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Do Credit Markets Discipline Sovereign Borrowers? Evidence from U.S. States

THERE HAS BEEN CONSIDERABLE theoretical interest in describing how rational lenders may respond to imperfect information by rationing credit to borrowers.[1] Much of this literature identifies the resulting credit constraints with a market failure (see, in particular, Jaffee and Russell 1976). Recently, however, it has been argued that default premia and credit constraints can play a more positive role in disciplining irresponsible, sovereign borrowers.

This more optimistic view of the effects of credit constraints has been called the market discipline hypothesis, and this hypothesis has played a key role in the debate on the most effective way to restrain fiscal policy adventurism in a European Monetary Union (Bishop, Damrau, and Miller 1989). An important aspect of the market discipline hypothesis is an assumed nonlinear relationship between yields and debt variables. In particular, the advocates of market discipline assume that yields will rise smoothly at an increasing rate with the level of borrowing, thereby providing the borrower with an incentive to restrain excessive borrowing. If these incentives, however, prove ineffective, the credit markets will eventually respond by denying the irresponsible borrower further access to credit, and the irresponsible borrower will be credit constrained.

This paper draws on a unique set of survey data on municipal bond yields for U.S. states to shed light on the theory of credit constraints in general and, in particu-

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1. For example, Jaffee and Russell (1976), Stiglitz and Weiss (1981), and Eaton and Gersovitz (1981).

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lar, to test the market discipline hypothesis by identifying the nonlinear supply curve faced by risky sovereign borrowers.

The next section of this paper provides a more detailed discussion of the market discipline hypothesis and of the debate on the appropriate mechanism for reining in irresponsible fiscal policy behavior in a European Monetary Union. The second section develops a simple theory of lending to sovereign borrowers, while the third section discusses the empirical specification of the model and describes a previously unused data source, which we believe is uniquely well suited for measuring default premia in the yield spreads of U.S. state general obligation bonds. The fourth section presents our results, and the final section provides our conclusions. To anticipate our results, we find strong support for a nonlinear specification of the supply curve, which is consistent with the market discipline hypothesis. Our point estimates imply that at the mean level of debt in our sample the promised yield rises by about 23 basis points per percentage point of trend output increase in debt. But at debt levels one standard deviation above the mean, the increase in yields rises to over 35 basis points, and our estimates imply credit may become rationed at debt levels about 25 percent above the highest debt level in our sample.

1. FISCAL COORDINATION AND EUROPEAN MONETARY UNIFICATION

It is widely accepted that participation in a currency union is inconsistent with independence in the conduct of monetary policy. Indeed, in the negotiations leading to the Maastricht Treaty on economic and monetary union (EMU) in Europe, much attention was devoted both to the establishment of a central monetary authority and to securing a mandate for that institution that would give primacy to the goal of price stability. In this sense, there would appear to be an emerging consensus about how to constrain or "discipline" monetary policy.

Less settled at this stage is what constraints, if any, should be placed on national fiscal policies in a currency union. At least three distinct approaches to disciplining fiscal policy have been put forward in the literature. One view, echoed in the Delors Report, is that binding fiscal rules represent the preferred solution to the problem. In this connection, the Maastricht Treaty includes ceilings on the ratios of government debt (60 percent) and the fiscal deficit to Gross Domestic Product (3 percent) as criteria for entry into European Economic and Monetary Union, as well as prohibitions on monetary financing and bailing out of budget deficits. A second approach (see European Commission 1990a, b) also calls for external constraints on national fiscal policies, but adopts a more discretionary format, namely, that peer group multilateral surveillance be employed to discourage errant fiscal policies of individual member countries. Yet a third route to fiscal discipline is to entrust private financial markets with that role. Such *market-based fiscal discipline* would initially take the form of a rising default premium on the debt of the country running excessive deficits; if these deficits persisted, the default premium would increase at an increasing rate until, eventually, the offending country would be denied access to additional credit. The increase in the cost of borrowing, along with the threat of reduced availability of credit, would then provide the incentive to correct irresponsible fiscal behavior.

