad \mathrm{Var}(V_t) = \gamma\sigma^2 \tag{7}$$

where $0 < \gamma < 1$. Equation (5) specifies that λ_t is the sum of a purely random or "transient" component (U_t) and a "permanent" factor (λ_t^P) which follows a random walk given by (6). The specification of the variances given by (7) allows the model to represent any intercept variation between two polar cases: when $\gamma = 0$, the model is identical to the standard regression model because the variance of V_t is zero. When $\gamma = 1$, all variation in the data is represented by the random walk of the permanent component since in this case the variance of U_t is zero.

There are $T + 3$ parameters of the model to estimate: three fixed parameters β, γ, and σ^2, and T intercepts $\lambda_j^P (j = 1, \cdots, T)$. The "permanent" component of the random parameter can be estimated by solving (5) and (6) for one λ_j^P in terms

[10] We do not mean to imply that ratings agencies are "fooled" by outside events or that their analysis is inadequate. We hypothesize only that a rating is no more or less than what Moody's and Standard and Poors say it is—a measure of an issuer's default probability. The rating of a bond certainly may capture all information relevant for assessing this probability. Our argument is that a given probability of default may expose investors to more risks with municipal bonds than corporate bonds.

[11] Van Horne [16] outlines the numerous studies which empirically demonstrate that risk-premiums on all bonds behave countercyclically (low in good economic times, high in recessions).

[12] See Samuelson [14].

of the remaining coefficients. Since this can be done for any time period, the entire sample path of the permanent component may be estimated. Given an estimate of γ, the remaining parameters are estimated by generalized least squares (GLS). The estimate of γ may be obtained from the data with a maximum likelihood procedure which Cooley and Prescott [2] show is consistent. This implies that the GLS estimators of λ_j, β, and γ are asymptotically efficient (they are unbiased).[13]

If the hypothesis is correct that municipal bond returns carry an extra risk premium when compared to corporate yields of the same maturity and rating, we should find that λ_t is positive and significant. It should follow a random walk, which leads to the expectation that γ is significantly different from zero. It was argued above that the risk premium is likely to be larger the longer the maturity of the bond; consequently, the estimated permanent components of the intercepts should increase with maturity.

Note that the risk premium hypothesis is logically compatible with either Miller's or the traditional explanation of the marginal tax rate. It is possible for the institutional demand hypothesis to be true while municipals are systematically riskier than corporates of the same rating. In this case, any variation in λ_t will be due to both the risk-premium and the variable tax rate, since the slope, $1 - t_p$, is held constant. Furthermore, the two factors will be reinforcing; that is, both the risk premium and $1 - t_p$ theoretically move countercyclically. In good economic times, commercial banks and property insurance companies tend to purchase more tax-exempts which will cause the R_m/R_t ratio to fall. Similarly, risk premiums are expected to be low during economic upturns.

The first test between the two theories is to determine if the slope of Equation (4) is 52 percent. Next, if the Miller hypothesis is correct, firms should find it profitable to offset any disturbance of the R_m/R_T ratio which implies that neither demand variables nor supply variables should be a significant determinant of the ratio. Finally, the ratio must remain stable over the estimation period if the corporate tax rate does not change. While it is difficult to test the stability of the parameters in a random intercept model, a Bayesian test can be constructed to examine whether the random intercept model or a random slope model better represents the data. Since the institutional demand theory predicts that the marginal tax rate (one minus the slope coefficient) will be volatile, a finding that the data are better modeled by a random intercept formulation would reject the institutional demand theory in favor of the Miller hypothesis.

III. Empirical Results

Data

The data were collected from Salomon Brothers' *Analytical Record of Yields and Yield Spreads.* The interest rates are new-issue, monthly averages of yields with various grades and maturities. Long term rates were used because, as

[13] The model is general in the sense that slope coefficients may be chosen as the random parameter. If more than one regression coefficient is random, the covariance matrix must be known a priori.

discussed above, both hypotheses predict a 52 percent ratio for short term interest rates. Salomon Brothers reports averages of prime, good, and medium municipal interest rates for maturities of ten, twenty, and thirty years monthly from 1950 to present, but all of the corresponding corporate interest rates begin in January 1970 or later. Thus, the largest number of observations is 117 representing January 1970 to September 1979, the last observation for each sample. The nine municipal interest rates are matched by rating and maturity with nine utility and nine industrial yields providing eighteen pairs of interest rates.[14]

