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Are District Presidents More Conservative than Board Governors?

Geoffrey M. B. Tootell

It is widely believed that the Federal Open Market Committee policy votes of Federal Reserve Bank presidents are more "conservative" than those of their Board governor counterparts. In both academia and Congress, the suspicion runs deep that the political appointment procedure exercised over Federal Reserve Board governors—nomination by the President and confirmation by the Senate—results in monetary policy that is more concerned with output and less concerned with inflation than the policy produced by the more politically independent District Bank presidents.

This article examines the data to determine whether it supports this conventional wisdom. The statistical techniques used in this paper permit a test of the hypothesis necessary to support their conclusions. The evidence rejects the conclusion that significant differences exist. 3

The Municipal Bond Market, Part I: Politics, Taxes, and Yields

Peter Fortune

This article assesses recent changes in the structure of the municipal bond market. It reviews the tax legislation, judicial interpretations, and other factors that affect the yield on municipal bonds. These factors are then employed in a statistical analysis of the determinants of municipal bond yields.

The results of the analysis show that the ratio of yield to maturity on municipal bonds to yields on U.S. Treasury bonds (the interest rate ratio) has varied greatly in the past two decades and is greater for longer maturities. They also show that debate during 1986 about tax reform increased interest rate ratios, suggesting independent evidence for the importance of anticipated future tax rates. 13

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The Real Estate Cycle and the Economy: Consequences of the Massachusetts Boom of 1984–87

Karl E. Case

The economy of Massachusetts is in a deep recession. What makes the downturn all the more painful is that it comes on the heels of a period of unprecedented prosperity. What happened? How could a state go from having the lowest unemployment rate in the United States to having the second highest in the space of less than four years?

Some claim that the current recession is a natural and inevitable downturn after a prolonged expansion and that the region soon will return to a reasonable growth path. Others claim that the state is likely to experience a prolonged period of decline. The thesis of this article is that the dramatic real estate cycle, which began with a housing price boom between 1984 and 1987, was an important element that not only contributed to but also very significantly amplified the economic fortunes and misfortunes of the Commonwealth and the region. 37

Infrastructure and Regional Economic Performance: Comment

Robert Eisner

Widely disparate results have flowed from various attempts to analyze the impact of public investment in tangible infrastructure on measures of economic activity. The author takes the substantial body of data put together by Munnell and Cook for 48 states over the years 1970 to 1986 and uses the data in pooled time series regressions, in pooled cross sections, and finally in distributed-lag investment functions.

The author's results support Munnell's finding that states that have more capital have greater output, even after taking into account both their amounts of labor (nonagricultural employment) and private capital. The author notes that serious questions remain, however, as to which is the cause and which is the effect. 47

Are District Presidents More Conservative than Board Governors?

Geoffrey M. B. Tootell

Economist, Federal Reserve Bank of Boston. *The author thanks Stephen McNees and Richard Kopcke for all their useful comments. Valuable research assistance was provided by Jeffrey B. Liebman and Adam Rosen.*

It is widely believed that the Federal Open Market Committee policy votes of Federal Reserve Bank presidents are more "conservative" than those of their Board governor counterparts. Belden (1989) supports the conclusion that "District Bank presidents, who serve without executive or legislative approval, prefer policy that produces lower inflation and higher unemployment, relative to the Board." Puckett (1984) and Havrilesky and Gildea (1990) have also claimed to have found evidence reinforcing this conventional wisdom. In both academia and Congress, the suspicion runs deep that the political appointment procedure exercised over Federal Reserve Board governors—nomination by the President and confirmation by the Senate—results in monetary policy that is more concerned with output and less concerned with inflation than the policy produced by the more politically independent District Bank presidents. This article examines the data to determine whether it supports this conventional wisdom.

It is impossible, using the methodology utilized in the dissent studies, to test the hypothesis that is required to support this literature's conclusions. The statistical techniques used in this paper permit a test of the hypothesis necessary to support their conclusions. The evidence rejects the conclusion that significant differences exist between the policy votes of District Bank presidents and those of Board governors.

The previous literature examining this issue suffers from several important methodological problems. Many of these works, Belden (1989), Puckett (1984), and Havrilesky and Gildea (1990), for example, have compared the frequencies of dissent for tighter or looser monetary policy of District presidents and Board governors. Comparing simple frequencies of dissent, however, may suffer from a serious omitted-variable bias. Actual votes on monetary policy depend on the economic variables of interest to the Federal Reserve (Fed) as well as the Fed's expectations of the future values of these variables. This study uses multinomial logit analysis to incorporate these omitted variables into the

voting function.[1] To test whether presidents care more about inflation, a common theory in the dissent literature, requires a comparison of the voting reactions of presidents and governors to movements in that variable. Furthermore, this article examines not two but three policy choices—votes for tighter policy, looser policy, or no change in policy—to more accurately represent differences in the members' votes.[2] These improvements on the previously used methodology allow an accurate exploration of the predilections of different members of the Federal Open Market Committee (FOMC) and the stability of these tendencies over time. Only by examining the voting functions of different subgroups of the FOMC can a reliable assessment be made about whether Reserve Bank presidents are relatively more conservative than Board governors.

This article proceeds as follows. The first section outlines the important theoretical and empirical issues in this debate. Section II presents the results of the multinomial logit estimation. A comparison of the policy propensities of Bank presidents relative to Board governors is performed. The evidence reveals that no significant difference exists in the voting behavior of these two different groups. The stability of these voting patterns over time is then examined. The third section illustrates how robust the results are to alternate forms of the voting function. Finally, the implications of this study for the current policy debate are discussed in the conclusion.

I. The Model

Luckett and Potts (1978) point out the hazards of analyzing Fed behavior by quantifying the movement of one of its potential instruments. Misspecifying the policy instrument the Fed is actually using invalidates any resulting conclusions about Fed behavior. If, for example, the Fed is setting interest rates and money demand unexpectedly increases, the subsequent rise in the money supply M does not signify a change in Fed intentions.[3] Such a misspecification would be impossible if everyone in the economy agreed on the correct instrument; unfortunately, a consensus about the optimal tool of monetary policy has not been reached, inside or outside the Fed. As a result, any conclusions about Fed intentions based on the movement of a hypothesized Fed instrument are suspect. To avoid this problem, FOMC votes are used here to discern the Fed's intentions directly. Accordingly, these votes are modeled as functions of certain target variables. The reaction of the FOMC to these variables indicates the FOMC's relative and absolute concerns for these various objectives.[4]

On the other hand, differentiating one subgroup's behavior from that of the rest of the FOMC by simply comparing dissents suffers from omitted-variable bias. Is a dissent for tighter policy when the economy is in a recession identical to a dissent for tighter action when the economy is booming? Counting frequencies alone would suggest that the two are equivalent. Furthermore, different FOMC members could have different targets, which makes imputing their conservatism about a target from dissents impossible. Assume that Bank presidents target real GNP and Board governors are more concerned about inflation. If, for example, the economy experiences a positive supply shock and output growth increases while prices decline, the more numerous Board governors will tend to vote for looser policy while the Bank presidents will tend to dissent for tighter action. Which group is more conservative? Counting dissents would imply that the Bank presidents tend to advocate tighter policy, yet those who target real GNP are generally considered less conservative than those who target inflation. Without knowing how FOMC members react to the fundamental variables driving their behavior, no conclusions can be drawn

[1] Previous attempts have been made to estimate the factors that influence FOMC votes, as in Luckett and Potts (1978, 1980) and Hakes (1990). Both Luckett and Potts and Hakes use discrimination analysis between two FOMC choices, votes for tighter or votes for looser policy, to test a form of the partisan politics hypothesis. The methodology here uses logit estimation and allows three policy choices. Furthermore, the issues examined in this paper differ from those in the earlier studies.

[2] Including the vote of no change allows a distinction to be made between dissenting to a tightening of policy, for example, because one is for no change in policy versus when one is for a loosening of policy. Furthermore, since votes for no change are the most frequent category, the occasions for arbitrary judgment of what is loose and tight policy are reduced.

[3] Although technically the federal funds rate and the money supply are short-run targets, while reserves are the instrument, the connection between reserves and either of these targets is assumed to be secure enough to refer to them as instruments.

[4] Abrams, Froyen, and Waud (1980) discuss the inability to discern the preferences of the Fed when examining a Fed instrument, as movements in that instrument also contain information about the Fed's perceptions of the structural equations in the economy. Looking at FOMC votes defuses much of this criticism. Votes give only the direction of the policy, not the magnitude of the movement in the instrument needed to bring about the desired effect. In fact, the directives are clear about when a change is due to technical, "structural" factors or altered directions in policy. Disputes due to differences of opinion about the structural equations guiding the economy are made as technical dissents, and are not included as policy differences in this paper.

about their relative goals. It is essential to understand why members dissent in order to determine if they dissented because they are "conservative"; by omitting the variables that explain their behavior, one omits any possibility of judging whether their behavior is "conservative." This problem is avoided by directly examining the objectives of the different members of the FOMC.

Comparing dissents by Bank presidents and Board governors also begs the question of which members of the FOMC can be treated as identical; is the important distinction to be made between president and governor, or do individuals differ significantly? In the econometric literature this issue is referred to as the agent heterogeneity problem. If, for example, one Reserve Bank were to dissent for tighter policy every time the FOMC voted for looser policy or no change in policy, the frequency of dissents for Bank presidents as a group would be high compared to governors. But such dissents would illuminate more about one institution, or individual, than about the differing appointment procedures of Bank presidents and Board governors. For both theoretical and empirical reasons it is necessary to analyze not only whether differences exist between Bank presidents and Board members, but whether the Banks themselves should be aggregated.

A simple model suggests which variables to include in the FOMC voting function. To begin with, it is assumed that members of the FOMC care only about the growth in real output and the rate of inflation. The Fed attempts to minimize a loss function, as proposed in Kydland and Prescott (1977) and Barro and Gordon (1983),

$$\underset{\pi}{\text{MIN}}\ \alpha(\dot{Q})^2 + \Gamma(\pi)^2 \qquad (1)$$

where $\dot{Q} \equiv$ the growth rate in real GNP and $\pi \equiv$ inflation. When real GNP growth declines, members are more likely to vote for ease and less likely for tightening, while a rise in inflation will increase the probability of voting to tighten policy and decrease the probability of voting to ease.[5] The weights allow the tastes for these targets to vary over the two objectives and between the members of the FOMC. If $\alpha = \Gamma$, for example, the FOMC cares equally about inflation and real GNP growth and is, thus, targeting nominal GNP. Comparing these parameters across Bank presidents and Board governors indicates whether one group is "more conservative," in the sense that its members care more about inflation. Any analysis of the absolute tightness or looseness of any group's policy must be determined by examining some measure of these weights.

The dependent variable is the actual vote of the FOMC members. Since they can vote for a tightening, a loosening, or no change in policy, a multinomial logit model is used to determine the effects of these two target variables on the probabilities that the FOMC members vote for a given policy. Ordered probits were also performed on all the data; these results are omitted as they completely replicate the findings reported in the remainder of the paper. The collection of these votes is not devoid of judgment. Anyone who has read the FOMC minutes is aware that the directives can be fairly cryptic. Furthermore, dissents are sometimes made for technical reasons, not because of disagreements over the direction of policy per se; since this paper is concerned with FOMC predilections, these dissents are not counted as disagreements with the FOMC policy. Although this exercise is not completely objective, all studies that examine votes or dissents suffer from such intrusions of judgment.

Without knowing how FOMC members react to the fundamental variables driving their behavior, no conclusions can be drawn about their relative goals.

The possibility that all members of the FOMC are not alike must be examined in order to ensure the accuracy of any estimates of the effects of business cycle variables on policy votes. The multinomial logit model is used primarily for cross-sectional analysis over a distribution of individuals. Since FOMC voting contains many observations of the same agent over time, however, idiosyncratic differences in individual tastes can bias tests on the coefficients, as is thoroughly discussed in Chamberlain (1980).[6] Essentially,

[5] The terms are squared in this equation since the Fed is assumed to dislike large deviations in either direction. For example, the Fed hates deflation as much as it does inflation. It is price level changes that have costs to society, no matter the direction.

[6] This agent heterogeneity is similar to heteroskedasticity in the errors, and must be corrected for in order to accurately estimate and test the parameters in the model.

differences in individuals or institutions should be incorporated into the parameter estimates. If, for example, all 12 District Banks are aggregated, and one particular Bank has a strong predilection for zero inflation, that Bank's higher probability of choosing tightening must be accounted for in order to get an accurate measurement of District Banks' voting functions. Thus, to produce proper estimates of the FOMC voting functions, one must examine the issue of whether differences exist, between Board and Bank or between Bank and Bank. A variety of tests were performed to guarantee that this heterogeneity was not a serious problem in the data.

