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Interest Yields, Credit Ratings, and Economic Characteristics of State Bonds: An Empirical Analysis

A Note by Pu Liu and Anjan V. Thakor

1. Introduction

Empirical determination of the relationship between the ratings, economic indicators, and yields of municipal debt has long been a subject of interest. Carleton and

Lerner (1969), Copeland and Ingram (1982), Geis (1972), Hopewell and Kaufman (1977), Horton (1970), and Ingram, Brooks, and Copeland (1983) are among those who have studied the issue.

An important motivation for research in this area stems from the "need" to ascertain *how much* effect ratings *by themselves* have on yields. Prominent city and state administrators have traditionally displayed great sensitivity to their bonds' ratings. This sensitivity is exemplified in the attitude of New York City's Comptroller Abraham Beame, who claimed that the seven years in the late 1960s during which the city languished as a "Baa" credit resulted in $150 million additional "unnecessary" and "unfair" interest costs to the city. Policy debates on the regulation of capital markets would, therefore, be well served by an enhanced understanding of the link between ratings and yields. Unfortunately, few "clean" empirical tests have been performed. The problem is obvious. A state bond's yield is likely to depend on its rating as well as the state's economic characteristics. But the rating itself is related to these characteristics. Thus, a multivariate regression with yield as the dependent variable and the rating and economic factors as independent variables can be expected to encounter serious multicollinearity problems.

Yields are likely to depend on ratings independently of the issue's economic characteristics because the raison d'être for ratings is that they contain information unavailable publicly; that is, information that can only be obtained through costly search and processing. Thus, bond ratings can be viewed as screening mechanisms à la Stiglitz (1975), and an issuer's purchase of ratings for a fee can be considered an attempt to distinguish its issue from others of inferior quality, thereby avoiding the "average quality pricing" described by Akerlof (1970).

In this paper we define and statistically estimate an interactive model that circumvents this difficulty. We have three principal findings. First, four economic variables—total net direct debt, per capita debt, unemployment rate, and median home value—can explain much of the variation in ratings. Second, the first three of these four variables in conjunction with ratings have a significant effect on yields. Third, we cannot reject the hypothesis that credit ratings have a statistically significant independent effect (over and above that attributable to a common reliance of ratings and yields on the state's economic characteristics) on yields.

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2. *The Model*

Suppose the credit rating of a state bond is a function of some economic variables associated with the issuing state. Assume further that the interest yield for that bond depends on the rating as well as the same economic variables that determine the rating. If there are m economic variables and n state bonds, the equations for the model in matrix notation are

$$R = \lambda \mathbf{1} + Z\pi + \xi \tag{1}$$

$$Y = \alpha \mathbf{1} + \sigma R + Z\beta + \varepsilon , \tag{2}$$

where R is an n dimensional column vector of ratings, λ and α are scalar constant intercepts, $\mathbf{1}$ is an n dimensional column vector of ones, Z is an $n \times m$ matrix of economic variables, π and β are m dimensional column vectors of regression coefficients, ξ and ε are n dimensional column vectors of stochastic error terms, Y is an n dimensional column vector of yields, and σ is a scalar regression coefficient.

If this system is correctly identified, (2) cannot be used directly due to the high standard errors induced by the multicollinearity caused by the dependence of ratings on economic and demographic variables. If the equations are cast in reduced form with the yield expressed as a function of the economic and demographic variables alone, it seems impossible to estimate the original regression coefficients in (2).

By employing a two-stage estimation, however, we can salvage the necessary estimates of the regression coefficients and correctly identify the significant variables. In the first stage, we estimate (1) to identify the relationship between bond ratings and economic variables. This provides estimates of the coefficients, λ and π, and the vector of residual terms, ξ, denoted $\hat{\lambda}$, $\hat{\pi}$, and $\hat{\xi}$, respectively. By definition, if $\hat{R}$ is the estimated rating and R the actual rating, then

$$\hat{\xi} \equiv R - \hat{R} = R - [\hat{\lambda}\mathbf{1} + Z\hat{\pi}] . \tag{3}$$

Further, since $\hat{\xi}$ is orthogonal to the regressor matrix Z, we have

$$Z'\hat{\xi} = \mathbf{0} , \tag{4}$$

where Z' is the transpose of Z and $\mathbf{0}$ is a column vector of m zeros.