Advocates of the market approach (Bishop, Damrau, and Miller 1989) recognize that it will work only if certain conditions are satisfied. Capital must be able to move freely; the market must be convinced both that there are no implicit or explicit outside guarantees on sovereign debt and that the borrower's debt will not be monetized; and the financial system must be strong enough to withstand the failure of a "large" borrower. They do not regard these conditions as unrealistically restrictive. Not surprisingly, those who favor the fiscal rules or surveillance options are less convinced, and point to the developing-country debt crisis of the early 1980s and to the New York City financial crisis of the mid-1970s as graphic illustrations of the limitations of the market's disciplining power.

A key question for the market discipline approach (assuming that the central bank can make a credible, no-bailout pledge) is: will credit markets impose sufficient default premia to restrain irresponsible borrowing? This paper uses data from the U.S. state bond market to provide relevant evidence on this question.

2. A THEORY OF CREDIT RATIONING

The Supply of Credit

The theory is developed in the simplest possible terms. It is assumed that all state bonds are sold on competitive financial markets to risk-neutral lenders and mature in one period. As a result, the expected after-tax return on state bonds must equal the equivalent, after-tax return on a safe security, say a Treasury bill. This condition can be expressed as

$$(1 + R + s)P(H) = (1 + R - \alpha\tau) \tag{1}$$

where s is the premium paid by the state over the risk-free rate, R. $P(H)$ is the probability of no default ($P' < 0$, $P(0) = 1$), where H measures the determinants of default, τ is the state and local tax income tax rate, and α is a parameter. The term $\alpha\tau$ is included to account for the disproportionately high demand for in-state bonds in states with high state income tax rates.[2] For simplicity, equation (1) implicitly assumes that in the case of default, the borrower repays nothing.

The idea behind $P(H)$ is that the state's income in the next period is unknown, but is drawn from a known distribution. The higher the value of H, the greater the probability that the state's income will be so low that it will default. The value of H can

2. See, for example, Kidwell, Koch, and Stock (1984). In most states, the interest from in-state municipal bonds is tax free, while the interest on out-of-state municipal bonds is subject to income taxation. τ measures the difference between the highest marginal income tax rate on the interest from out-of-state bonds relative to in-state municipal bonds.

be thought of as the maximum realization of state income that will lead to default, and $P(H)$ is the probability that state income will exceed this level.[3]

The shape of the supply curve depends on both the determinants of H and on the functional form of $P(H)$. If H depends upon the interest payments on the debt as well as the principal value of the debt, the supply curve must become backward bending. For example, if H is linear, the determinants of default can be written as

$$H = \mathbf{X}'\boldsymbol{\beta} + \pi B + \delta(R + s)B + \epsilon \tag{2}$$

where π and δ are nonnegative parameters, B is the quantity of outstanding debt, $\mathbf{X}$ is a vector of nondebt factors affecting the probability of default, $\boldsymbol{\beta}$ is a vector of parameters, and ϵ is an error term. The separate coefficients for the level of debt and for interest payments on debt reflect the fact that some of the outstanding debt has been issued in the past at fixed rates. Totally differentiating (1) with respect to B and s yields

$$ds/dB = -P'[\pi + \delta(R + s)](1 + R + s)/[P + P'\delta B(1 + R + s)] \, . \tag{3}$$

The numerator of (3) is nonnegative, so that the sign of the slope is determined by the sign of the denominator. Notice that when $B = 0$ (that is, there is no debt outstanding), the denominator is positive, and that as B approaches $-P/\delta P'(1 + R + s)$, the denominator approaches infinity, so that the slope of the supply curve becomes vertical at this level of debt, and this level of debt the borrower is credit constrained.

To convert the nonlinear supply curve into a form that can be estimated, we must make assumptions about the functional form of $P(H)$. A convenient specification is to assume that $P(H) = \exp(-H)$. Substituting into equation (1), and using the approximation that $\log(1 + x)$ is equal to x when x is small, yields the following equation:

$$s = [\mathbf{X}'\boldsymbol{\beta} + (\pi + \delta R)B - \alpha\tau]/(1 - \delta B) + \epsilon' \, . \tag{4}$$

Equation (4) is the basic estimating equation used in this paper.