II. FOMC Voting Functions

Because monetary policy affects the economy only with lags, the FOMC's expectations of GNP growth and inflation should determine its votes. Fortunately, a good instrument for these expectations is available. The Fed staff's forecasts of these variables are contained in the Green Book, which is distributed to all FOMC members before each meeting. Since the Green Book does not consistently contain forecasts for the variables of interest before 1965 and Green Book forecasts are not made public until five years after their use, the sample consists of FOMC votes from 1965 to 1985; all inferences drawn from this sample pertain only to that period. Each FOMC meeting contains the votes of the seven Board governors and five of the District Bank presidents; the Federal Reserve Bank of New York always has a vote while the other four votes are rotated among the remaining eleven Banks.[7] With roughly 217 meetings over the sample period, the data set consists of 2,584 votes.[8]

The actual voting frequencies of the FOMC contain information about the FOMC's inclinations, its models, and the economic conditions experienced over the sample.

The actual voting frequencies of the FOMC contain information not only about the FOMC's inclinations, but about its models and the economic conditions experienced over the sample as well. Of all these votes, 59 percent were for no change, 25 percent were for tightening, and 16 percent were for loosening. The voting frequencies for Bank presidents do differ somewhat from those of Board governors. The frequency of "no change" votes by District presidents was about 2 percentage points lower than that of Board governors, their "tighten" voting frequency about 3.5 percentage points higher, and their "loosen" voting frequency about 1.5 percentage points less. The large number of votes for no change suggests that the Fed altered policy gradually and deliberately rather than wildly chasing its targets. The previous literature assumed that these frequencies represented differences in tastes while omitting that they also contain information about the models of the FOMC and the shocks experienced by the economy over this time period.

The results of a multinomial logit estimation based on the objective function in text equation (1) for the FOMC as a whole are contained in equation 1 of Table 1. The coefficients measure the effect of the independent variables on the probability of voting for looser or tighter policy relative to a vote of no change, at given values of these independent variables. As predicted by theory, an increase in the Green Book forecast of future real GNP growth raises the probability of voting for tighter policy and reduces the probability of voting for looser policy relative to a vote of no change. The output coefficient for the probability of both loosening and tightening is significant and correctly signed. Furthermore, the expected future inflation rate has the predicted effect on the probabilities of voting for tighter or looser policy, and both its coefficients are significant. Equation 1 of Table 1 clearly shows that the FOMC responds to Fed expectations of the future performance of the economy. This result is robust over different measures of the output target. De-trended growth rates, growth rates with drift, and growth rates with dummies accounting for the post-1974 sample were all tested, in an attempt to quantify deviations from a potential

[7] Cleveland and Chicago alternate turns on the FOMC. The remaining nine District banks are divided into groups of three, and they rotate FOMC votes within those sub-groups.

[8] Green Book forecasts were unavailable for three meetings over this sample. Any lagged variables were appropriately corrected for these observations. Furthermore, random absences of presidents and governors prevented the number of observations from simply being (12)x(217).

Table 1
Multinominal Logit Estimation of FOMC Voting

	(1) FOMC	(2) Bank	(3) Board	(4) FOMC	(5) Bank	(6) Board
Tightening						
C	−2.241	−1.928	−2.513	−.851	−.730	−.950
	(13.20)	(7.83)	(10.69)	(18.0)	(10.49)	(14.72)
$\dot{Q}^E$	.136	.124	.148			
	(8.07)	(5.05)	(6.34)			
$\dot{P}^E$	.163	.137	.185			
	(7.30)	(4.21)	(6.05)			
Loosening						
C	.177	.193	.165	−1.204	−1.261	−1.163
	(.97)	(.68)	(.70)	(22.37)	(14.93)	(16.66)
$\dot{Q}^E$	−.211	−.225	−.201			
	(11.79)	(8.08)	(8.61)			
$\dot{P}^E$	−.177	−.189	−.168			
	(6.11)	(4.18)	(4.47)			
Log Likelihood	−2338.3	−1017.83	−1315.39	−2496.22	−1087.43	−1404.89
Likelihood Ratio	10.16			7.8		

Note: C is the constant; $\dot{Q}^E$ and $\dot{P}^E$ are the Green Book forecasts of real output growth and inflation, respectively. The likelihood ratio test for the first three equations is a χ^2 with 6 restrictions. A χ^2_6 over 10.6 would reject that the two groups vote the same at the 10 percent level. Thus the Null Hypothesis that the two groups are identical cannot be rejected, even at the 10 percent level. Testing the identity of the constants in equations (5) and (6) is a χ^2_2; a value of the likelihood ratio above 5.99 rejects the equivalence of these constants at the 5 percent level. (T-Statistics in parentheses.)

Fed targeted growth rate, yet they all produced essentially the same coefficients and levels of significance as the output variable given in equation 1 of Table 1. Only the unemployment rate and changes in the unemployment rate did not perform as well.

Governors versus Presidents

Equations 2 and 3 of Table 1 contain the logit estimations for Bank presidents and Board governors separately, in order to compare the responses of presidents and governors to changes in the two proposed target variables. A cursory examination of the coefficients suggests that although the Bank presidents may be less apt to loosen when the economy is booming, they are also less apt to tighten. The constants in the two equations are also very close. Because of the lack of independence between coefficients, specifically between the constant term and the remaining parameters, the superior test of whether these two groups are identical is a joint test of all their coefficients. This log likelihood ratio test fails to reject the hypothesis that the coefficients of Bank presidents are identical to those of Board governors, even at the 10 percent level.[9] The hypothesis that District Bank presidents and Board governors have significantly different voting predilections is not sustained by the data.

The problem with the simple comparison of

[9] Statistical comparisons of individual coefficients were performed. Although this procedure attempts to answer different questions than whether substantial differences exist between District presidents and Board governors, these single tests might reveal what may cause some disagreements in policy. The results of these tests strongly support the conclusion that the two groups are identical. Performing the same test on just the inflation coefficient, or just the real output parameter, still could not reject, at the 5 percent level, the hypothesis that each coefficient was the same for these two groups. One group clearly does not feel any stronger about real growth or inflation than the other. In some model specifications a Bank dummy for tightening was small, positive, and significant. Yet this is an uninteresting result for several reasons. First, the exact model chosen is necessary to truly test whether the constant for tightening is the same between the two agents, and the most complete specification found this dummy both statistically and economically insignificant. Furthermore, the dependence of the estimate of the constant on the other parameters in the model requires a joint test. Finally, even in the models where the constant did differ, it was economically irrelevant; at the mean of the independent variables the District president probability of tightening increased by 2 percent, and their probability of voting for no change decreased by 2 percent.

Board governor and Bank president dissent frequencies in, for example, Belden (1989), Puckett (1984), and Havrilesky and Gildea (1990), can be clearly illustrated using logit analysis. The equivalent procedure in the logit framework is to compare the logit estimations for the Bank presidents and Board governors when a constant is the only independent variable; in this case, the constants are the actual voting frequencies. Equations 4 to 6 in Table 1 provide the coefficients from this procedure for the FOMC as a whole and for the District presidents and Board governors separately. The constants are negative because the votes for both loosening and tightening are relative to votes for no change, which were by far the largest category over the sample period. The likelihood ratio test accepts at the 5 percent level that the constants in the Board and Bank equations are significantly different.[10] However, the constants in equations 5 and 6 clearly differ from those in equations 2 and 3, emphasizing the effect of omitting the business cycle targets from the voting functions. The estimated constant is a function of the other explanatory variables and their estimated coefficients; omission of these other variables biases the estimation of the constant. Thus, the inclusion of the business cycle objectives is essential to reversing the conclusion found in the frequency-of-dissent analysis that the two groups are different.

Various steps were taken to ensure that the aggregation of the Bank presidents was not biasing the results. It is often argued that certain Reserve Banks tend to be consistently more conservative than others; the constancy of Bank behavior is explained by the nomination process for Bank presidents. The resulting institutional memory allows one to examine the Bank rather than the individual.[11] Yet institutional memory can produce difficulties in qualitative data estimation as the individual Bank effects must be accounted for in order to efficiently estimate the coefficients. Since each Bank has at least 80 observations, District Bank dummies are used to capture possible fixed effects. Adding the Bank dummies to equation 2 of Table 1 produces the estimates in Table 2.

Only the St. Louis Bank dummy for tightening is significant. A log likelihood test of whether the bank dummies were insignificant could not be rejected at even the 10 percent level. In fact, when all but the St. Louis dummy are dropped, the St. Louis dummy itself becomes insignificant. District Bank behavior may vary, but it is spread along a very narrow spectrum. The inclusion of all the Bank dummies allows enough differentiation to distinguish St. Louis;

Table 2
Dummies for the District Banks

	(1) Bank		(1) Bank
Tightening		Loosening	
C	−2.50	C	.274
	(6.18)		(.70)
$\dot{Q}^E$	.118	$\dot{Q}^E$	−.23
	(4.66)		(8.15)
$\dot{P}^E$	.13	$\dot{P}^E$	−.20
	(3.95)		(4.32)
DBos	.74	DBos	.54
	(1.72)		(1.22)
DNew	.55	DNew	−.44
	(1.47)		(1.88)
DPhil	.56	DPhil	−.04
	(1.31)		(.08)
DClev	.76	DClev	.33
	(1.86)		(.82)
DRich	.52	DRich	.09
	(1.18)		(.22)
DAtl	.73	DAtl	.01
	(1.71)		(.35)
DChi	.42	DChi	−.14
	(1.04)		(.02)
DSt.L	1.14	DSt.L	−.01
	(2.60)		(.33)
DMin	.72	DMin	.21
	(1.57)		(.39)
DKan	.72	DKan	.14
	(1.75)		(.33)
DDal	.73	DDal	−.39
	(1.73)		(.82)
Log Likelihood	−1008.12		
Likelihood Ratio	19.42		

Note: D Bank are the bank dummies. The Federal Reserve Bank of San Francisco is the omitted dummy variable so all Banks are measured in comparison to it. The likelihood ratio is a χ^2 with 24 restrictions, and it cannot reject that all banks share the same constants at even the 75 percent level. (T-statistics in parentheses.)

[10] This approach differs slightly from Belden's test: it is a joint test on the similarity of the probability of tightening and loosening between Bank presidents and Board members. However, both votes must be examined as a Bank could have significantly more dissents for both tightening and loosening. Such a Bank clearly cannot be labeled as more "conservative," even by the dissent literature's own criterion.

[11] The Fed could also derive benefits from and promote the diversity within the System in order to encourage debate. In any event, all the studies that compare presidents and governors implicitly assume that District Banks, not individual presidents, differ from Board governors.

once all the other banks are averaged together, however, the St. Louis Bank cannot be differentiated from the rest. This evidence suggests that no fixed individual effects are biasing the results when all the Banks are combined; individual Bank differences do not appear to produce serious problems for efficient estimation. Therefore, the aggregation of all the Banks does not appear to be an empirical problem.

Simply comparing the estimates of all the coefficients of the Banks separately is another way to examine potential Bank differences. To ensure that certain Banks are not dominating the sample, a log likelihood test was performed when one Bank was estimated apart from the pooled sample of the remaining Banks. This procedure assures that one loose or tight Bank is not biasing the comparison of the two groups, a serious problem when merely analyzing frequencies of dissent. The hypothesis of constant coefficients across all Banks could not be rejected for any Bank. The equality of the coefficients between Banks could not be rejected even when a group of reputed "conservative" Banks was separated out. Both the Bank dummies and the logits on subgroups of the Banks failed to find any Bank heterogeneity biasing the rejection of Board governor and Bank president dissimilarity, thus reinforcing the conclusion that no differences exist between these two groups.

What Does the FOMC Target?

Since the tests in the previous section conclude that the FOMC is the relevant unit to examine, it is appropriate to attempt to explore exactly what the FOMC was targeting over the sample period. In equation 1 of Table 1, the coefficients for real GNP growth and inflation are very close to identical, suggesting that the FOMC does not differentiate between inflation and output growth when it sets policy. It seems the Fed was, in effect, targeting nominal GNP from 1965 to 1985. In fact, a log likelihood test cannot reject that the Fed was targeting nominal GNP.[12] The Green Book evidence, therefore, suggests the Fed was targeting a nominal variable over the sample, providing an anchor for inflation.