Estimation of the Model

The results of estimating the fixed parameters in the model are reported in Table II. The table reports the estimated slope, gamma, and the standard error of the equation. The slope coefficients are never significantly different (at .05 level) from Miller's prediction of .52. The average value of the slope estimate is .54, which implies a marginal tax rate of about 46 percent. The slope using the utility rates averages .526 while the corresponding slope for industrials averages .545. There are ten slope coefficients larger than .52 and eight coefficients smaller. Only two of the estimates which are smaller and four of the coefficients which are larger, are more than one standard deviation from .52 and these are not significantly different from .52. Thus, it appears that previous estimates of the marginal tax rate have been too small and that the data support Miller's prediction of a 48 percent marginal tax rate.

All estimates of gamma are significant, as hypothesized. There is a tendency for the estimates to fall as term to maturity decreases. This is always the case when maturity falls from 30 years to 20 years, and for the equations using utility interest rates it is also true between 20 and 10 years. Gamma is the parameter measuring the extent to which the variation in the dependent variable is explained by the random walk.[15] It was argued above that if the intercept is measuring a differential risk premium, it is reasonable to believe that as maturity falls, the risk premium should be a less significant component of the municipal interest rate. The fact that the estimate of gamma tends to fall with maturity indicates that the risk premium explains less of the variation in short term interest rates than in the long-term interest rates.

Tables III provides an analysis of the sample paths of the permanent component of the intercept in each equation, λ_t^P. The table reports the mean, standard deviation, and median of each sample path. Under the column heading "I", the

[14] Statistics describing all of the utility-municipal pairs are reported in Table I and the prime utility-municipal rates are shown in Figure 1. These data along with the industrial rates have numerous problems. They are averages of yields not actual prices. It is well known that the yield to maturity does not necessarily represent the return to an investor. Furthermore, at least for the municipals, there is some adjustment of the yields by Salomon Brothers. An attempt was made to duplicate the municipal averages from a file of municipal bonds representing all issues of one million dollars or more during 1974–75. The numbers were close but not exact and it is clear that some judgement enters the average. Nevertheless, prices of municipal bonds are simply not available (at least to this author) and the yields provided by Salomon Brothers appear to be the best available. See Cook and Hendershott [2] for a discussion of the corporate data and comparison of Salomon Brothers and Moody's data.

[15] See Cooley and Prescott [3], pp. 135–36.

Table II

Relationship between Tax-Exempt and Taxable Yields[a]

Municipals on Utilities						Municipals on Industrials					
Municipal	β	Utility	γ	$\hat{\nabla}$	N	Municipal	β	Utility	γ	$\hat{\nabla}$	N
30 Prime	.5162	Long Aaa	.6049	.1653	117	30 Prime	.4887	Long Aaa	.5539	.1683	108
	(9.50)		(4.61)				(7.15)		(4.04)		
20 Prime	.5716	Long Aaa	.5267	.1666	117	20 Prime	.5754	Long Aaa	.4684	.1688	108
	(10.10)		(3.73)				(8.43)		(3.47)		
10 Prime	.6083	10 yr. Aa	.2919	.1032	45	10 Prime	.6212	10 yr. Aaa	.2321	.1051	45
	(8.24)		(2.20)				(8.43)		(2.16)		
30 Good	.4836	Long Aa	.5529	.1678	117	30 Good	.5103	Long Aa	.5536	.1785	117
	(9.14)		(3.92)				(7.68)		(3.78)		
20 Good	.5471	Long Aa	.4259	.1680	117	20 Good	.6079	Long Aa	.4157	.1756	117
	(10.5)		(3.32)				(9.37)		(3.14)		
10 Good	.5423	10 yr. Aa	.3736	.1352	81	10 Good	.6006	10 yr. Aa	.4205	.1377	81
	(11.5)		(3.27)				(11.0)		(3.40)		
30 Medium	.4459	Long A	.5002	.2116	117	30 Medium	.4332	Long A	.5224	.2028	117
	(7.08)		(3.61)				(5.63)		(3.87)		
20 Medium	.4875	Long A	.4037	.1959	117	20 Medium	.4985	Long A	.4668	.1768	117
	(8.56)		(3.23)				(7.52)		(3.69)		
10 Medium	.5267	10 yr. A	.3995	.1626	103	10 Medium	.5719	10 yr. A	.4819	.1637	103
	(11.2)		(3.22)				(10.5)		(3.46)		

[a] All parentheses contain t-statistics.