In the second stage, we estimate the following regression equation:

$$Y = \gamma \mathbf{1} + Z\delta + \hat{\xi}\eta + \theta , \tag{5}$$

where γ is a (scalar) constant intercept, δ is an m dimensional column vector of regression coefficients, η is a (scalar) regression coefficient, and θ is an n dimensional column vector of residual (error) terms. Equation (5) performs two functions. First, it avoids the multicollinearity problem of (2), because of the orthogonality of regressors Z and $\hat{\xi}$. Second, it ascertains the incremental impact of ratings on yields, over and above any effect due to differences in economic characteristics; that is, η, the regression coefficient associated with $\hat{\xi}$ in (5), represents the effect of a "unit" change in the rating on the interest yield. If η is statistically different from zero, we cannot reject the conclusion that ratings convey pertinent information to investors in addition to what they can deduce from publicly available data. The dependence of R on Z negates the possibility of directly estimating either η or $\delta\text{-}\pi\eta$. Hence, we will use (5) to estimate γ, δ, and η. When combined with the $\hat{\lambda}$, $\hat{\pi}$, and $\hat{\xi}$ obtained from the first stage, these estimates will enable us to compute all the regression coefficients of relevance.[1]

3. *Choice of Variables*

An important element of the estimation is identifying those economic variables likely to affect yields and ratings. Bond ratings are commonly interpreted as reflecting the ability of the issuing unit to meet its debt repayment obligations. A measure of this repayment ability in the case of general obligation bonds is the net revenue (tax receipts minus the cash flow needed to service *existing* debt) generation capability of the state. Two principal factors determine this capability—the sources the state has to produce tax revenues, and the volume of its existing debt.

Four variables are chosen to represent the state's existing debt liability. These are (1) the total net direct debt burden of the state in billions of dollars (Z_1), (2) the ratio of net direct debt to estimated full valuation in percentage (Z_2),[2] (3) the ratio of net direct debt to total personal income in percentage (Z_3), and (4) the per capita debt in thousands of dollars (Z_4). Six variables are selected to represent the state's tax revenue sources. These variables are of two types. One type deals with population and unemployment figures. These variables are important because the *potential* a state has to produce revenues is predicated upon how many people reside in the state, how many of them are employed, and what the recent trends in population have been. The variables we have chosen are percentage unemployment rate as of December 1975 (Z_5), total estimated population in 1975 in millions (Z_6), and percentage population change between 1970 and 1975 (Z_7). The second type of variable is concerned with the wealth of the population. The wealthier the population, the

[1]Since multicollinearity increases the standard errors of the estimates but does not bias these estimates, we should expect our two-step process to produce the same values for the regression coefficients as (2). But a direct estimation of (2) is likely to label as insignificant variables that may be significant. Thus, estimating via a two-stage procedure is needed to *correctly* identify the significant independent variables. A possible alternative to our approach is to employ a ridge regression.

[2]Net direct debt is defined as the gross debt of the state net of the debt issued for or on behalf of the agencies of the state, and estimated full valuation is defined as the total assessed taxable property value in the state.

greater is the potential for producing higher tax revenues. Since states can levy both property and income taxes, we have chosen variables that capture both property values and family income. The three chosen variables are median family income in thousands of dollars (Z_8), median home value in thousands of dollars (Z_9), and per capita personal income in thousands of dollars (Z_{10}).

Clearly, this list is not exhaustive.[3] The quality of a state's government, its expenditure patterns, the productivity of its working class, and other tangible and intangible factors will affect its creditworthiness. We are, however, hampered by the availability of good data.