The stability of these FOMC goals over time can also be tested. It is possible the Fed's objectives, or its weights on these objectives, changed with the dominant economic models of the day. For example, the Fed could have switched to targeting nominal GNP in the later part of the 1970s. Assuming that the change in Fed operating procedures signaled an alteration in the Fed's model of the economy, the sample period is broken at October 1979. Equations 1 and 2 of Table 3 provide the results of a log likelihood test of within-sample coefficient stability, and it is strongly rejected. To test whether a move to targeting nominal GNP in the late 1970s caused the instability, equations 3 and 4 give the nominal GNP targeting equations over each subsample. A likelihood ratio test for the equality of the coefficients on real GNP growth and inflation was performed for the two subsamples. The results indicate that the instability over the sample could be caused by a shift to targeting nominal variables in the late 1970s.[13]

Table 3
Subsample Stability

	(1) 1965–79	(2) 1980–85	(3) 1965–79	(4) 1980–85
Tightening				
C	−2.228	−2.455	−2.083	−2.364
	(11.14)	(7.38)	(11.41)	(7.59)
$\dot{Q}^E$	.131	.127		
	(6.76)	(3.57)		
$\dot{P}^E$	.176	.157		
	(6.52)	(3.88)		
$\dot{P}^E \cdot \dot{Q}^E$			.141	.139
			(7.68)	(4.33)
Loosening				
C	.320	−.485	.560	−.295
	(1.56)	(1.21)	(3.52)	(1.02)
$\dot{Q}^E$	−.231	−.159		
	(11.18)	(4.07)		
$\dot{P}^E$	−.178	−.125		
	(5.42)	(2.06)		
$\dot{P}^E \cdot \dot{Q}^E$			−.227	−.157
			(11.12)	(3.98)
Log Likelihood	−1858.87	−470.117	−1861.58	−470.554
Likelihood Ratio	18.626		5.42	.874

Note: $\dot{P}^E \cdot \dot{Q}^E$ is the Green Book forecast of nominal GNP growth. The first χ^2 has 6 restrictions and strongly rejects subsample stability at the 1 percent level. The next two statistics have 2 restrictions and the 1965–79 sample rejects nominal GNP targeting at the 10 percent level although not at the 5 percent level. The 1980–85 sample cannot reject nominal GNP targeting. (T-statistics in parentheses.)

[12] The log likelihood value of 2.94, with a chi-squared with two restrictions, cannot reject at the 10 percent level the hypothesis that the coefficients on expected real GNP and expected inflation are the same.

[13] In the early period, with a likelihood ratio of 5.42, targeting nominal GNP cannot be rejected at the 5 percent level but can at the 10 percent level. In the post-1979 period, however, a likelihood ratio of 0.874 cannot reject nominal GNP targeting.

In short, including business cycle objectives in the FOMC voting functions reverses the conclusion that Bank presidents and Board governors are significantly different; no evidence was found that the District Bank presidents are any more "conservative" than the members of the Board. Furthermore, aggregation over different members of the FOMC does not appear to be a significant problem. And although some subsample instability exists, its possible causes could be explained by shifts in the Fed's relative concern for the two independent variables.

III. Other Models of FOMC Voting

The voting function in the previous section may still be misspecified. Perhaps a more fully specified function would reverse the rejection of significant differences between Bank presidents and Board governors. More complicated reaction functions have been used in most of the literature in this area, for example McNees (1986), Havrilesky (1987), and Alesina and Sachs (1988). Many alternatives to this model were discussed in Tootell (1991). Table 4 contains the main results from that search. Equation 1 is for the FOMC as a whole. Included in the voting function along with the expectations for inflation and real growth are the growth in the money supply and the lagged change in the federal funds rate. Money growth is included because it is traditionally hypothesized as an intermediate Fed target. The lagged change in the federal funds rate is often included to pick up the Fed's concern for stability in the capital markets. As seen in Table 4, the coefficient on money is extremely small, yet correctly signed and statistically significant. The coefficient on the lagged change in the federal funds rate is large and positive. This variable is apparently capturing the fact that the Fed moves gradually, and thus, with positive serial correlation.[14]

This new equation cannot reject the hypothesis that governors and presidents are the same. Equations 2 and 3 of Table 4 break the logit estimation into Bank and Board equations. The likelihood test with ten restrictions cannot reject the hypothesis that the two groups are identical, even at the 10 percent level. Furthermore, the inability to reject the hypothesis that these two groups are identical is not dependent on using only forward-looking variables. The same tests were performed using the lags of actual real GNP growth and inflation. These logits were estimated on quarterly data, as the frequency of the actual real GNP figures is quarterly. Using this regression, the hypothesis that the two groups are different is still strongly rejected.[15] Finally, when the latest known values of inflation and real growth, also contained in the Green Book, were added to the equations in Table 4, the coefficients and significance

Table 4
Alternative Model of FOMC Voting

	(1) FOMC	(2) Bank	(3) Board
Tightening			
C	−2.535	−2.350	−2.709
	(12.66)	(7.99)	(9.87)
$\dot{Q}^E$	.132	.118	.145
	(7.29)	(4.44)	(5.83)
$\dot{P}^E$	.110	.086	.132
	(4.40)	(2.32)	(3.86)
$\dot{M}$	.060	.077	.047
	(6.06)	(5.16)	(3.51)
LDFF	.921	1.032	.840
	(8.82)	(6.55)	(5.99)
Loosening			
C	.329	.347	.319
	(1.68)	(1.13)	(1.25)
$\dot{Q}^E$	−.150	−.162	−.142
	(7.90)	(5.44)	(5.76)
$\dot{P}^E$	−.179	−.203	−.163
	(6.01)	(4.33)	(4.20)
$\dot{M}$	−.063	−.060	−.065
	(5.43)	(3.28)	(4.37)
LDFF	−1.213	−1.282	−1.174
	(10.51)	(7.05)	(7.84)
Log Likelihood	−2201.91	−948.775	−1245.92
Likelihood Ratio	14.43		

Note: $\dot{M}$ is the money growth rate, and LDFF is the lagged change in the federal funds rate. The likelihood ratio test is a χ^2 with 10 restrictions. A χ^2_{10} over 16.0 rejects that the 2 groups are the same at the 10 percent level. (T-statistics in parentheses.)

[14] In fact, when lagged FOMC votes were included in the logit estimation, the coefficients for and significance of the lagged change in the federal funds rate fell to zero. Because of the apparent collinearity between lagged votes and lagged changes in the federal funds rate, a test for differences in Bank and Board voting functions was performed with equations including each of these two variables separately and one including both. None of these logit equations rejected the similarity of the two groups.

[15] The chi-squared statistic with six restrictions for the likelihood ratio test that the two groups are identical was 7.65, well below even the 25 percent level for rejection.

levels of the expectational variables were unaffected, while the backward-looking variables were significant only for the probability of tightening. In this broader equation, equivalence of the coefficients could not be rejected at even the 25 percent level. It is clear that the failure to reject the identity of these two groups of agents is robust to a variety of different models, frequencies, and specifications.

These more comprehensive voting specifications, however, uncover another important issue in this debate. Given the many different dimensions along which the FOMC members can act, if one could distinguish between members' behavior, how would one define "conservative"? Is it one who targets money growth, nominal GNP, or one who has a great distaste for inflation? Monetarists can advocate loose money and people who target real or nominal GNP can have very low or very high targets. The dissent literature defines a conservative as one averse to inflation, but does not examine the reaction of District presidents and Board governors to inflation. To examine the effect of appointment procedures on the behavior of members of the FOMC requires analysis of a voting function that allows tests of a concrete definition of what is "conservative."

Finally, an examination of these coefficients can help to determine whether FOMC policy is either too tight or too loose. Measuring an agent's policy predilections should depend on its responses to conditions in the economy, not on its votes relative to the FOMC majority, as is done in the dissent literature. Quantifying the relative probability of voting for looser or tighter policy, given output growth and inflation, is achieved by substituting values for the independent variables in the estimated equations. At that given point, usually chosen as the mean of the independent variables, one can derive the effect on the probabilities of an increase or decrease in output or inflation. Figures 1 and 2 graph the probabilities of voting for looser, tighter, or no change in policy, as estimated in equation 1 of Table 1, when either expected real GNP or inflation varies; whether the Fed's response to its target variables conforms to society's desired response can be measured in this way. Scrutinizing dissents gives no information about FOMC action relative to the optimal social policy.

Figure 1

FOMC Voting Probabilities with Expected Inflation Rate at Its Mean (5.47%)

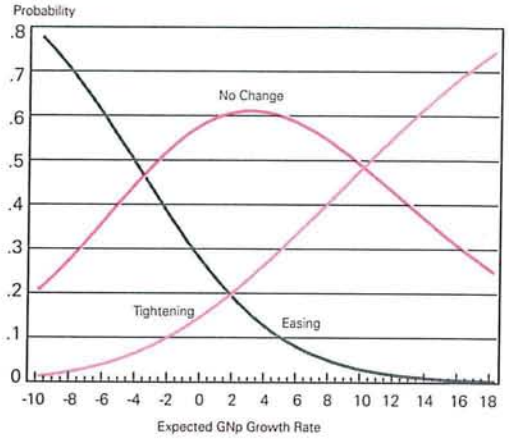
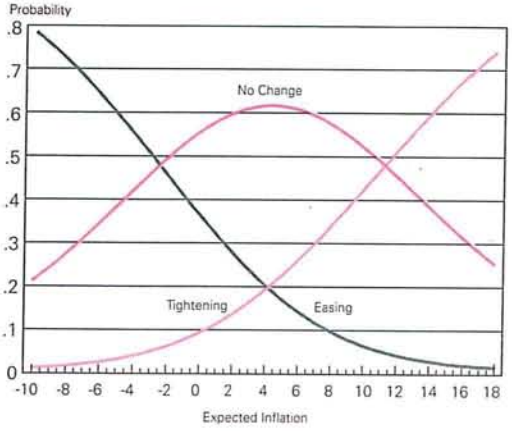


Figure 2

FOMC Voting Probabilities with Expected GNP Growth at Its Mean (2.94%)



IV. Conclusion

Previous examinations of the frequencies of dissent in FOMC votes, as in Belden (1989) and Puckett (1984), have concluded that District Bank presidents are more conservative than Board members. Potential explanations for this difference are explored in Tootell (1991). This conclusion has been interpreted by some as proof that Board policy is too loose and by others that District Bank policy is too tight. Proposed solutions to this "problem" have, thus, been either to depoliticize the Federal Reserve System, and in particular the Board of Governors, or to increase political control over the District Bank presidents. These policy prescriptions seem to have far outrun any evi-

dence that a problem even exists. This study examines the evidence from FOMC voting patterns. Qualitative response analysis reveals that the FOMC voting data do not support the conclusion that District Bank presidents and Board members vote differently. Policy prescriptions based on such an assessment are, therefore, unfounded.

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The Municipal Bond Market, Part I: Politics, Taxes, and Yields

Peter Fortune

Professor of Economics at Tufts University, and Visiting Scholar at the Federal Reserve Bank of Boston. *The author is grateful to Gilbert Metcalf, Daphne Kenyon, Richard Kopcke, Joe Peek and James Poterba for constructive comments.*

This article assesses recent changes in the structure of the municipal bond market. It reviews the tax legislation, judicial interpretations, and other factors that affect the yield on municipal bonds. These factors are then employed in a statistical analysis of the determinants of municipal bond yields. A companion piece will examine the public policy issues surrounding tax exemption and assess reforms of the market. The two papers represent a continuation of research at the Federal Reserve Bank of Boston on the subject (Huefner 1971; Fortune 1973; Peek and Wilcox 1986).

The first section of this article is an overview of the key features of municipal bonds, of the most significant changes in the structure of the market in recent years, and of the question of the constitutional and legislative basis for tax exemption. The second section focuses on the significant features of the income tax code that affect the municipal bond market. The third section reviews recent tax legislation affecting the market. The fourth section presents an econometric analysis of municipal bond yields, designed to determine whether the factors discussed in previous sections do, in fact, influence yields. The final section is a summary.

I. An Overview of the Municipal Bond Market

Several innovations in the nature of municipal debt have occurred in recent years. The purpose of this section is to outline the basic forms of municipal debt and to describe their yields, their exemption from tax, and their ownership. Petersen (1991) provides an excellent source for innovations in municipal financial instruments, such as variable-rate bonds and municipal commercial paper.

Forms of Municipal Debt

Municipalities issue debt in a variety of forms. State constitutions and statutes typically restrict short-term debt to purposes related to working capital, bridging the gap between expenditures and receipts. The most prominent forms of short-term debt, or notes,[1] are tax anticipation notes, revenue anticipation notes, grant anticipation notes and bond anticipation notes. Tax, revenue, and grant anticipation notes are used to provide funds for operating expenses, such as payments for wages, salaries, utilities and materials. They are repaid from anticipated tax revenues, federal or state grants, and non-grant, non-tax revenues, respectively. Bond anticipation notes are used to provide temporary financing of capital outlays, such as purchase of equipment and construction of schools and roads. They are repaid from the permanent long-term bond financing.