N = the number of monthly observations, ending in September 1979.

The interest rates are in basis points. (e.g., a 10 percent rate is 10.00).

Table III

Analysis of Random Intercept

	Utility				Industrial			
	I[a]	Mean	Std. Dev.	Median	I[a]	Mean	Std. Dev.	Median
30 Prime	0/117	1.433	.295	1.366	0/108	1.833	.301	1.775
20 Prime	56/117	.768	.272	.719	47/108	.865	.248	.849
10 Prime	43/45	−.208	.186	−.226	44/45	−.241	.176	−.283
30 Good	0/117	1.754	.310	1.685	0/117	1.701	.325	1.624
20 Good	33/117	.954	.290	.949	83/117	.632	.290	.647
10 Good	46/81	.666	.152	.684	74/81	.319	.160	.325
30 Medium	0/117	2.575	.421	2.139	0/117	2.531	.412	2.448
20 Medium	0/117	1.648	.345	1.571	0/117	1.686	.314	1.616
10 Medium	29/103	.782	.249	.764	64/103	.522	.284	.540

[a] The number of coefficients insignificantly different from zero (.05 level) out of the total number of coefficients estimated.

table reports for each equation the number of estimated coefficients out of the total number estimated which are insignificantly different from zero at the .05 level. The table shows that as term to maturity falls, the number of insignificant coefficients rises and the average size falls whether measured by the mean or median. For only two equations, 20-year prime on Aaa utility and 20-year good on Aa industrial, is the value of "I" above the number for the 10 year coefficients. As discussed in Section II, this was not true of all tax-exempts/taxable interest rate ratios and these findings support the risk premium hypothesis which predicts that the ratings bias will increase as maturity increases. Furthermore, note that as the rating of each pair of interest rates falls from prime to medium, the average size of the coefficients rises in every case and the number of insignificant intercepts tends to decrease, which is also consistent with the interpretation of the intercept as a risk premium.[16] Finally, when the ratios are plotted over time the distance between the twenty- and ten-year ratios are quite volatile with some ten-year ratios being larger. Yet, the sample paths of the intercept from the twenty-year equations maintains a stable distance above the ten-year sample paths. This is again consistent with the risk premium hypothesis which does not support a volatile relationship between intercepts, e.g., an increase in the intercepts of thirty-year rates in the same month that intercepts of ten-year rates fall.

Relative Demand and Supply Tests

While the results are consistent with the explanation that risk premiums are higher for municipals than corporates of the same rating, the ranking of the intercept coefficients across maturity is also consistent with the institutional demand theory. Recall that when corporate taxpayers (such as banks or property insurance companies) decrease their purchases of tax-exempts, the institutional demand hypothesis predicts that R_m/R_T should rise to entice taxpayers in lower

[16] The negative average for the 10 year prime equation along with the high number of insignificant coefficients indicates that the differential risk premium is virtually nonexistent for these rates.

marginal tax brackets into the market. In this model with a fixed slope, this implies that the intercept would rise. The movement of the sample paths could be due to corporate taxpayers decreasing their purchases of tax-exempts in poor economic times when profits are low and increasing purchases in good economic times. The sample paths do exhibit a countercyclical movement, generally rising in recessionary periods and falling during expansions, but this would also be expected if the coefficients represented risk-premia.

To test that the intercept is not representing movements in demand or supply, the following are added as independent variables:

Name	Definition	Expected Sign
X_1	Household purchases of tax-exempts as a percentage of tax-exempt sales	positive
X_2	Commercial bank demand as a percentage of tax-exempts sales	negative
X_3	Bank plus property insurance company demand as a percentage of tax-exempt sales (i.e., $X_3 = X_1 + X_2$)	negative
X_4	Long-term tax-exempt sales as a percentage of long-term corporate bond sales	positive
X_5	Long-term tax-exempt sales as a percentage of total long-term bond sales	positive

The expected signs for the demand variables are discussed above, while any change in supply is expected to have a direct (positive) impact on tax-exempt rates.

If the hypothesis is true that the intercept represents a differential risk premium, the new variables should not alter the properties of the sample paths discussed above and gamma should still be significant. Furthermore, the additional variables will test the two competing theories, since the Miller hypothesis holds that firms have an incentive to offset any disturbance in the 52 percent relationship. Thus, if the variables are significant with the correct sign, the Miller hypothesis may be rejected. It should be emphasized that as discussed above, the institutional demand theory usually assumes that the supply of tax-exempts is interest inelastic; consequently, it is the demand variables which have the most potential for distinguishing between the two competing theories.