4. *Empirical Results*

To estimate the necessary equations, economic data of twenty-eight states were used. Market interest yield figures were obtained from Standard and Poor's Blue List of Current Municipal Offerings as of February 1977. To ensure comparability, all the bonds selected were general obligation bonds that matured within two years of 1990.[4]

Since credit ratings are ordinal scales represented by letters, it was necessary to convert them into numerical values. To do this, we spread the numerical values of the ratings in accordance with a proxy for the risk differential between ratings. We thus assigned each rating a value proportional to the mean interest rate for that class, with a zero value for Baa (although none of the bonds in our sample had that rating) and progressively higher values for higher ratings.[5] To confirm our conjecture about multicollinearity, we estimated (2) and found that the contribution of the rating to the R^2 dominated that of any of the other variables. Moreover, none of the variables was significant at the 10 percent level.

Of course, this is not conclusive evidence that multicollinearity is caused solely by the dependence of ratings on economic variables. It may well be due to the economic variables being correlated with one another. To examine this possibility, we computed the correlation coefficient matrix for the ten economic variables and abandoned those variables that displayed pairwise correlation coefficients in excess of 60 percent with the other variables. Only four variables—Z_1, Z_4, Z_5, and

[3]Our choice of variables is consistent, though, with the prescriptions in the literature as well as the beliefs of "practitioners" like banks. See Carleton and Lerner (1969), Hempel (1967), and Margolis and Grossman (1970). Also see "Competitive Analysis of State Credits: A Guide for Municipal Bond Investors," prepared by Continental Illinois National Bank and Trust Company of Chicago (July 1976), which is the source of the data used in this study.

[4]The Blue List shows offering yields, not transaction yields. This is not ideal. We are, unfortunately, severely constrained by data limitations. Ingram et al. (1983) have, like us, also used offering yields to maturity. They performed a test of conformity between offering and transaction yields and found a strong correspondence for municipal revenue bonds. This seems to indicate that offering yields are effective proxies, but does not constitute irrefutable evidence that our use of offering yields will not distort the findings. Note also that in the case of multiple offerings of the same bond, the yield used by us was the mode.

[5]The results reported in this paper are based on the following numerical values for the ratings: Baa = 0, A = 2.83, Al = 2.88, Aa = 3.54, and Aaa = 3.76. *Source:* Moody's Bond Record, Moody's Investor Service, 1977. Moody's considers Aaa bonds to be of the "best quality," Aa bonds to be of "high quality by all standards," A bonds to be "upper medium grade," and Baa bonds as "medium grade." It also assigns ratings Ba through C for bonds which rank from "speculative" to "extremely poor."

TABLE 1

SUMMARY OF ESTIMATION OF REGRESSION EQUATION (2)

		t Test		F Test for Overall Regression		Haitovsky Test	
Variable	Regression Coefficient	t Value	Significance	F Value	Significance	χ^2	Significance
Rating	−0.9017	−2.2820	2.5%				
Z_1	0.0289	0.4402	*				
Z_4	−0.0437	−0.1069	*	6.689	0.5%	2.65	*
Z_5	0.0150	0.3303	*				
Z_9	0.0077	−0.3850	*				

*Insignificant at the 5 percent level.

TABLE 2

SUMMARY OF ESTIMATION OF REGRESSION EQUATION (1)

Variable	Regression Coefficient	Significance	Overall F	Significance	R^2
Z_1	−0.1199	0.5%			
Z_4	−0.9176	0.05%			
Z_5	−0.0637	0.5%	14.279	0.5%	0.80
Z_6	0.0000	*			
Z_7	0.0049	*			
Z_9	0.0303	0.5%			

*Insignificant at the 5 percent level.

Z_9—were found to survive. Equation (2) was then reestimated using ratings with these four variables. Table 1 summarizes the results. It is apparent from the Haitovsky test that there is still a major multicollinearity problem.[6]

The parameters of (1) were estimated next. Two clusters were found such that the variables within each cluster were highly correlated with one another. One cluster had Z_2, Z_3, and Z_4, and the other cluster had Z_8, Z_9, and Z_{10}.[7] Z_4 and Z_9 were chosen from the clusters because, when combined with variables outside the clusters, they provided the largest number of significant coefficients and the best combination of statistical significance and R^2 for the overall regression equation. Our estimation of (1) is presented in Table 2. All the variables with significant coefficients enter the regression equation with the expected signs. Also, the F values are high and these variables explain nearly 80 percent of the fluctuations in ratings.