Long-term bonds address the problems of the lumpiness of municipal capital spending and the intergenerational nature of benefits.

Long-term bonds are issued for permanent financing of capital outlays, such as construction of bridges and roads, water and sewage systems, and schools. The purpose of long-term debt is to smooth out the path of tax revenues required to finance capital outlays and to distribute those revenues over time in conformity with the stream of benefits resulting from the project. For example, a solid waste disposal system is "too expensive" to be financed out of tax revenues in a single year, and the benefits of the disposal system occur over a long period. Therefore, financing from tax revenues would place a high burden on the current generation of taxpayers but no financial burden on future beneficiaries. Long-term bonds provide a way of addressing these problems of the lumpiness of capital spending and of the intergenerational nature of benefits.[2]

The two broad classes of long-term municipal debt differ according to the source of debt service payments (coupons plus principal). General obligations are backed by the "full faith and credit" of the community, meaning that debt service is to be paid from general tax revenues. General obligations are, other things equal, a safe form of investment for individuals and financial institutions, particularly when no limits exist on the ability of the issuer to raise the money via taxes to meet debt service requirements.[3] Only a few defaults of general obligations have occurred in this century, the most prominent being New York City in 1975 (on $2.4 billion of notes), Cleveland in 1978 (on $15.5 million of notes), and Bridgeport, Connecticut in 1991.

Revenue bonds have more limited backing—the revenues from specific projects. These bonds are issued by governmental agencies set up to finance, construct, and manage specific facilities. Examples of the hundreds of revenue authorities around the United States are the Massachusetts Turnpike Authority, the Massachusetts Port Authority, the Massachusetts Water Resource Authority and—for a national flavor—the Washington Public Power Supply System (WPPSS). If the revenues from the project (auto tolls, airplane landing fees, water and electricity billings, and the like) are not sufficient to meet debt service payments, the bonds can be defaulted and the issue goes to the courts to decide which claimants—employees, suppliers, or bondholders—will get paid. The bulk of municipal bond defaults have been revenue bonds, the most prominent in recent history being the 1983 default by WPPSS on $2.25 billion of bonds issued to finance nuclear generating facilities.[4]

Revenue bonds are the most rapidly growing form of bond indebtedness for states and local governments. This is due, in part, to restrictions in state constitutions that limit the ability of municipalities and states to issue general obligation bonds, leaving

[1] The term "notes" is usually applied when the maturity of the instrument is 12 months or less. "Bonds" refer to instruments with more than one year to maturity.

[2] This assumes that full capitalization of tax liabilities into property values does not occur. If full capitalization does exist, in which case the tax liability associated with borrowing by a state or local government is fully reflected in the value of residential and commercial property, the residents at the time of the bond issue will pay the full costs of the debt service regardless of maturity.

[3] The most default-free securities are, of course, U. S. Treasury bonds, for the government can always print the money to meet debt service payments if tax revenues are insufficient.

[4] One innovation in the past 20 years has been municipal bond insurance. About 10 percent of the WPPSS default was insured by a private company. The investors in the unit trusts that bought insurance did not lose principal or coupons as a result of the default.

the alternative of forming revenue authorities. While revenue bonds carry higher interest rates than general obligation bonds, the use of revenue bonds is the result of a mutually beneficial arrangement between issuers and investors: issuers can finance projects with revenue bonds without ransoming their taxing authority, paying the higher interest rates with fees and user charges borne by the beneficiaries of the projects, while investors can get higher rates of return in the form of a risk premium on municipal bonds.

Recent years have seen a rapid expansion of municipal bonds issued for purposes other than the traditional financing of infrastructure constructed by states and local governments. Among these are "private-activity" municipal bonds, advanced refundings, and arbitrage bonds. These will be discussed below.

Eligibility for Tax Exemption

The right to issue tax-exempt bonds is not automatic. In order to be eligible for exemption, a bond must meet standards imposed by law in section 103 of the Internal Revenue Code, as interpreted by the Internal Revenue Service. The purpose is, of course, to prevent municipalities from using tax-exempt debt to finance projects judged not to be for municipal purposes.

The problem of "private-activity" municipal bonds has grown dramatically in the last two decades (Zimmerman 1991). In the 1960s municipalities began to use their favored access to credit markets to induce businesses to locate within their jurisdiction. The device employed was the industrial development bond, issued by a municipality to finance construction of structures that were then leased to the private business, the lease payments providing the funds to meet debt service payments. In this way a business could finance its construction of factories and office space at municipal interest rates rather than at corporate bond rates.

The success of tax-exempt industrial development bonds led to a plethora of similar revenue bonds, each designed to serve a specific constituency: for example, mortgage revenue bonds, to finance loans at below-market rates to households to purchase homes; student loan bonds, to make loans to students at favorable rates; and pollution control bonds, to provide low-cost funds to corporations to acquire equipment for the reduction of water and air pollution. By the early 1980s the issuance of private-activity bonds was out of control. This can be seen in Figure 1, which shows the share of all long-term debt outstanding (corporate and foreign bonds, municipal bonds and mortgages) that is tax-exempt, whether for public or private purposes. The figure shows that total tax-exempt bonds declined as a share of all bonds and mortgages from 1960 through 1990, with a brief surge in the early 1980s. The state-local government share for public purposes declined throughout the period, while the private-activity share (issued on behalf of households and corporations) rose beginning in the early 1970s, growing to almost one-third of outstanding tax-exempt bonds by 1985.

The rapid growth of private-activity tax-exempt bonds led to the realization that those issues were having effects not intended by Congress. First, the federal taxpayer was underwriting a capital-cost subsidy for households and corporations, a subsidy never intended by Congress. Second, the competition for tax-exempt credit from private-activity bonds was forcing interest rates up for the intended beneficiaries of tax exemption—issuers of public purpose bonds.

A significant feature of the Tax Reform Act of 1986 was legislation limiting the eligibility of private-activity bonds for tax exemption. While limits had existed in earlier years, they were tightened considerably by this Act. Section 103(c), under which the private-activity definition is established, applies four different tests to determine whether a bond is private-activity. The first test—which is the most widely applied—is a joint test of uses-of-funds and of security interest: if more than 10 percent of a bond's proceeds are used for private purposes *and* if more than 10 percent of the debt service is derived, directly or indirectly, from a private use, the bond is deemed a "private-activity" bond.

A significant feature of the Tax Reform Act of 1986 limited the eligibility of private-activity bonds for tax exemption.

In order to be tax-exempt, a private-activity bond must (with some exceptions) be within the state volume limit and it must satisfy certain maturity

restrictions. The state volume limit, established in 1986, is now set at the greater of $50 per capita or $150 million. Tax exemption is automatically extended to private-activity bonds within that limit. However, seven categories of private-activity bonds are excluded from the volume limit and can be issued in tax-exempt form in any amount. These are "exempt facility bonds" (airports, docks and wharves, solid waste facilities, and the like), qualified mortgage bonds, qualified veterans' mortgage bonds, qualified small-issue industrial development bonds, qualified student loan bonds, qualified redevelopment bonds, and qualified section 501(c)(3) nonprofit organization bonds.

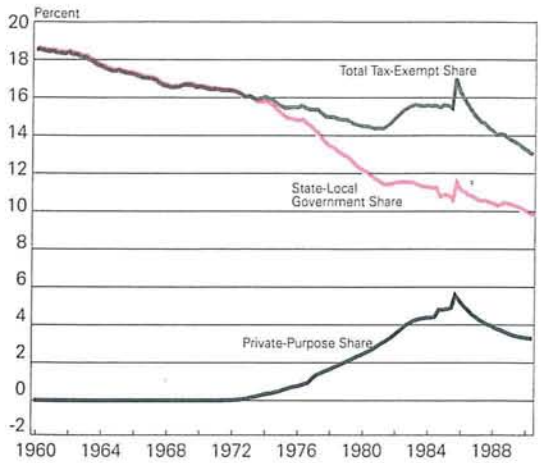
Figure 1 shows a dramatic reversal of the earlier trends after the 1986 Tax Reform Act. Following a brief surge in private-activity issues in 1985 in anticipation of the limitations imposed in the 1986 Act, the outstanding amount of tax-exempt bonds for private purposes declined sharply.

Another problem category of bonds is arbitrage bonds. In the 1960s, states and local governments became aware that tax exemption was a money machine: by issuing tax-exempt bonds at favored interest rates and investing the proceeds in taxable bonds, a municipality could earn a spread equal to the difference between the taxable and tax-exempt rates. Note that while these arbitrage profits can aid the states and local governments by providing funds to finance additional public services or to reduce tax rates, they are not necessarily in the financial interests of the taxpayers: that depends on the difference between the municipal bond rate paid and the after-tax rate of return the taxpayers earn on their investments.

In 1969, section 103(c) of the Internal Revenue Code was changed to define arbitrage bonds as bonds whose proceeds, beyond a "reasonably required" reserve, were used to invest in securities with a "materially higher yield" for more than a "temporary period." The problem of arbitrage bonds is presented most clearly when a bond is issued with the sole purpose of investing the proceeds at a higher interest rate and earning the spread over the period until the bond is repaid; this blatant use of tax exemption was clearly eliminated by the 1969 legislation. However, over the intervening 20-odd years the interpretation of section 103(c) has changed frequently. This is the result of two conflicting goals, the first being to close off the arbitrage opportunities still employed despite the regulation, and the second to allow tax exemption for bonds issued for "reasonable" uses, when the proceeds are temporarily invested in earning assets.[5] Because municipalities often find themselves in the situation of issuing a bond before the proceeds are expended, temporarily holding the proceeds, the difficulty in the arbitrage restrictions is setting standards that allow this to happen for reasonable pur-

Figure I

Tax-Exempt Share of Outstanding Bonds and Mortgages



Source: Board of Governors of the Federal Reserve System, *Flow of Funds Accounts*.

[5] An example is advanced refunding: the issuance of a new municipal bond to pay off an outstanding bond. The proceeds of the new issue are typically placed in an escrow account that holds U.S. Treasury securities whose income is sufficient to pay the debt service on the advance refunding bonds and to yield net income. The amount of the proceeds of the advance refunding issue, plus accumulated net income, is designed to be sufficient to pay off the original bond. Clearly this must be done before the retirement of the original issue at either maturity or a call date.

The optimal timing for an advanced refunding is when interest rates are low, so the advance refunding is often done well before the actual retirement of the outstanding issue. If the delay is sufficient to arouse the interest of the Internal Revenue Service, the new issue can be interpreted as an arbitrage bond and, in order to maintain the tax-exempt status of the advance refunding issue, the municipality must rebate to the U.S. Treasury the spread between the interest earned on the Treasury securities and the interest paid on the newly issued municipal bond. If this rebate is not made, the investor will lose the tax exemption, even if he had every reason to believe that the exemption was allowed when he purchased the bond.

poses, while eliminating the abuses of tax exemption.[6]

The Question of Constitutionality

The exemption of state and local interest payments on municipal bonds from federal income taxation has a long history, originating in a question about the legality of taxation of activities of one level of government by another level of government. During the years immediately following the American Revolution, power rested in the states and the federal government was weak. Concern for the financial fragility of the new federal government, combined with several attempts by states to tax activities of the federal government, led to a series of Supreme Court decisions, under Chief Justice Marshall, that protected the central government from the taxing powers of the states. Marshall's well-known dictum that "the power to tax is the power to destroy" was, in fact, a statement designed to protect the central government, although in modern times it has been used to support protection of the states from federal taxing powers. One of the most important of these cases was *McCulloch v. Maryland* (1819), in which Marshall's court struck down a tax levied by the state of Maryland on the Bank of the United States. This was the origin of the exemption of federal activities from state taxation.

The first federal income tax was enacted during the Civil War. It taxed both salaries and interest payments by states and local governments, but in *Collector v. Day* (1871) the Supreme Court ruled that the application of the tax to the salary of a state judge was unconstitutional. This decision established the doctrine of reciprocal immunity, in which the federal government and state-local governments were protected from the tax powers of the other. The expiration of the federal income tax in 1872 meant that this decision had a limited effect, but enactment of a new federal income tax in 1894 revived the issue. The 1894 federal income tax explicitly recognized *Collector v. Day* by exempting salaries paid by state and local governments, but included interest payments by states and local governments in the tax base. The federal taxation of state and local interest payments was struck down in 1895 in *Pollock v. Farmers' Loan & Trust Company*, when the U.S. Supreme Court held that interest on a state bond should be exempted from federal taxation. This case has been central to the argument that the exemption is protected by the Constitution.