The data were collected from the *Flow of Funds Accounts* of Federal Reserve. Unfortunately, the Federal Reserve does not report the supply and demand data by maturity and rating so that the data were the same for each equation. Nevertheless, the data are apparently the best available.[17] The variables listed above were run individually with a corporate interest rate as follows:

$$R_{mt} = \lambda_t + \beta_1 R_t + \beta_2 X_{jt}$$
$$t = 1, \cdots, N$$
$$j = 1, \cdots, 5 \tag{8}$$

[17] See Van Horne [16] for a description of these data along with a list of studies which have used the flow of funds accounts for supply and demand data (such as Hendershott and Koch [10]).

where R_{mt}, R_t is the same as in Equation (4), and X_{jt} is a relative demand or supply variable at time t.

As predicted by both theories, none of the relative supply variables were significant. Furthermore, the demand variable representing commercial bank plus property insurance company demand was also not significant and frequently had the wrong sign. Table IV reports the coefficients along with the estimate of gamma for the X_1 and X_2 variables. Every *pair* of coefficients (the demand variable and gamma) is the result of estimating Equation (8) with one demand variable. The four coefficients for "30 prime" represent two separate equations. The table shows that while the coefficients in equations using the longer term rates have the correct sign, only two are significant: X_2 when combined with Aaa Industrial's explaining the 30-year prime municipal rate and X_1 with Aaa Industrial's explaining the 20-year prime rate. The coefficients on equations using 10 year rates are never significant and frequently have the wrong sign. Furthermore, the estimates of the slope coefficients (not shown) are never significantly different from 52 percent.

While these results provide little support for the institutional demand theory, the size of the estimates of gamma along with the t-statistics provides additional support for the risk-premium hypothesis. In every equation using 20- and 30-year rates, where the demand coefficients are strongest, the estimate of gamma is larger than the estimate without the demand variable, shown in Table II. It appears that the X_1 and X_2 variables reduce the "transient" component of the intercept and do not capture the variation of the "permanent" component. This means that when significant, the demand variables do not represent the same factors as the intercept. This provides more support for interpretation of the intercept as a risk premium.

Model Specification Test

While the relative demand tests provide evidence against the institutional demand hypothesis, it is possible that the level of aggregation of these variables masks the influence of corporate taxpayers. Since no data could be obtained breaking down bank and household demand by rating and maturity, a different test of the two theories was constructed. The Miller hypothesis predicts that firms will find it profitable to offset any deviation of the marginal tax rate from 48 percent; this contrasts with the institutional demand hypothesis which predicts a volatile tax rate. Thus, a test of whether the tax rate is stable would distinguish between the two theories. However, in our model, this amounts to testing the stability of the slope parameter when it is assumed that there is stochastic variation in the intercept. If such a test showed stability, it could simply be argued that the variation predicted by the institutional demand theory was captured by the random intercept. Yet, if both the slope and intercept are assumed random, the covariance matrix must be known a priori. The solution to this dilemma is to estimate the model with a random slope and fixed intercept and compare the results with the random intercept and fixed slope to determine which formulation better represents the data. If the data supports the random slope model, this will clearly be evidence against the Miller hypothesis.

Table IV

Relative Demand Tests[a]