This function provides an easy test for the presence of nonlinearities in the supply function. If the estimated coefficient on B in the denominator turns out to be zero, then the supply function is linear, implying that the bond market will accept any level of debt at a constantly increasing default premium. Alternatively, if the coefficient is greater than 0, the supply function is nonlinear with a maximum quantity supplied given by one over the estimated coefficient. Hence, the hypothesis of a linear supply curve is nested in the more general specification of (4).[4]

3. H depends on the state's preferences and the penalty for default, as in Eaton and Gersovitz (1981), Metcalf (1993), and Capeci (1994).

4. Equation (4) does have some disadvantages, namely: (1) For some states the value of H could be less than zero, implying a probability of no default greater than one; and (2) In principle, a state with no debt should have zero probability of default, but our estimates don't impose this restriction.

We also estimated an alternative nonlinear functional form, which assumes that the probability of default is given by a logistic function, $1/(1 + \exp(H))$, but where H depends only on the principal value of the debt, B, and not on interest payments.[5] The presence of the tax term complicates the specification, which we approximate by

$$s = \exp(\mathbf{X}'\boldsymbol{\beta} + \pi B - \alpha\tau + \epsilon) . \tag{5}$$

In this formulation, the relationship between the yield and the determinants of default is nonlinear, but the slope of the supply curve is always finite.

The Demand for Credit

The primary focus of this paper is on the supply of credit. Thus, we do not develop a formal model of maximizing state behavior to explain the states' demand for credit as in Metcalf (1993) and Capeci (1994). For our purposes, the demand for credit is important because of issues related to the identification of the supply curve. With rational state borrowers, the demand for state borrowing will be negatively related to the expected yield on state debt, which suggests that the level of borrowing and expected yields are simultaneously determined by both supply and demand. In addition, state borrowing is one aspect of the larger problem of the optimal size and financing of state government. Another aspect of the larger problem is the level of state taxes. Consequently, a state's choice of tax rates is determined by the same factors that affect borrowing, including the yield on state debt.

To illustrate the importance of these simultaneity issues consider a state which has idiosyncratic factors raising its probability of default, thereby raising the state's promised yield at any level of borrowing [that is, $\epsilon > 0$ in (2)]. The state will respond to this higher yield by switching from borrowing to current taxation. This source of variation imparts a simultaneity bias between yields, taxes, and borrowing. There is also a simultaneity issue raised by the state unemployment rate to the extent that some state-specific variation in unemployment may be correlated with unobservable variation in credit risk. The solution to these problems is to use an instrumental variable technique that uses only variations in borrowing and tax rates that reflect factors affecting the state's financing choices (that is, exogenous variables included in the demand curve, but not in the supply curve). The work of Capeci (1994) and Metcalf (1993) suggests that state demographic factors may be appropriate instruments.

3. THE ESTIMATING EQUATION AND DATA

Previous work by some of us (Goldstein and Woglom 1992) and the literature on the interest rates on state bonds (Liu and Thakor 1984) indicate that the probability of default is affected by cyclical factors and constitutional constraints on borrow-

5. This is the functional form used by Edwards (1986).

ing.[6] Consequently, in addition to state tax rates and the ratio of state debt to trend gross state product, the specification includes a measure of the strength of controls on state borrowing and the unemployment rate (lagged once since the fiscal year for state governments starts in the previous July, making the level of unemployment in the current year a leading variable). From equation (4), the estimating equation becomes

$$s_{it} = const + \delta_i * DUM_t + \frac{\alpha_1 * B_{it} + \alpha_3 * TAXRit + \alpha_4 * UN_{it-1} + \alpha_5 * FISC_i}{1 - \alpha_2 * B_{it}} + e_{it} \tag{6}$$

where DUM_t are annual dummy variables, B is the ratio of debt to gross state product, *TAXR* is the highest marginal state tax rate for states that tax in-state and out-of-state bonds differently, *UN* is the level of unemployment in state i lagged one period, and *FISC* is an index of the strength of constitutional controls on state borrowing. There are two coefficients associated with debt, α_1, which measures the level effect of debt on yields, and α_2, which measures the nonlinearity in the estimating equation caused by the interaction between yields and interest payments. In going from (4) to (6) we have assumed that $(\pi + \delta R)$ is equal across borrowers.