The modern federal income tax was ushered in with the Sixteenth Amendment to the Constitution in 1913. The Sixteenth Amendment gave Congress the power "to lay and collect taxes on income, from whatever source derived." In the new income tax, enacted after the Sixteenth Amendment, the question of reciprocal immunity was avoided by explicitly exempting both interest *and* salaries paid by states and local governments, thus adhering to both *Collector v. Day* and *Pollock v. Farmers'*.

Because the initial tax rates were very low, the effect of this exemption on the state-local cost of capital was small. However, as federal income tax rates rose, the exemption of municipal interest became an economic issue. The 1920s and 1930s were periods of considerable debate about the interest exemption, with parties lined up on the basis of economic self-interest. Business organizations, such as the U.S. Chamber of Commerce, private utility companies that opposed a subsidy to their public competitors, and many state governments in the industrial North joined to oppose tax exemption. On the other side, many state governments in the non-industrial South strongly supported the exemption because of the subsidy it conferred and because they had little industrial base to be harmed by the competition for funds.

A constitutional amendment to eliminate the exemption failed in 1922, but it continued to be urged by the Coolidge, Harding, and Hoover Administrations. Gradually the scope of the exemption was narrowed by judicial decision rather than legislation. In *Graves v. New York ex rel. O'Keefe* (1939) the Court upheld a state tax on a federal salary, thereby overturning *Collector v. Day*. Ultimately this paved the way to elimination of the intergovernmental exemption for salaries. However, the exemption continued for interest payments, primarily as a result of the efforts of state and local governments.[7]

Proponents of the view that the exemption is protected by the Constitution have appealed to early Supreme Court decisions, such as *Pollock v. Farmers' Loan & Trust Company*, and to the proposals in the

[6] For much of the life of the arbitrage regulations, a municipality could avoid the arbitrage bond limitations by investing no more than 15 percent of the bond proceeds in a reserve fund, and by showing "due diligence" in completing the project the bond was intended to finance, with an upper limit of five years on the temporary holding period (Buschman and Winterer 1983). This still allowed considerable leeway for earning arbitrage profits, and a part of the 1986 Tax Reform Act tightened the restrictions further.

[7] This history of the early debate is drawn from Huefner (1971).

1920s to eliminate the exemption through a constitutional amendment. A significant minority of the legal profession continues to assert that taxation of state-local interest is barred by the U.S. Constitution, even though that uncertainty was eliminated in a series of U.S. Supreme Court decisions in the 1980s. Whatever one's views of the constitutionality issue, however, legislation has clearly conferred tax exemption: section 103(a) of the Internal Revenue Code of 1954, the basis for the present tax code, specifically exempts municipal interest income from the federal income tax.

Whatever one's view of the constitutionality issue, legislation has clearly conferred tax exemption for state and local interest payments on municipal bonds.

This legislative basis for tax exemption has been weakened in recent years. The first important decision addressed the Social Security Act Amendments of 1983, which imposed a tax on Social Security benefits if the taxpayer's income was above a specified level. For the purposes of this computation, "income" was defined as including interest from municipal bonds. As a result, the amendments indirectly imposed a tax on municipal interest: sufficient municipal interest income could lead to payment of additional taxes. The Supreme Court refused to hear cases charging that this was unconstitutional, thereby allowing continuation of the indirect taxation of municipal interest.

The second important piece of legislation weakening tax exemption was the 1982 Tax Equity and Fiscal Responsibility Act (TEFRA), which limited the exemption to municipal bonds issued in registered form, forcing all bearer bonds into the taxable category.[8] The purpose of this was to allow the federal government to track municipal interest income, an objective furthered in 1987 when the federal income tax forms required the taxpayer to report his municipal interest income even though it was not subject to tax.

Just when Congress was weakening the exemption, the Supreme Court clearly rejected any constitutional foundation for it. In *Garcia v. San Antonio Metropolitan Transit Authority* (1985), the Court held that the taxation of state and local interest payments was a matter of legislation, not a constitutional issue: if Congress wished to tax municipal interest, it was free to do so. This was upheld and clarified in a 1988 Supreme Court decision, *South Carolina v. Baker*, which upheld the 1982 TEFRA removal of tax exemption for state and local bonds not held in registered form. In his majority opinion, Justice Brennan argued that "states must find their protection from Congressional regulation through the national political process, not through judicially defined spheres of unregulated state activities."

Thus, at this point no constitutional barrier to elimination of the exemption of municipal interest remains. However, Congress has given no indication of interest in including municipal interest in the federal income tax base. The reason is that tax exemption has become a very valuable subsidy for states and local governments, and states and local governments have formed a powerful lobby to protect their preferred access to credit markets.

Unusual Features of Municipal Bonds

Municipal bonds differ from corporate, U.S. Treasury, and other taxable bonds in ways other than tax exemption. Perhaps the most prominent is the serial form of municipal bond issues, which affects both the liquidity and trading costs of municipal bonds.

Corporate and Treasury bonds are typically originated as a single issue in which each certificate carries the same coupon rate, call date, and maturity date. While retirement schedules typically differ—some corporate bonds are retired in a lump sum, while others are retired gradually through sinking funds—the essential feature of a taxable security is a single issue broken up into a large number of certificates, each with the same characteristics.

Municipal bonds, on the other hand, are typically sold in a "serial" form in which each "strip" is a separate bond. This means that instead of a single large issue, the bond consists of a series of smaller issues, each with its own maturity. For example, suppose that a city wants to borrow $100 million to

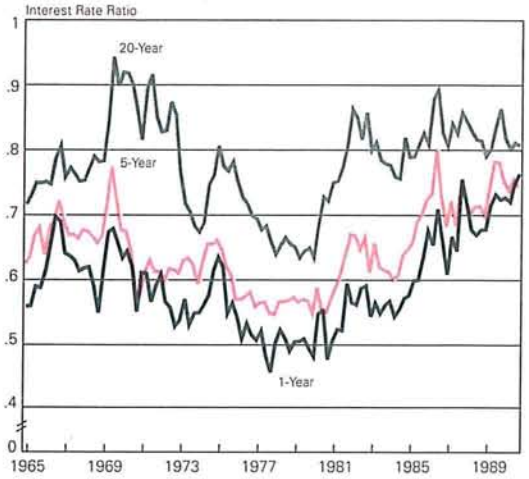
[8] A bond is held in registered form if the owner's name is recorded by a transfer agent—usually a bank—whose function it is to keep ownership records. The other form is a bearer bond, deemed to be owned by whoever holds it and for which no record of ownership is kept.

construct a sewage system. Instead of issuing one 20-year bond, which trades as a unit, it might issue 20 bonds, each having a different maturity: the first "strip" has a one-year maturity, the second strip has two years to maturity, and so on until the twentieth strip, which has 20 years to maturity. The distribution of the total amount between strips is a financial decision that the city must make at the time of the issue; for example, the city might want to retire an equal amount in each year, so each strip would have a par value of $5 million.

The serial bond is sold as a block to the winning underwriting syndicate. But when the syndicate sells the issue, it splits the issue into the individual strips, and the individual strips into certificates, which are marketed separately. The advantage of this approach is that the underwriter can typically get a higher price for the entire issue by selling each strip to investors who most want that maturity, and the issuer can tailor the retirement schedule to its needs by deciding how much of the issue will be allocated to each strip. If each strip is small, however, the cost of secondary market trading in individual strips might be higher than if the issue were traded as a unit, and this higher transaction cost will be reflected in a lower price paid by the investor.

Figure 2

Interest Rate Ratios for Selected Terms, Prime Municipal Bonds vs. U.S. Treasury Bonds



Source: Salomon Brothers, Inc.

Yields on Tax-Exempt Bonds

Exemption from federal income taxes confers an advantage upon the holder of municipal bonds. That advantage leads investors to require lower before-tax yields on municipal bonds than on taxable bonds of equivalent maturity and risk. The result is that the yield to maturity on tax-exempt bonds is less than the yield on taxable bonds with equivalent maturity and quality.

This advantage is shown in Figure 2, which reports the ratio of the yield on prime-grade municipal bonds to the yield on U.S. Treasury bonds. This "interest rate ratio" is shown for one-year, five-year and 20-year bonds.[9]

Several important observations can be drawn from Figure 2. First, for each of the three maturities shown, the interest rate ratio is less than unity, reflecting the tax advantages of municipal bonds. Second, for each maturity the interest rate ratio is highly variable: at times the advantage to the issuer of tax exemption appears to be quite small, as in 1969 when 20-year municipal bonds carried yields almost equal to 20-year Treasury bonds, while at other times the advantage is very great, as in the late 1970s when the interest rate ratio for 20-year bonds was about 0.65.[10]

Finally, the yield curve for municipal interest rates rises more rapidly than the yield curve for Treasury securities. This is evident from the fact that the interest rate ratio is higher for five-year bonds than for one-year bonds, and higher for 20 years than for five years. This phenomenon almost disappeared

[9] Prime-grade municipal and U.S. Treasury bonds are not precisely equivalent: Treasuries are of higher credit quality because the federal government can print the money necessary to repay its debt; Treasuries trade at lower transactions costs because they have a single issuer, while municipals are issued by a variety of states, local governments, and authorities whose quality is difficult to determine and whose issue sizes can be small; Treasuries are traded in a thick market while municipals have a lower level of liquidity. But these differences are (arguably) sufficiently small to allow us to use the interest rate ratio as a measure of the influence of tax exemption on municipal bond yields.

[10] The 1969 experience is an anomaly, probably due to the debate surrounding the 1969 Tax Reform Act. The House proposals would have included state-local interest in the new Alternative Minimum Tax. While the AMT was adopted, state-local interest income was not subject to the AMT. However, the prospect that these proposals would be adopted led to very high interest rate ratios in that year. For a discussion of the debate, see Huefner (1971), p. 100 ff.

in the late 1980s, especially for short- to intermediate-term bonds. Both the more rapidly rising yield curve (relative to Treasuries) of 1966–85, and the elimination of the differential for short- to intermediate-term bonds, are due to the role of commercial banks in the municipal bond market. These changes—which mean that the municipal bonds appear to trade more like taxable bonds—have been particularly marked since the Tax Reform Act of 1986.

Changes in Municipal Bond Ownership

Prior to the mid-1980s the largest holders of tax-exempt debt were financial institutions, primarily commercial banks and property and casualty insurance companies (Figure 3).[11] Indeed, from 1962 through 1980 the share held by households declined from over 40 percent to about 25 percent, with most of the market share moving toward commercial banks. State-local governments (primarily retirement funds) were significant holders of municipal bonds in the early 1960s, with about 10 percent of the outstanding stock, but this share declined thereafter. Insurance companies (primarily property and casualty insurers) have maintained a 15 to 20 percent share of outstanding state-local bonds, with a brief surge in 1975–80 and a return to their normal share by 1985.

Beginning in the mid-1980s the ownership pattern of tax-exempt bonds changed dramatically, with commercial banks sharply reducing their share from almost 55 percent in 1980 to about 25 percent by 1990. The withdrawal of commercial banks from the market was matched by an increase in the share held by households, from about 25 percent in 1980 to over 60 percent in 1990. The nature of household ownership also changed, as unit investment trusts and mutual funds provided both diversification opportunities and liquidity services not available to most households prior to the 1980s.

Beginning in the mid 1980s the ownership pattern of tax-exempt bonds changed dramatically, with commercial banks sharply reducing their share and the share held by households increasing.

The tax structure provides some explanation of these changes in ownership. Until the 1982 Economic Recovery Tax Act (ERTA), households faced tax rates as high as 70 percent, while commercial banks and property and casualty insurance companies faced a tax rate of 46 to 52 percent. Furthermore, until 1982 commercial banks could deduct from their taxable income all interest paid to carry municipal securities, a tax advantage that gave them a strong incentive to hold tax-exempt debt. Thus, high-income households, commercial banks, and property and casualty insurance companies had the greatest incentives to hold tax-exempt bonds and were the dominant holders.[12]

The 1982 Tax Equity and Fiscal Responsibility Act reduced the deductibility of interest expense for banks carrying tax-exempt securities to 85 percent of the interest paid. The 1984 Deficit Reduction Act further reduced the tax advantage for banks to 80 percent of carrying costs. Finally, with some exceptions,[13] the 1986 Tax Reform Act completely eliminated any deduction by banks of interest paid to carry municipal bonds, virtually extinguishing the advantages for banks of tax-exempt securities. Figure 3 shows the banks' share of the market stabilizing in the early 1980s and falling sharply after 1985. The plunge after 1985 is the result of the sharp decline in corporate income tax rates and the elimination of banks' deduction of interest paid to carry municipal bonds.