	Municipals on Utilities					Municipals on Industrials			
	X_1	Gamma	X_2	Gamma		X_1	Gamma	X_2	Gamma
30 Prime	.0909	.6745	−.1117	.6649	30 Prime	.1116	.6120	−.1692[b]	.6053
	(1.31)	(4.40)	(−1.33)	(4.38)		(1.54)	(4.22)	(−1.76)	(4.16)
20 Prime	.1008	.5998	−.0822	.5744	20 Prime	.1229[b]	.5320	−.1401	.5134
	(1.43)	(4.01)	(.96)	(3.81)		(1.70)	(3.60)	(−1.45)	(3.49)
10 Prime	.1538	.2826	−.0544	.2929	10 Prime	.1537	.2380	−.0535	.2316
	(1.48)	(2.10)	(−.61)	(2.12)		(1.48)	(2.05)	(−.60)	(2.19)
30 Good	.0833	.6067	−.1183	.5989	30 Good	.1030	.6126	−.1429	.6024
	(1.12)	(4.12)	(−1.42)	(4.02)		(1.40)	(3.91)	(−1.62)	(3.87)
20 Good	.0685	.4652	−.0853	.4550	20 Good	.0876	.4597	−.1135	.4466
	(.99)	(3.32)	(−1.03)	(3.28)		(1.23)	(3.15)	(−1.33)	(3.06)
10 Good	−.0489	.4503	.0443	.4554	10 Good	−.0105	.4306	.0208	.4300
	(−.67)	(3.60)	(.50)	(3.65)		(.15)	(3.60)	(.24)	(3.60)
30 Medium	.1139	.5282	−.1192	.5213	30 Medium	.1317	.5334	−.1447	.5328
	(1.35)	(3.75)	(−1.16)	(3.60)		(1.56)	(4.03)	(1.28)	(3.87)
20 Medium	.0582	.4217	−.0977	.4157	20 Medium	.0645	.4827	−.1021	.4834
	(.75)	(3.18)	(−1.05)	(3.12)		(.87)	(3.69)	(−1.03)	(3.62)
10 Medium	−.1108	.3653	.1397	.3843	10 Medium	−.0495	.4703	.1209	.4691
	(1.55)	(3.13)	(1.44)	(3.34)		(−.70)	(3.40)	(1.05)	(3.50)

[a] Each pair of demand variable and gamma coefficients represents *one* equation.
All parentheses contain t-statistics. X_1 represents commercial bank demand and X_2 represents household demand.
[b] Demand variable is significant at .05 level ($t = 1.645$).

Table V

Posterior Odds Test

	Municipal on Utility		Municipal on Industrial	
	Intercept Model	Slope Model	Intercept Model	Slope Model
30 Prime	.949	.051	.823	.177
20 Prime	.971	.029	.852	.148
10 Prime	.018	.982	.401	.599
30 Good	.899	.101	.890	.110
20 Good	.846	.154	.837	.162
10 Good	.286	.714	.563	.437
30 Medium	.999	.001	.973	.027
20 Medium	.942	.058	.980	.020
10 Medium	.981	.019	.998	.002

To accomplish this test, both models were estimated using a Bayesian approach and a number proportional to the posterior odds was computed. It was assumed that each model is equally likely (prior odds of ½) and the posterior odds were compared. The results are shown in Table V. The table reports the comparative posterior odds associated with each model specification based on the number computed. If, for example, the number is 19 times larger for the random slope model, the table would list .95 for the random slope and .05 for the random intercept.[18]

The table shows that the random intercept model always has higher odds than the random slope model when long term rates are employed. For the ten-year rates, the random slope model has much higher odds when prime rates are used, the random intercept has much larger odds when medium grade rates are used, and the results for good grades are mixed. In view of the previous results and the theory underlying the risk-premium hypothesis, it was expected that the odds would not be clear-cut for the ten-year rates, and this is certainly the case. Nevertheless, it does appear that for the long-term rates, the odds are consistently in favor of the random-intercept model. Thus, these results provide little support for the institutional demand hypothesis.[19]

IV. Summary and Conclusions

The purpose of this paper is to employ commonly used data to test the predictions of the Miller hypothesis against the institutional-demand hypothesis. It was

[18] Cooley-Prescott [2] discuss the Bayesian approach to estimation of the model with diffuse priors used here. Zellner [18], pp. 291–317 discusses the computation of posterior probabilities and their use in comparing regression models.

[19] As Zellner [18] observes, there is an unavoidable degree of arbitrariness in the interpretation of such probabilities. If one decides that a model is appropriate if its posterior odds are .95 (i.e., 19 to 1), then one may always ask why .98 (i.e., 49 to 1) was not used. Certainly some of the numbers in Table V such as .823 provide, at best, modest support for the random intercept model. Yet, taken as a whole, the numbers appear to support the Miller hypothesis. It is worth noting that the same degree of arbitrariness arises in the choice of significance level in classical hypothesis testing.

argued in the paper that municipal interest rates are more risky than corporate interest rates of the same rating, implying the municipals have a differential risk premium. It was found that when a random intercept model was used to adjust for the effect of this risk-premium, the estimated marginal tax rate between tax-exempts and taxables was not significantly different from Miller's predicted 48 percent. Furthermore, the sample paths of the estimated intercepts were, on average, larger the greater the maturity and the lower the rating of the bond, supporting the interpretation of the intercept as a risk-premium. In fact, the ranking by maturity was the case for every observation. Similarly, the gamma parameter, which measures the extent to which the intercept explained variation in dependent variable, also ranked by maturity. The two competing hypotheses were further tested first by employing relative demand variables and second, by determining whether a random slope or random intercept model better explained the data. It was found that in all but two cases the demand variables were insignificant and the odds were consistently in favor of the random intercept model for the longer term rates.