Data

The primary data needed to test for the existence of default premia on state debt are market yields on the "full faith and credit" obligations of the various state government—that is, state general obligation bonds, or GOs. This raises immediate problems because most of these bonds are not actively traded. Surprising as it may seem, information is not widely available on the market prices of individual state bonds.

Even if transaction price data were easily available, the comparability of different issues would still be a problem. In addition to default risk, state bond prices and yields are affected by other features that vary by issue. For example, a randomly selected issue of JP Morgan's *Municipal Market Monitor* (1989) lists the market yields based on closing bid prices on two Florida State Board of Education bonds. On August 24, 1989, the two market yields were 7.05 and 7.27 percent. The bonds were identical, except that the lower-yielding bond matured in 2013 as opposed to 2010, was callable at 100 in 1996 as opposed to 102, and bore a coupon of 5 percent instead of 7.25 percent. During the same week, the yield spread between AA and AAA twenty-year municipal bonds was reported by Delphis Hanover as 20 basis points. Thus, the yield spread caused by the special features of the two Florida State GOs was wider than the yield spread between two credit-rating categories.

6. Other work on the impact of fiscal controls has shown mixed results. Von Hagen (1992) finds no relationship between total state debt per capita and fiscal controls in a regression that uses no other explanatory variables. However, Eichengreen (1992), who includes other explanatory factors in his regressions, does find a significant relationship between fiscal controls and both debt and interest rates.

TABLE 1

CHUBB RELATIVE VALUE STUDY, DECEMBER 1989
(Basis Point Spread for twenty-year state GO, relative to a New Jersey Twenty-Year GO)

Ranking:	Moody's Rating	Avg. Response	Std. Dev.
1 California	Aaa	−14.04	3.84
2 North Carolina	Aaa	−11.91	4.32
3 Virginia	Aaa	−10.65	4.76
4 Connecticut	Aa1	−9.96	5.09
5 Missouri	Aaa	−8.30	5.28
6 South Carolina	Aaa	−6.74	5.58
7 Georgia	Aaa	−6.39	2.58
8 Maryland	Aaa	−4.65	3.51
9 Tennessee	Aaa	−4.09	5.80
10 New Jersey	Aaa	0.00	0.00
11 Ohio	Aa	1.39	3.41
12 Utah	Aaa	5.57	4.84
13 Maine	Aa1	7.00	4.95
14 Minnesota	Aa	8.13	3.79
15 Montana	Aa	8.39	5.25
16 Delaware	Aa	8.61	4.51
17 Kentucky	Aa	8.70	5.31
18 New Hampshire	Aa1	9.52	3.84
19 Rhode Island	Aa	10.26	3.58
20 Vermont	Aa	11.17	3.56
21 Alabama	Aa	12.09	3.83
22 Wisconsin	Aa	12.13	3.93
23 Pennsylvania	A1	12.91	4.83
24 Mississippi	Aa	13.39	4.49
25 Hawaii	Aa	13.87	3.83
26 Michigan	A1	14.04	4.84
27 New Mexico	Aa	14.48	3.59
28 Illinois	Aaa	14.48	4.67
29 Oregon	A1	16.57	3.59
30 Florida	Aa	17.26	4.11
31 Nevada	Aa	18.74	4.00
32 New York	A1	20.39	4.75
33 Oklahoma	Aa	21.61	7.29
34 Texas	Aa	22.74	5.93
35 North Dakota	Aa	22.83	10.11
36 Washington	A1	24.48	3.05
37 Alaska	Aa	27.39	7.49
38 West Virginia	A1	28.22	5.34
39 Puerto Rico	Baa1	48.09	6.99
40 Massachusetts	Baa1	62.39	11.50
41 Louisiana	Baa1	70.00	12.07

Fortunately, there is a data source, the Chubb Relative Value Study, that overcomes the comparability problem of state GO bonds. The Chubb Corporation, an insurance company, has conducted a semiannual survey of twenty to twenty-five (sell-side) municipal bond traders since 1973. The traders are asked to give the yields on five-, ten-, and twenty-year maturity GOs for thirty-nine states and Puerto Rico *relative* to the yield on a comparable New Jersey state GO.[7] The survey results for December 1989 are reproduced in Table 1. The survey results imply that, on

7. We did not use the data for Puerto Rico, Hawaii, or Alaska. We did not have access to Moody's debt data for Puerto Rico, and Hawaii and Alaska have unique fiscal structures.

average, traders felt that a California twenty-year GO should have a market yield 14 basis points below New Jersey's market yield, while a Louisiana twenty-year GO should bear a yield 70 basis points higher than New Jersey. Most important, for our purposes, the Relative Value Study implies that the yield spreads between California and Louisiana twenty-year GOs should be 84 basis points.