The Effect of Future Tax Rates on Bond Yields

The bond yields that prevail at any moment will be affected by anticipations of future tax rates: if investors believe that tax rates will rise (fall) in the future, they will require a lower (higher) yield on newly issued municipal bonds, relative to the yield

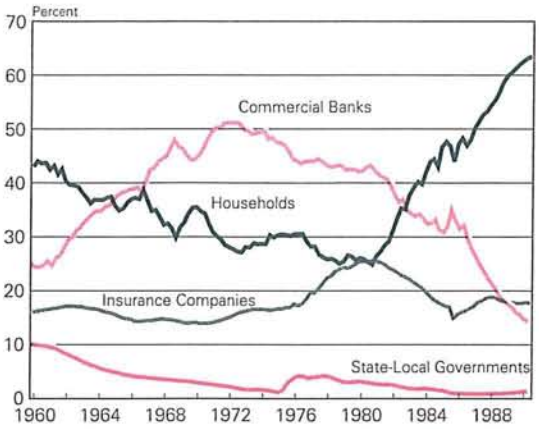
[11] Property and casualty insurance companies were by far the most important insurance companies in the municipal bond market. Until recently, life insurance companies faced relatively low tax rates, limiting their interest in municipal bonds.

[12] The property and casualty insurance sector's share of the market remained low in spite of high statutory tax rates because those companies experience a strong cycle in profitability. Thus, the tax advantages of municipals were enjoyed only during profitable years. This reduced the effective tax advantages.

[13] Municipal bonds acquired before August 16, 1986 still had deductible carrying costs. This led to a surge in bank purchases of private purpose bonds in anticipation of grandfathering of the exemption. Also, deductibility was continued for bank purchases of small local issues.

Figure 3

Shares of Outstanding State and Local Bonds Held by Selected Sectors



Source: Board of Governors of the Federal Reserve System, *Flow of Funds Accounts*, quarterly data.

on newly issued taxable bonds. It is difficult to quantify the role played by anticipations of tax rates: nobody keeps a record of what "the market" thinks tax rates will be in the future. One approach is to use "event analysis" to infer the influence of anticipated taxes. Poterba (1986) and Fortune (1988) have investigated the behavior of interest rates at times of tax policy changes, and find that the behavior of interest rates is consistent with the influence of anticipated tax rates on municipal bond yields.

Another approach is to assume that the market correctly anticipates the future and use these estimates as "actual" future tax rates to infer the effect of tax rate anticipations at any moment. However, the notion that—on average—the market is correct has received considerable attention, and very little support, from academics. For example, Fortune (1991a) surveys the evidence from the stock market, concluding that "the efficient market" is a concept worth selling short.

A third approach, adopted here, is to use market data to infer tax rate anticipations. One source for this is the yield curve on municipal and taxable securities. The implied marginal future tax rate for municipal bond investors can be derived as follows. Assume that an estimate is sought for the tax rate anticipated by the marginal investor in municipal bonds between five and ten years from now. If the interest rates are known for five-year municipal and taxable bonds that are newly issued five years from now, it is possible to estimate the implied tax rate for five to ten years in the future. Denoting $R_{M,5,10}$ as the yield on a municipal bond bought five years from now that matures ten years from now, and $R_{T,5,10}$ as the yield on an equivalent taxable bond, the implied future tax rate is $t_{5-10} = 1 - (R_{M,5,10}/R_{T,5,10})$.

Unfortunately, no direct information on future interest rates is available. The futures market in municipal bonds does not extend very far into the future and it is based on a bond yield index, not on yields for specific securities. However, indirect information can be found in the term structure of interest rates. According to the Expectations Hypothesis, the most widely held theory of the term structure, the yield to maturity on a ten-year municipal bond bought now ($R_{M,0,10}$) is mathematically related to the yield on a five-year bond bought now ($R_{M,0,5}$) and the expected yield on a five-year bond bought in five years ($R_{M,5,10}$). The equilibrium relationship is:

$$(1) \quad (1 + R_{M,0,10})^{10} = (1 + R_{M,0,5})^5(1 + R_{M,5,10})^5.$$

According to this relationship, $1 invested now in a ten-year bond will have an accumulated value in ten years equal to the accumulated value in ten years of a sequence of two investments: $1 invested now in a five-year bond, followed by investment of that accumulated value in a second five-year bond maturing five years from that date of purchase. Equation (1) assumes that the bonds are zero-coupon bonds.

The bond yields that prevail at any moment will be affected by anticipations of future tax rates.

If the relationship did not hold, investors would not diversify their portfolios by holding both five-year and ten-year bonds. Consider investors with a ten-year horizon. If the left side of equation (1) exceeds the right side, those investors would hold only ten-year bonds because the terminal value would exceed the terminal value from buying five-

year bonds and reinvesting the proceeds at maturity in five-year bonds. If, on the other hand, the left side is less than the right side, the investors would buy five-year bonds and reinvest in five-year bonds at maturity. Only when the equality in equation (1) holds will investors hold both five-year and ten-year bonds.

This relationship allows us to derive an estimate of the anticipated yield on five-year municipal bonds in five years. Solving equation (1) for $R_{M,5,10}$ gives:

$$(2) \quad R_{M,5,10} = [(1 + R_{M,0,10})^2/(1 + R_{M,0,5})] - 1.$$

Because the values of $R_{M,0,10}$ and $R_{M,0,5}$ are known right now, equation (2) can be used to calculate the value of $R_{M,5,10}$ which is implicit in the yield curve. This can also be done for taxable securities. An estimate of the tax rate expected to prevail between five and ten years in the future can then be obtained:

$$(3) \quad t_{5-10} = 1 - (R_{M,5,10}/R_{T,5,10}).$$

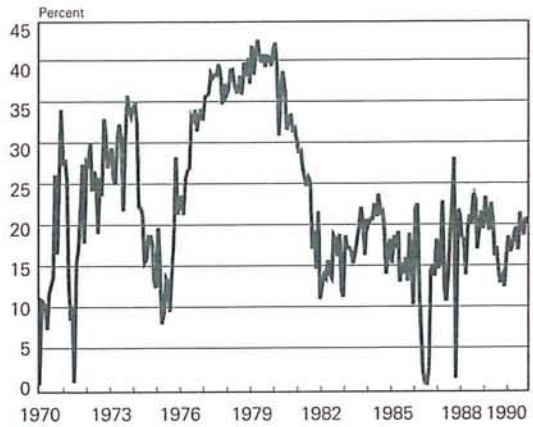
This approach is subject to a number of criticisms. First, it assumes that the taxable and tax-exempt yields used in the calculations are for securities that are equivalent in all respects except tax exemption. This is unlikely, because the issuers of taxable and tax-exempt bonds are inherently different in terms of default risk, because call features or other special features might make the bonds different, and because transactions costs can differ, with municipal bonds generally less liquid and traded in a thinner market than taxable bonds.

Second, this approach assumes that investors are indifferent to the maturity structure of their portfolio; no "market segmentation" exists. All investors care about is the expected yield on their portfolios, and market risks are irrelevant to portfolio decisions.

Using the Salomon Brothers data for five-year and ten-year prime municipal bonds and U.S. Treasury bonds, the estimates of t_{5-10} have been derived (Figure 4). The implied future tax rate shows a good bit of noise in it, as one would expect because of the potential for factors such as call features to distort the yield curve relationships. But the general outlines of the series seem to fit reasonably well: the implied future tax rate fell sharply after 1979, in apparent anticipation of the tax rate reductions in the 1981 Economic Recovery Tax Act (ERTA). Furthermore, after 1982 the implied future tax rate is about 15 to 20 percent, consistent with the low tax rates introduced in the 1981 ERTA and subsequent tax acts. Also, the mid-to-late 1970s show a high anticipated future tax rate, a result not inconsistent with the discussions of the times, an example being President Carter's statement that "the tax system is a disgrace to the human race." It is no surprise that this period of high anticipated tax rates was also a period of low interest rate ratios.

Figure 4

Future Tax Rate, Five to Ten Years Out



Source: Salomon Brothers, Inc. and author's calculations.

II. The Income Tax Code and Municipal Bonds

The previous section touched on some aspects of recent tax legislation to explain major changes in the municipal bond market. This section reviews the key features of the income tax code that influence the demand for tax-exempt debt, and, therefore, help to explain municipal bond yields. This journey through the income tax code provides background essential to the formal analysis of the determination of municipal bond yields in later sections.

Taxation of Ordinary Income from Bonds

The Internal Revenue Code identifies two forms

of taxable income. The first is "ordinary income," which consists of cash payments such as coupons, interest paid, cash dividends, and original issue discounts.[14] The second is "capital gains," defined as the difference between the price at which an asset is sold and its "cost basis" at the time of sale. The code allows the holder of a tax-exempt bond to exclude ordinary income but not capital gains from taxable income.

Original issue discount is the difference between the par value of the bond—the amount paid at maturity—and the initial price at which the bond came to market. For example, suppose a bond has a par value of $1000 and was originally issued at a price of $900. The difference of $100 occurs because the coupon rate on the bond is less than the interest rate prevailing on similar securities at the time of issue. The tax code treats this as cash income even though it does not give rise to cash payment until the bond matures. If the bond is taxable, the discount is included in taxable income as it accrues; if the bond is tax-exempt, it is not included in taxable income.

The tax code does not allow the investor to wait until the bond matures before he "earns" the original issue discount. Instead, investors must amortize the discount over the life of the bond. If the bond's income is taxable, the amortized value is added to each year's taxable income; if the bond is tax-exempt, it is not added to taxable income. In either case, the amortized value of the original issue discount is added to the cost basis of the bond and becomes relevant to the calculation of capital gains.[15]

As noted above, the amortization of the original issue discount also affects the cost basis of the bond. The amount of the discount assigned to each year is added to the cost basis of the bond, so that the accumulated discount is not treated as capital gains when the bond matures or is sold. The logic is straightforward: if the discount was earned in the past, it was either taxed if the bond was taxable or treated as tax-exempt if the bond was tax-exempt. But if the cost basis is not adjusted upward to reflect the accumulated original issue discount, when the bond is sold that amount will be treated as capital gains—and capital gains are taxed whether the bond is tax-exempt or not!

Taxation of Capital Gains

The Internal Revenue Code taxes capital gains on a cash basis rather than on an accrual basis. This means that gains are taxed only when realized upon the sale of the asset, not as they accrue "on paper" over the holding period. As noted above, the amount of capital gains is defined as the difference between the price at which the asset was sold and the "cost basis" of the asset. The cost basis is usually the price (including brokerage commissions) at which the asset was purchased, but the cost basis can also reflect certain adjustments such as the original issue discount.

The effect of the opportunity to defer capital gains taxes is to reduce the effective tax rate on accrued gains. For example, suppose that during 1991 a stock in your portfolio increases by $10 per share. If capital gains were taxed on an accrual basis, you would have to include that $10 in your 1991 taxable income even though you had not sold the asset. But suppose that you do not sell the stock until 1996. Assuming a capital gains tax rate of 31 percent, you will pay a tax of $3.10 per share in 1996, but at an interest rate of 10 percent, the present value in 1991 of your 1996 capital gains tax liability is only $1.92. Thus, your effective capital gains tax rate in the year of accrual is only 19.2 percent if you defer the gains for five years.[16]

Until recently, capital gains were taxed at a lower rate than ordinary income. For example, from 1942 to 1978, the tax code allowed an investor to exclude 50 percent of capital gains from taxable income, thus setting the capital gains rate at 50 percent of the ordinary income tax rate. During much of that time, however, the maximum capital gains tax rate was set at 25 percent. From 1978 to 1986 the code allowed 60

[14] Coupons, interest, and cash dividends are, with some exceptions, defined as ordinary income and included in a taxpayer's taxable income in the year they are received unless they are explicitly excluded, as in the case of a tax-exempt bond. Among the other exceptions are return of capital dividends and a major portion of dividends received by financial institutions.

[15] After the 1982 Tax Equity and Fiscal Responsibility Act (TEFRA), original issue discount was amortized as accrued interest: the investor calculated the interest rate that would accumulate the initial price to be equal to the price at maturity, and an amount equal to that interest rate times the cost basis was treated as ordinary income in each year. Before TEFRA the amortization was constant in each year.