Since Z_6 and Z_7 have regression coefficients that are not significantly different from zero, they can be dropped without materially affecting the predictive power of the regression equation. Table 3 summarizes this estimation. All the variables have signs that agree with our priors, and the t values of the individual regression coefficients as well as the overall F value are highly significant. Moreover, dropping Z_6 and Z_7 has a negligible impact on the explanatory power of the regression

[6]The Haitovsky test is a measure of the severity of multicollinearity. It measures, with a chi-square statistic, the extent of the failure of the $X'X$ matrix (where X is the matrix of independent variables) to depart from singularity. See Haitovsky (1969).

[7]Variables outside these clusters did not present a serious multicollinearity problem. So, by choosing only one variable to represent each cluster, the multicollinearity problem can be alleviated without reducing the explanatory power (R^2) of the equation.

TABLE 3

SUMMARY OF REGRESSION EQUATION (1) WITH ONLY SIGNIFICANT VARIABLES

Variable	Regression Coefficient	Significance	Overall F	Significance	R^2
Z_1	−0.1259	0.05%			
Z_4	−0.8509	0.05%	22.745	0.5%	0.80
Z_5	−0.0675	0.5%			
Z_9	0.0298	0.5%			

TABLE 4

SUMMARY OF REGRESSION EQUATION (5)

Variable	Regression Coefficient	Significance	Overall F	Overall Significance	R^2
Z_1	0.1425	0.5%			
Z_4	0.7236	0.5%			
Z_5	0.0758	5%	6.689	0.5%	0.60
Z_9	−0.0192	**			
$\hat{\xi}$	−0.9017	2.5%			

**Insignificant at the 10 percent level.

equation. A substantial portion of the fluctuations in ratings can be explained by only four variables.

The next step was to run a regression using (5) to identify the relationship between yields, economic variables, and $\hat{\xi}$ and to obtain estimates for δ and η. The same four variables that contributed significantly to credit ratings were used for this estimation.[8] Again, all the variables enter the regression equation with economically sensible signs. Table 4 summarizes the statistical findings.

The overall F values are high for both regressions, and four economic variables in conjunction with the rating ($\hat{\xi}$) explain up to 60 percent of yield differentials. Interestingly, although a state's median home value is statistically significant (at the 0.5 percent level) in explaining ratings, it is not significant in explaining differences in yields. This means that the market reinterprets information that the rating agencies consider of value. Further, the regression coefficient η is statistically significant in explaining yields. These findings have two messages. First, ratings do seem to have a significant *separable* impact on yields.[9] Second, the market is not guided solely by ratings. It also makes its own independent discrimination among borrowers of different risk characteristics.

Using Table 4 we can now quantify the independent impact of ratings on yields. This impact, represented by $\hat{\eta}$, is −0.9017. Table 4 also shows that this regression coefficient is statistically significant.

[8]We regressed the yield against $\hat{\xi}$ and Z_1, Z_4, Z_5, Z_6, Z_7, and Z_9, which were the variables that remained after the highly correlated economic variables were eliminated, and found that all the variables that were unimportant for estimating ratings were also unimportant for estimating yields.

[9]We cannot be sure we have included *every* economic variable affecting yields. If there are important variables omitted, the rating variable will pick up the unexplained effect. This *could* lead us to conclude that ratings have an independent effect on yields when they do not. Thus, our findings only permit us to *not* reject the hypothesis that ratings independently affect yields.

5. *Conclusion*

We have proposed and tested a method for evaluating the independent impact of ratings on yields. Our approach should be of direct use to future studies with similar objectives. From a policy standpoint, our research suggests that the sensitivity of state administrators to their bond ratings may not be unjustified. Our study also recommends that administrators interested in lowering borrowing costs should focus on reducing existing indebtedness and unemployment. And if the objective is to improve the bond rating, property values should be an additional cause for concern.

Data for this paper are available from the JMCB *editorial office.*

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