The Chubb survey instructions don't say anything about special features on the different bonds, but Chubb reports that there is an implicit understanding that the bonds being evaluated are comparable with regard to special features.[8] Hence, the difference in yield spreads will primarily reflect differences in default risk, although some of the variation may be due to varying liquidity premia. The movement in yield spreads is broadly consistent with varying default premia: the spreads vary over the course of the business cycle, and the spread for a particular state changes substantially over time, as state fortunes wax and wane. For example, during the recession year of 1982, the spread between the highest- and lowest-rated states of Oklahoma and Michigan was over 146 basis points; in contrast by 1990, the high-low spread had fallen by a factor of two and Michigan was a higher-rated state than Oklahoma.

Because the yield spreads are relative to the yield on the New Jersey bond, our raw data include both positive and negative values. The negative values present a problem when it comes to the logistic specifications of the supply curve. To get around this problem, we subtracted the lowest value of the spread for each year from the raw data. This assumes that the yield on the bond with the lowest spread was the same as the after-tax risk free rate. If this assumption is invalid, it introduces an additional error term that is constant for all states in a given year. We deal with this problem by including annual dummies in our empirical specification.

The other major data requirement is a measure of state indebtedness. For this purpose, we used data on net, tax-supported debt as reported by Moody's. This debt figure is calculated each time Moody's issues a *Credit Report* on a new state issue. These data reflect the most accurate picture of state's fiscal position from the perspective of one of the two major credit rating agencies, although each state's debt figure is not updated at the same time during the year. To derive measures of the relative size of debt, the nominal debt numbers were deflated by the implicit GNP deflator for the year and divided by trend Gross State Product (based on Department of Commerce, real Gross State Product data).

Our sample period is 1981-1990. The mean of the adjusted yield spreads is 32.4 basis points with a standard deviation of 24.8. The maximum spread is 146.4. The mean relative debt is 2.3 percent with a 1.4 percentage point standard deviation, and a maximum and minimum of 7.1 percent and 0.2 percent. At first glance, these relative debt levels seem very small, at least in comparison with some European national debt levels of over 100 percent of GDP. This comparison of state with national debt levels is misleading because the U.S. states reside in a federal structure with a much larger federal taxing power than is contemplated for any European fed-

8. From a telephone conversation with Thomas Swartz of the Chubb Insurance Company.

eral structure. Thus, the U.S. states have a much smaller capacity to tax their residents than do European countries.

In addition to the yield and debt data, we used Department of Commerce data for state unemployment rates and fiscal variables from the Advisory Commission on Intergovernmental Relations (ACIR). The ACIR gathers information on all state and local income taxes, from which we constructed our estimate of *TAXR*. The ACIR also measures state constitutional restrictions on debt issue, and summarizes these restrictions in an index that varies from 0 in Vermont (an Aa-rated state with no constitutional limits) to a maximum value of 10 in twenty-six states. The ACIR index is our measure of FISC.

As already discussed, we used instruments to deal with the possibility of the endogeneity of some of the independent variables in equation (6). In addition to the level of fiscal controls, the instruments for the endogenous variables were annual dummies, Census Bureau demographic variables (the percentage of the population under eighteen and over sixty-five, the average number of people in a household, and the level and rate of growth of the population), and trend Gross States Product. As discussed by Nelson and Startz (1990), poor instruments can lead to problems in estimation. To test for the adequacy of our instrument set we regressed the appropriate independent variables on our instrument set. In all three cases an F-test of the hypothesis that the instruments were jointly insignificant was easily rejected, indicating that the instruments have reasonable explanatory power for the potentially endogenous variables.