[16] Indeed, capital gains taxes can be avoided completely by holding assets until death, because the cost basis of assets is adjusted to the market price at the time of death, effectively eliminating any taxation of the capital gains when heirs sell the assets. However, the potential avoidance of taxation of capital gains as income does not mean that the gains are shielded from all taxation: federal estate taxes are levied if the estate is large enough. Because the estate tax liability depends upon the size of the estate, not upon the amount of the capital gains, two estates of equal size will pay the same tax even though one might have a considerably greater appreciation component than the other. Thus, the estate with the greater capital gains will not pay any additional taxes.

percent of gains to be excluded, which, because of the 50 percent maximum tax rate on ordinary income, had the effect of reducing the maximum tax rate on capital gains to 20 percent. Thus, an individual taxpayer in the highest bracket would pay 50 percent on ordinary income but only 20 percent on capital gains.[17]

The Tax Reform Act of 1986 eliminated this differential. Under that law, 100 percent of capital gains are included in taxable income and, with a 33 percent maximum tax rate on ordinary income, the maximum capital gains tax rate was also 33 percent. The Revenue Reconciliation Act of 1990 restored a slight differential in favor of capital gains by setting a maximum capital gains tax rate of 28 percent.

The effect of the opportunity to defer capital gains taxes until the sale of the asset is to reduce the effective tax rate on accrued gains.

Note that capital gains taxation makes municipal bonds selling at a discount less attractive because the investor is taxed on part of the return. To see this, assume that an investor is choosing between a newly issued taxable bond and a newly issued tax-exempt bond, each priced at par. He knows that if interest rates rise, the price of each bond will fall, and that if he sells the bond at a loss, the capital loss is deductible regardless of whether the bond is taxable or tax-exempt. But the market discount at the time of sale will expose the new buyer to capital gains taxes. Because part of the return to the municipal bond will now be taxable, the new buyer will pay a still lower price to compensate him for the capital gains taxes. The taxation of capital gains is, however, not disadvantageous for the taxable bond since the new buyer will pay taxes whether his income is in the form of coupons or capital gains.

Therefore, the prospect of price decreases should make municipal bonds less desirable than taxable bonds, inducing a higher interest rate ratio. This effect should have been greater prior to the 1986 Tax Reform Act, when capital gains were taxed at lower rates than ordinary income. Furthermore, the effect of the taxation of capital gains on municipal bonds should also be greater when interest rates and asset prices are more volatile. The econometric analysis in Section IV will employ a measure of price variability to determine whether this hypothesis is supported.

Taxation of Capital Losses

The tax treatment of capital losses is not symmetrical with the treatment of gains. While 100 percent of realized gains are included in taxable income, the tax code might not allow full deduction of losses from taxable income if losses exceed capital gains: for a married couple filing jointly, losses can be fully deducted up to the amount of capital gains plus $3,000, but any losses above that amount must be carried over to future years. Thus, while a taxpayer can ultimately deduct all losses so long as taxable income is sufficient to take the deduction, the ceiling on the loss deduction allowed in a single year reduces the present value of the tax saving by the requirement to defer the deduction to future years.

For example, consider a married person filing jointly who has taxable ordinary income of $20,000. Suppose that this person has a capital gain of $2,000 and a capital loss of $10,000. In the current tax year he can deduct $5,000 of capital losses—$2,000 against the capital gain plus the $3,000 maximum loss offset. The remaining $5,000 of capital losses can be carried over to future years: $3,000 can be deducted in the next year, and the remaining $2,000 in the following year.

The absence of full loss offsets leads investors to alter their portfolios to reduce their exposure to price risk. This does not mean that they should avoid risky assets, only that the absence of full loss offset provides an incentive to reduce investments in risky assets below the level that would prevail with full loss offset.

State Income Taxes

The focus of this paper is the federal income tax code, but no survey of the connection between taxation and the municipal bond market is complete without reference to state income taxation. Forty-two states levy an income tax on interest and dividends,

[17] Since 1969 an Alternative Minimum Tax has applied in unusual circumstances and can have the effect of increasing the tax rate on capital gains. The Alternative Minimum Tax does not have a substantial effect on the tax positions of most investors, and has not been considered in this overview of capital gains taxation.

with tax rates ranging from very low levels to a high of 12 percent in Massachusetts and North Dakota.[18] In addition, 36 of the states with an income tax exempt some or all interest paid by government agencies within their own jurisdiction, and tax all out-of-state municipal interest income. Thus, in most states in-state municipal bonds offer a tax advantage.

If the marginal investor in a state's bonds is a resident of the state, jurisdictions in those states will pay lower municipal bond rates than those paid in states with lower tax rates. This will occur because the intra-state investors will pay a higher price for those bonds than will investors in other states. However, if the marginal investor is out-of-state, high state income tax rates will not affect the municipal bond yields paid by jurisdictions within the state. In this case, the advantages of within-state tax-exempt bonds accrue as a "windfall" to within-state investors.

The importance of this segmentation has been examined by Kidwell, Koch and Stock (1984), who conclude that—as a generalization—a state's residents are the marginal investors in that state's state-local bonds. Therefore, they find that (other things equal) high state income taxes do confer lower borrowing costs on the state and its political subdivisions.

III. Recent Tax Legislation

The key events in legislation in recent years are summarized in the box. The most prominent change is a radical revision of tax rate schedules, with both a general reduction in tax rates and a reduction in the degree of progressivity. The rate reductions should lead to an increase in interest rate ratios, while the decline in progressivity should reduce the rate ratios. In addition, since 1985 the tax rate schedule has been indexed, thereby reducing the "bracket creep" which, slowly and over time, pushed tax rates up and reduced the interest rate ratio. Finally, specific changes have limited the desirability of municipal bonds to financial institutions and restricted the use of tax-exempt bonds for "private" purposes. These changes will be discussed in order.

Changes in Tax Rates

Federal taxation of corporate income establishes a lower tax bracket for corporations with very low net incomes, but most corporate income is taxed at the maximum statutory tax rate. That rate changed very little until 1987: the maximum tax rate on corporate income was 52 percent in the early 1960s, fell to 50 percent in 1964, to 48 percent in 1965, then to 46 percent in 1979, then to the present 34 percent in 1987. Thus, the corporate tax rate has not varied sufficiently to account for the significant variation in the interest rate ratio.

Recent changes in tax rates have been more generous for high levels of income than for low, with greater effects on securities held by upper-income groups, such as common stocks and municipal bonds.

Changes in the personal income tax rate schedule have been more dramatic. The 1981 ERTA reduced the maximum personal income tax rate to 50 percent, and reduced other personal income tax rates by 25 percent over a three-year period. The Tax Reform Act of 1986 dramatically reduced tax rates for most income levels. The maximum tax rate on personal income was reduced from 50 percent to 38.5 percent in 1987 and 33 percent for 1988 and later years. The 1986 Act also simplified the individual income tax rate schedule by cutting the number of brackets from 14 to only four (15 percent, 28 percent, 33 percent, and 28 percent), widening the income levels associated with each bracket and thus reducing the problem of bracket creep.

The most recent change—the Revenue Reconciliation Act of 1990—further reduced the number of tax brackets to three (15 percent, 28 percent, and 31 percent) for 1991 and later years, thereby eliminating the "bubble" for upper-income levels. In addition, the amount of itemized deductions was reduced by 3 percent of income over $100,000: if a taxpayer's

[18] These rates are for 1990 income. Connecticut has a 14 percent maximum rate on interest and dividends; the Connecticut tax is levied only if 1990 federal adjusted gross income exceeds $54,000.

Major Tax Legislation in Recent Years

1976	Tax Reform Act	· Lengthened holding periods for long-term capital gains from six months to one year. · Created tax-sheltered Individual Retirement Accounts (IRAs).
1978	Revenue Act	· Widened personal income tax brackets. · Reduced maximum corporate income tax rate from 48% to 46%.
1981	Economic Recovery Tax Act (ERTA)	· Cut maximum personal income tax rates from 70% to 50%. · Reduced personal income tax rates at all levels by 25% over a three-year period. · Initiated indexation of tax brackets beginning in 1985. · Introduced super-accelerated depreciation of business assets (ACRS). · Expanded tax-sheltered investment opportunities —introduced All Savers Certificates —expanded eligibility for IRAs —introduced net interest exclusion.
1982	Tax Equity and Fiscal Responsibility Act (TEFRA)	· Allowed deduction of only 80% of interest paid to carry municipal bonds. · Established 10% withholding tax on interest and dividends.
1983	Social Security Act Amendment	· Subjected Social Security benefits to federal income tax. · Formula for Social Security benefit tax led to indirect taxation of municipal interest.
1984	Deficit Reduction Act	· Postponed ERTA's interest exclusion. · Extended tax exemption for mortgage revenue bonds to 1987. · Reduced holding period for long-term capital gains to 6 months. · Limited depreciation on assets leased to tax-exempt entities.
1986	Tax Reform Act	· Reduced maximum personal income tax rate to 33% and maximum corporate income tax rate to 34%. · Replaced 14 personal income tax brackets with only four (15%, 28%, 33%, 28%). · Eliminated deduction of interest paid by commercial banks to carry municipal bonds. · Placed limits on eligibility of "private-purpose" municipal bonds for tax exemption. · Dramatically reduced the tax advantages of many "tax shelters," such as real estate.
1990	Revenue Reconciliation Act	· Established three tax brackets (15%, 28%, 31%). · Set maximum capital gains tax rate at 28%. · Reduced itemized deduction by 3% of income over $100,000, resulting in an increase in the effective ordinary income tax rate by roughly 1%.

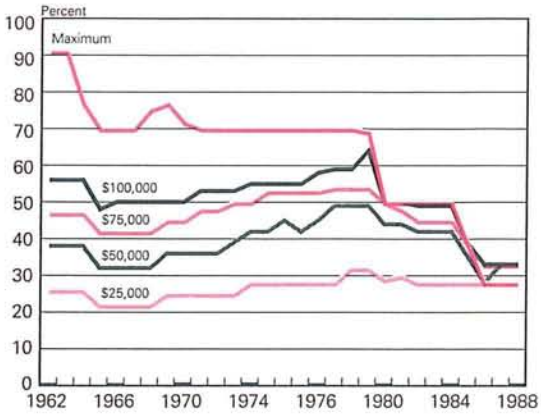
income is, say, $110,000, his itemized deductions are reduced by $300, effectively raising his marginal tax rate from 31 percent to about 32 percent.

Figure 5 reports the maximum statutory tax rate on personal income as well as the marginal tax bracket for four levels of real income between 1962 and 1990. The maximum tax rate was 91 percent in the early 1960s, then fell to 70 percent in 1965 where it stayed through 1981 with a brief period of increase (1968–70) because of a surtax levied to finance the Vietnam War. In 1982 the maximum rate was reduced to 50 percent, then to 33 percent in 1987.

The marginal tax rates for four levels of real income, measured in 1980 dollars, are also shown in Figure 5. For all real income levels, the marginal tax bracket increased from 1962 through 1981; this increase was due to bracket creep. It is clear that the changes in tax rates initiated by ERTA in 1981 and followed by the 1986 Tax Reform Act have been more generous for high levels of income than for low: the marginal tax rate at the $25,000 real income level was actually higher in 1990 than in 1962. Thus, to the extent that tax rates affect investment decisions, small effects, if any, should be seen for securities held by lower-income groups (bank deposits, corporate bonds) and the effects should be more dramatic for securities held by upper-income groups (common stocks, municipal bonds).

Figure 5

Marginal Personal Income Tax Rates at Selected Income Levels (1980 Dollars)



Source: Internal Revenue Code and author's calculations.

Indexation of the Tax System

Prior to the 1980s, the tax system was based solely on nominal income levels. This meant that the depreciation allowed businesses for plant and equipment was based on original cost, not replacement cost, and the tax rate schedule was based on the money value of taxable income. This clearly presented a problem in an inflationary environment such as that prevailing in the 1970s and early 1980s.

One effect of inflation is that the cost of replacing physical assets, such as vehicles, equipment, and structures, exceeds the original cost of the assets. As a result, historical cost depreciation—based on the original cost of the depreciable asset—means that businesses cannot fully recognize the cost of replacing equipment as a deductible cost of business. The effect is to overstate business income by including in it the difference between "economic" depreciation on a replacement cost basis and historical cost depreciation. This overstatement of business profits results in higher tax payments and a deterioration of the firm's financial position.

A second effect of an inflationary environment is that it results in higher tax rates on real income because individuals moved into higher tax brackets when their money income rose, even though their real incomes remained unchanged or even declined.[19] This phenomenon, called "bracket creep," raised the effective tax rate on real income over time as inflation continued.