It should be emphasized that these tests are not a pure test of Miller's capital structure proposition that in equilibrium a firm's debt equity ratio is irrelevant. There are other forces maintaining the marginal tax rate at 48 percent and even if supply adjustments by firms is the only reason for a 48 percent tax rate, it is still possible that leverage is relevant. For example, the incomplete markets model of Taggert [15] results in a 48 percent tax rate but shareholders are not indifferent to leverage because of a breakdown in shareholder unanimity. Furthermore, there may be tax advantages to corporate debt even in equilibrium if the personal tax rate on income from stocks is positive (See Kim [11]). Nevertheless, it is clear that unadjusted ratios of tax-exempt to taxable interest rates cannot be used to reject the Miller hypothesis. The results provide support for the hypothesis that risk causes systematic differences in municipal and corporate interest rates of the same rating and maturity. When these differences are accounted for, the data behave in accordance with Miller's predictions that the tax rate is stable and unaffected by demand or supply.

REFERENCES

1. T. Cook and P. H. Hendershott. "The Impact of Taxes, Risk and Relative Security Supplies on the Spread Between the Yields on Corporate and U.S. Bonds." *Journal of Finance* 33 (September 1978), 932–53.
2. T. Cooley and E. Prescott. "Estimation in the Presence of Stochastic Parameter Variation." *Econometrica* 44 (January 1976), 167–84.
3. H. DeAngelo and R. Masulis. "Optimal Capital Structure Under Corporate and Personal Taxation." *Journal of Financial Economics* 8 (March 1980), 5–29.
4. E. F. Fama. "A Pricing Model for the Municipal Bond Market," Unpublished Working Paper, University of Chicago, March 1977.
5. P. Fortune. "The Impact of Taxable Municipal Bonds: Policy Simulations with a Large Econometric Model." *National Tax Journal* (March 1973), pp. 3-31.
6. H. Galper and J. Peterson. "An Analysis of Subsidy Plans to Support State and Local Borrowing." *National Tax Journal* (June 1971), pp. 344–67.
7. C. Haley, R. Higgins, and C. Howard. "Tax Arbitrage and Commercial Bank Demand for Municipal Securities." Unpublished Working Paper, June 1979.

8. G. Hempel. "An Evaluation of Municipal Bankruptcy Laws and Proceedings." *Journal of Finance* 27 (December 1972), 1012–29.
9. P. H. Hendershott and T. Koch. "An Empirical Analysis of the Market for Tax-Exempt Securities: Estimates and Forecasts." *Monograph Series in Finance and Economics*, New York University, 1977.
10. R. Kimbal. "Commercial Banks, Tax-Avoidance and the Market for State and Local Debt." *New England Economics Review* (January/February 1977), pp. 80–97.
11. E. Han Kim. "Miller Equilibrium Shareholder Leverage Clienteles and Optimal Capital Structure." Forthcoming: *Journal of Finance.*
12. M. Miller. "Debt and Taxes," *Journal of Finance* 32 (May 1977), 261–75.
13. T. Moore. "Corporate Borrowing for Investment in Equity Securities: Tax Advantages via the Interest Deduction and Dividends Received Deductions." *Vanderbilt Law Review* 33, 1423–50.
14. P. A. Samuelson. "Proof that Properly Anticipated Prices Fluctuate Randomly." *Industrial Management Review* (Spring 1965), pp. 136–51.
15. R. Taggert. "Taxes and Corporate Capital Structure in an Incomplete Market." *Journal of Finance* 35 (June 1980), 645–60.
16. J. Van Horne. *Financial Market Rates and Flows.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1978.
17. J. Yawitz. "Risk Premia on Municipal Bonds." *Journal of Financial and Quantitative Analysis* (September 1978), pp. 773–90.
18. A. Zellner. *An Introduction to Bayesian Econometrics.* New York: John Wiley, 1971.
19. J. Zimmerman. "The Municipal Accounting Maze: An Analysis of Political Incentives." *Journal of Accounting Research*, Supplement (1977), pp. 107–44.