4. RESULTS

Main Estimates

Equation (6) was estimated on data for thirty-eight states over the period 1981-1990 (380 observations) using nonlinear, two-stage least squares with the instruments discussed above. Table 2 shows the estimated coefficients, their standard errors, and the associated R^2 for the equation.[9] In addition, statistics related to the curvature of the relationship and to diagnostics tests are given in the bottom of the Table.

Of the five estimated coefficients, four are significant at conventional levels, the exception being the coefficient on the tax rate, which is at the very margin of being accepted at the 5 percent significance level. The statistical significance of the coefficient on debt in the denominator (α_2) implies a rejection of the linear specification.

The point estimates imply a highly nonlinear supply curve. At the mean values of the sample, each percentage point increase in relative debt raises the promised yield by 23 basis points, but this slope rise to over 35 basis points at relative debt levels one standard deviation above the mean of our sample. The backward bend in the supply curve occurs at a level of debt equal to $1/\alpha_2$, at which point the market stops

9. The coefficients on the constant term and annual dummy variables are not reported.

TABLE 2

BASIC REGRESSION RESULTS

Debt: Level Effect (α_1)	18.90	(9.58)*
Debt: Yield Effect (α_2)	0.11	(0.05)*
Tax Rates (α_3)	−9.93	(5.07)
Unemployment (α_4)	6.74	(1.94)**
Fiscal Controls (α_5)	−4.10	(1.04)**
R^2	0.20	
ds/dB at the point of means	23.1	(10.1)*
ds/dB B at 1 s.d. above mean	37.9	(19.7)
$B_{max} = 1/\alpha_2$	8.7	(3.7)*
Wald test $\alpha_1 = \alpha_2 = 0$, $\chi^2(2)$	10.4	(P=0.01)**
Wald Test for joint significance of annual time dummies $\chi^2(9)$	2.6	(P=0.98)
Sargan Test for instruments $\chi^2(2)$	2.6	(P=0.27)
Hausman Test for exogeneity of debt, unemployment and the tax rate $\chi^2(4)$	27.1	(P=0.00)**

NOTES: Numbers in parentheses are heteroskedasticity-consistent standard errors. The instruments were the annual dummy variables, the percentage of the population below eighteen, the percentage of the population over sixty-five, the average number of people per household, the rate of growth and level of the population, and the index of fiscal controls. One asterisk indicates that the coefficient is significant at the 5 percent level of significance, two asterisks, the 1 percent level.

supplying debt. This point is reached at a debt level of 8.7 percent of gross state product, about 25 percent above the maximum debt level observed in the data (7.1 percent).

The other coefficients are also influenced by the nonlinear term in debt, although the effect is smaller than that for the stock of debt since only the denominator is affected. At the average level of debt, a rise in local taxes of one percentage point leads to an 13-basis-point fall in interest rates, while a one percentage point rise in state unemployment raises costs by 9 basis points. The coefficient on the dummy variable for fiscal controls implies that (at average levels of debt) such controls can lower interest costs by over 50 basis points.

Two diagnostic tests are also reported. The equation passes a Sargan test (Sargan 1958) for the adequacy of the instruments, in which the residuals from the initial estimation are regressed upon the instruments. This implies that all of the explanatory power of the instruments are being captured in the independent variables and that there is no independent role for them within the regression.[10] A Hausman specification test was also calculated. This compares the estimated coefficients on the potentially endogenous variables (debt, tax rates, and unemployment) using instrumental variable techniques, which are unbiased but not necessarily efficient, to the same coefficient estimates using nonlinear least squares, which are more efficient but are biased if the variables are indeed endogenous. The test rejects the equality of the two sets of estimated coefficients, indicating that simultaneity does indeed appear to be important for the results.

10. Sargan tests usually use a linear regression to test for the significance of the instruments, and this is the form of the test reported in Table 1. Since we have a nonlinear specification, however, we also experimented with a Taylor series approximation of a more complex functional form by including squares and cubes of the instruments in the regression. Like the conventional test, these results indicated that the instruments had no additional explanatory power.

TABLE 3

RESULTS FROM ALTERNATIVE ESTIMATES

	Excluding Household Size and Population Growth from Instruments	Nonlinear Least Squares	Logistics Function
Debt Level (α_1)	22.71 (20.38)	8.91 (3.66)*	0.87 (0.31)*
Debt Yield (α_2)	0.11 (0.15)	−0.12 (0.09)	
Taxes (α_3)	−11.40 (13.20)	−0.78 (0.37)*	−0.46 (0.19)*
Unemployment (α_4)	5.80 (3.91)	7.80 (1.43)**	0.36 (0.09)**
Fiscal Controls (α_5)	−4.23 (2.94)	−4.30 (0.76)**	−0.20 (0.05)**
R^2	0.17	0.50	0.19
Sargan Test $\chi^2(2)$	n.a.	n.a.	12.4 (P=0.00)**
ds/dB at means	26.0 (21.3)	4.2 (0.8)**	21.1 (10.1)*
ds/dB B at 1 s.d. above mean	40.7 (66.3)	3.3 (0.9)**	73.3 (62.1)

NOTES: Numbers in parentheses are heteroskedasticity-consistent standard errors. The basic instrument set is given in the notes to Table 2. One asterisk indicates that the coefficient is significant at the 5 percent level of significance, two asterisks, the 1 percent level.

Alternative Estimates

Table 3 shows the results from estimating a number of alternative equations involving different assumptions about the set of instruments and the functional form. We started by looking at the sensitivity of our results to different instrument sets. Our tests were limited, however, because the number of instruments in the original regression was only slightly larger than the number of coefficients being estimated. As a result, a maximum of two instruments could be excluded at a time. The first column of Table 3 shows the results when the trend gross state product and the average number of persons per household were excluded from the instrument set. These particular variables were chosen because it seemed possible that they were not exogenous to the supply of debt. The estimated values of the coefficients and slope of the yield curve from this regression are similar to those in the base case although they are estimated with less accuracy, as might be expected given that the model is only just identified. Results from other instrument sets (not reported) show a similar pattern.

The second column in Table 3 shows the results from using nonlinear least squares. This illustrates the quantitative importance of addressing the simultaneity issue in estimating the supply curve, highlighted by the Hausman test. While the independent variables remain generally statistically significant, the effects of tax rates and debt levels are substantially reduced and the hypothesis of a linear supply curve cannot be rejected. Most notably, the implied supply curve has only a modest slope.

The final column in Table 3 shows the results from estimating the function implied by the logistic probability function, defined by equation (5), using the original set of instruments. In this specification, which only has one debt term, all of the coefficients on the independent variables are significant. The implied relationship between debt and interest rates is even steeper than that found in the main case at one standard deviation above the mean level of relative debt, although the specification implies no backward bend in the supply curve. However, the Sargan test statistics indicates that there is a problem with the set of instruments in this case.

Unfortunately, tests are not able to distinguish between the exponential and the logistic specifications. "Pseudo nested" tests of the two specifications, in which a variable with the curvature on debt implied by one estimation results is included in the other equation, could not reject either specification due to colinearity.

We read these results as supportive of the idea that the supply curve facing state borrowers is steep because of rising default premia, irrespective of the functional form used in the estimation. Our preferred equation also indicates a maximum debt level of the order of 8–9 percent of GSP. Not surprisingly, however, given the small number of highly indebted states, our evidence with regard to such credit constraints is more uncertain, as highlighted by the results from the logistic specification which implies a steeply rising supply curve but no maximum level of debt.

5. CONCLUSIONS

The results reported in this paper are broadly consistent with the optimistic view of the market discipline hypothesis. Credit markets *do* appear to provide incentives for sovereign borrowers to restrain borrowing. These incentives appear to be imposed gradually at first, but eventually yield spreads rise in a steep, nonlinear way.

There are two further questions that follow from our results: (1) By how much and how quickly do sovereign borrowers respond to these incentives? (2) Are the incentives provided by market-imposed default premia sufficient? The answer to the first question must await further empirical work (although see Capeci 1994 and Metcalf 1993). The answer to the latter question depends on a more detailed specification of the externalities associated with sovereign default. However, the fact that state legislative controls are consistently significant in our regressions suggest that such controls are also useful in controlling default.

Even if market incentives were judged to be insufficient, our results have some interesting implications for the alternative approaches to fiscal discipline. While default premia may not be the right size, in informationally efficient capital markets they would still provide useful signals about the probability of default. This in turn raises the possibility that a rules-based approach could use observed yield spreads to magnify the incentive effects for fiscal discipline; for example, penalty taxes based on the size of a country's yield spread, or a critical yield spread itself could be employed as a trigger for multilateral surveillance, or further borrowing could be prohibited when spreads reached a critical level. Food for thought.

LITERATURE CITED

Advisory Commission on Intergovernmental Relations. *Significant Features of Fiscal Federalism*. Washington, D.C.: U.S. Government Printing Press, various issues.

Bishop, Graham, Dirk Damrau, and Michelle Miller. "1992 and Beyond: Market Discipline *Can* Work in the EC Monetary Union." Salomon Brothers, London, November 1989.

______. "The EC Public Debt Disease: Discipline with Credit Spreads and Cure with Price Stability." Salomon Brothers, London, May 22, 1991.

Capeci, John. "Local Fiscal Policies, Default Risk, and Municipal Borrowing Costs." *Journal of Public Economics* (Netherlands) 53 (January 1994), 73–89.

Delors' Report. *Report of Economic and Monetary Union in the European Community.* Committee for the Study of Economic and Monetary Union, June 1989.

Eaton, Jonathan, and Mark Gersovitz. "Debt with Potential Repudiation: A Theoretical and Empirical Analysis." *Review of Economic Studies* 49 (April 1981), 289–309.

European Community Commission. "Economic and Monetary Union: The Economic Rationale and Design of the System." March 1990.

______. "One Market, One Money—An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union." October 1990.

Edwards, Sebastian. "The Pricing of Bonds and Bank Loans." *European Economic Review* 30 (1986), 565–89.

Eichengreen, Barry. "One Money for Europe? Lessons from the U.S. Currency Union." *Economic Policy* (April 1990), 119–86.

______. "Should the Maastrict Treaty Be Saved?" *Princeton Essays in International Finance*, December 1992.

English, William. "When America Defaulted: American State Debt in the 1840s." Paper, University of Pennsylvania, January 1991.

Goldstein, Morris, and Geoffrey Woglom. "Market-Based Fiscal Discipline in Monetary Unions: Evidence from the U.S. Municipal Bond Market." In *Establishing a Central Bank*, edited by M. Canzoneri, V. Grilli, and P. Masson. Cambridge: Cambridge University Press, 1992.

Jaffee, Dwight and T. Russell. "Imperfect Information, Uncertainty, and Credit Rationing." *Quarterly Journal of Economics* 90 (1976), 651–66.

Kidwell, David, T. Koch, and D. Stock. "The Impact of State Income Taxes on Municipal Borrowing Costs." *National Tax Journal* 37 (1984), 551–61.

Liu, Pu, and Anjan Thakor. "Interest Yields, Credit Ratings, and Economic Characteristics of State Bonds: An Empirical Analysis." *Journal of Money, Credit, and Banking* 16 (August 1984), 345–50.

Metcalf, Gilbert. "Federal Taxation and the Supply of State Debt." *Journal of Public Economics* (Netherlands) 51 (1993), 269–85.

Nelson, C., and R. Startz. "The Distribution of the Instrumental Variables Estimator and Its *t*-Ratio When the Instrument Is a Poor One." *Journal of Business* 63:1 (1990) 125–40.

Orth, John V. *The Judicial Power of the United States: The Eleventh Amendment in American History*. New York: Oxford, 1987.

Sargan, J. D. "The Estimation of Economic Relationships Using Instrumental Variables." *Econometrica* 36 (1958), 393–413.

Startz, Richard. "Computation of Linear Hypothesis Tests for Two-Stage Least Squares." *Economics Letters* 11 (1983), 129–31.

Stiglitz, Joseph, and Andrew Weiss. "Credit Rationing in Markets with Imperfect Information." *American Economic Review* 73 (1981), 393–410.

von Hagen, Jurgen. "Fiscal Arrangements in a Monetary Union: Evidence from the United States." In *Fiscal Policy, Taxation, and the Financial System in an Increasingly Integrated Europe*, edited by Donald E. Fair and Christian de Boissieu. Dordrecht, The Netherlands: Kluwer Academic Publishers, 1992.