The 1981 Economic Recovery Tax Act introduced indexation of the personal income tax brackets, beginning in 1985. With indexation, the break points between tax brackets are increased according to a general price index. For example, in 1985 the tax rate was 28 percent for taxable income in the range $31,120 to $36,630, but in 1986 the 28 percent rate was applied to taxable personal income between $32,270 and $37,980, reflecting inflation of about 3.7 percent between 1985 and 1986. Indexation has eliminated the problem of bracket creep, at least for taxpayers

[19] This has been particularly important for personal income taxes, which, for much of this century, had a complex set of tax brackets. For example, in 1986, before the Tax Reform Act of 1986 became effective, there were 14 tax brackets: for a married taxpayer filing jointly, these ranged from 11 percent for income between $3,670 and $5,940 to 50 percent for taxable income over $175,250.

whose consumption bundle mimics the composition of expenditures that the general price index represents. For other taxpayers a weak connection between real tax rates and inflation might remain, but this has been reduced by the movement toward a flat-rate tax system in the 1986 and 1990 tax laws.

Other Aspects of the 1986 Act

As discussed in Section II, the 1986 Tax Reform Act imposed restrictions on private-activity use of tax-exempt bonds. This favored the tax-exempt bond market, forcing private borrowers back into the taxable bond market and, to the extent that relative supplies of taxable and tax-exempt debt affect relative yields, raising the spread between taxable and tax-exempt yields.

A second piece of the 1986 legislation restricted the tax advantages of a wide range of "tax shelters." For example, depreciation of real estate was dramatically reduced, raising the effective tax rate on real estate investments. This elimination of tax shelters was used as a selling point by the municipal bond industry, the claim being that municipal bonds were the sole remaining tax shelter. If this claim were true, the municipal bond rate should have fallen relative to taxable bond yields, reinforcing the effect of private-activity bond limitations.

A third non-tax-rate feature, also noted above, was the elimination of the commercial bank deduction for costs of carrying municipal bonds. The effect of this change offset, to some extent, the effect of the other two legislative changes: municipal bond yields would rise relative to taxable bond yields as nonbank sectors were induced to increase their holdings of municipal bonds.

Thus, the 1986 legislation not only dramatically changed the tax rate structure, it also introduced important non-tax-rate changes that could have, in principle, either favored or harmed the municipal bond market.

IV. The Determinants of Municipal Bond Yields

This section uses the insights developed in previous sections as the basis for a statistical analysis of municipal bond yields. The primary purpose is to test whether the recent experience for the yields on municipal bonds is, in fact, consistent with the propositions developed in the previous section. The analysis will focus on interest rate ratios, as defined in the first section and as shown in Figure 2.

The Traditional Explanation of the Interest Rate Ratio

Why do interest rate ratios vary so much over time? Why has the ratio been higher for long maturities than for short maturities? Why has the difference between the long and short maturities almost disappeared in recent years? This section presents a simple model of the municipal bond market that addresses these questions.

Assume that municipal bonds and taxable bonds are substitutes in investors' portfolios. Each investor will choose an amount of municipal bonds based on his tax rate and on his assessments of the relative liquidity of municipal bonds. For each investor, the optimal holding of municipal bonds will be that quantity for which $(R_M/R_T) = \lambda + (1 - t)$, where t is his tax rate and λ is the liquidity premium required by the investor. While the tax rate is exogenous to the investor's decision, the liquidity premium is endogenous: as an investor contemplates increasing the amount he invests in municipal bonds, he will require a higher interest rate ratio to compensate for the increased risk and lower liquidity of municipal bonds.

The liquidity premium is due to several sources of risk inherent in municipal bond ownership.

The liquidity premium is due to several sources of risk inherent in municipal bond ownership. The first is lower liquidity and higher transactions costs due to the serial form of municipal bonds: because each bond is traded in separate strips, the average transaction is often small, which leads to increased transactions costs, and investors cannot sell their municipal bonds as quickly as Treasury or corporate bonds can be sold. In addition, as shown in Section II, the tax code penalizes municipal bonds relative to taxable bonds when bond prices fall. Finally, investors are uncertain about future income tax rates and will require some premium to compensate them for this uncertainty. While the nature of each of these

risks is quite different, the term "liquidity premium" is used to describe the additional interest rate ratio required by investors to compensate for these extra risks.

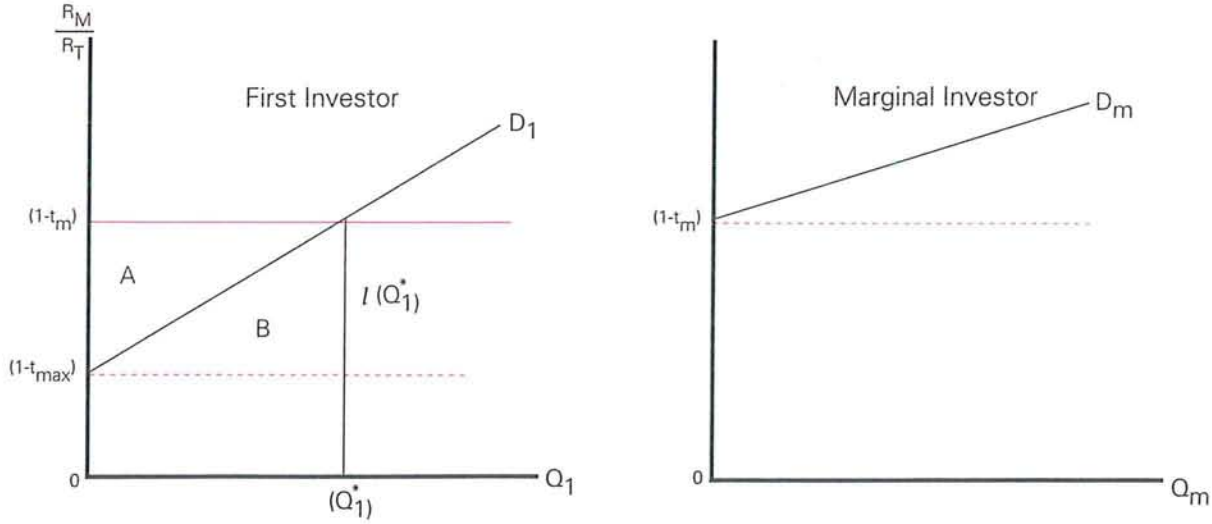
Assume that the liquidity premium is zero for the first dollar of municipal bonds held by an investor: if an investor holds no municipals, he considers the first dollar of municipals to be equivalent to a dollar of taxable bonds. This means that for intramarginal investors, the interest rate ratio will exceed the value $(1 - t)$ by the liquidity premium required to induce them to hold municipal bonds. But for the marginal investor, who holds a small amount of municipal bonds, the interest rate ratio is $(1 - t_m)$, where t_m is the marginal investor's tax rate.

Figure 6 shows the demand functions for municipal bonds of two investors, the "first investor," whose tax rate, t_{max}, is the highest, and the "marginal investor," with tax rate t_m. The quantity of municipal bonds acquired is measured along the horizontal axis. The vertical axis shows the interest rate ratio. The horizontal lines at interest rate ratios $(1 - t_{max})$ and $(1 - t_m)$, respectively, show each investor's demand function for municipal bonds if tax-exempt and taxable bonds are perfect substitutes. In that case, investors do not require a liquidity premium and only tax rates matter in determining whether to buy a tax-exempt or a taxable bond. The upward-sloping solid lines labeled D_1 and D_m are the actual demand functions, with the vertical distance to the broken line representing the liquidity premium required to induce the investor to hold each quantity of municipal bonds.

Figure 6 assumes that the bond markets have settled into an equilibrium in which the interest rate ratio is just sufficient to induce a marginal investor with tax rate t_m to buy a small amount of tax-exempt bonds. The equilibrium interest rate ratio is $(1 - t_m)$, which is high enough to induce the first investor to hold Q_1^* in tax-exempt bonds. For each investor, the interest rate ratio is composed of two parts. The first is the ratio required to give tax-exempts the same after-tax return as taxable bonds; for the first investor this is $(1 - t_{max})$. The second part is the liquidity premium required to compensate intramarginal investors for the extra risks they attach, at the margin, to tax-exempt bonds. For the first investor the liquidity component is the value of λ at Q_1^*, or $\lambda(Q_1^*)$. For the marginal investor the liquidity component is (by assumption) zero.

Figure 6

Individual Investors In the Municipal Bond Market



Following an unfortunate convention, the term "windfall income" will be used to designate any income from tax-exempts in excess of the income required to break even on an after-tax basis. For the first investor the dollar value of windfall income is measured by R_T* (area A + area B).[20] But R_T* area B is not really a windfall, for it is the amount of extra income required to induce the investor to hold Q_1* of municipal bonds. The only true excess income is measured by R_T* area A. This is the "investor's surplus," which exists because the investor earns interest on his intramarginal investment in excess of the amount required. Note that in the case of a linear demand function, the investor's surplus will be 50 percent of the investor's windfall income.

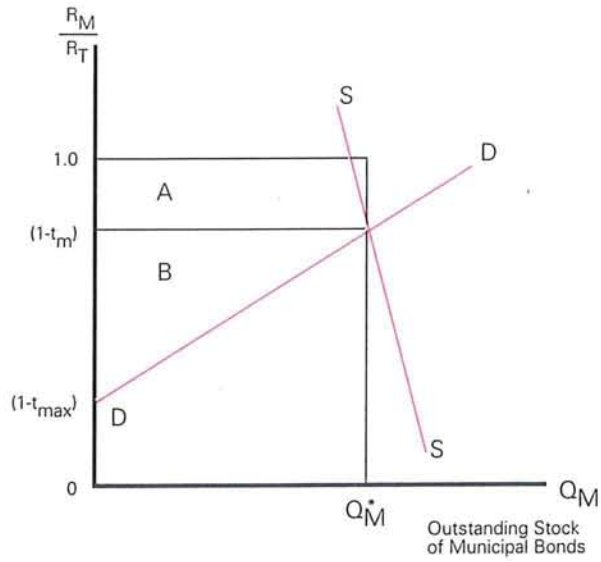
Figure 7 shows the municipal bond market under these conditions. The vertical axis represents the interest rate ratio while the horizontal axis shows the quantity of municipal bonds outstanding. The upward-sloping schedule, marked DD, is the demand function for municipal bonds: as the interest rate ratio rises, more investors are induced by tax considerations to hold municipal bonds. As the market travels up the demand schedule, the marginal tax rate of investors is falling because new investors drawn into the market have lower tax rates.

The bond supply schedule, SS, is assumed to be moderately sensitive to the municipal bond rate, hence it is downward-sloping but with a steep slope. The bond supply function will also shift with the level of the taxable bond rate. To understand this, note that the supply of municipal bonds is affected by the *municipal* bond rate, but the vertical axis in Figure 7 is the interest rate ratio, which depends on both interest rates. As a result, the position of the supply schedule will depend upon the level of the taxable bond rate: at any rate *ratio*, a higher R_T implies a higher municipal bond rate and a lower quantity of tax-exempt bonds issued. Thus, SS will shift leftward (rightward) when R_T rises (falls). For expository purposes, we will assume that R_T is at its equilibrium level and is not changing.

This model suggests two basic demand-side determinants of the municipal bond yield. The first is the maximum tax rate, t_{max}. A fall in t_{max} will make municipal bonds less attractive to the first investor, encouraging him to buy fewer municipals and shifting DD to the left.[21] The second factor is the progressivity of the federal income tax schedule: a less progressive tax rate schedule will create a flatter slope of the DD schedule so that the DD schedule rotates clockwise at the rate ratio $(1 - t_{max})$. This creates a

Figure 7

The Market for Municipal Bonds



lower rate ratio. Thus, the interest rate ratio should be inversely related to the maximum tax rate and directly related to the degree of progressivity in income tax rates. The econometric analysis in Section V will support these hypotheses.

Before proceeding, it should be noted that in recent years another school of thought on municipal bond yield determination has arisen. This school, associated with Fama (1977) and Miller (1977), argues that the personal income tax rate schedule—the focal point of the traditional explanation—is irrelevant, and that the interest rate ratio is determined by the corporate income tax rate (t_c). This "New View" is described below in an appendix. Although it received some empirical support in its early years, recent changes in the structure of the market have weakened any validity of the New View.

[20] Because the vertical axis is in units of taxable interest, any area in Figure 6 is measured in units of the taxable interest rate. To convert an area to a dollar value we must multiply it by R_T. This is why the dollar value of windfall income is R_T* (area A + area B), rather than simply area A plus area B.

[21] Note that if taxables and tax-exempts were perfect substitutes, this would not be true. High-bracket investors would invest all of their available funds in tax-exempts. A change in the tax rate they face will alter the windfall income they receive, but not the amount invested.

The Term Structure of Municipal Bond Yields

The analysis of the previous sections assumes a single type of municipal bond, and does not allow consideration of such issues as the term structure of municipal bond yields. The interest rate ratio rose sharply after 1986 for one-year and five-year terms, however, while it changed little for 20-year bonds. Figure 2 shows this clearly, and also shows that after 1986 the one-year ratio was almost equal to the five-year ratio.

The most widely held explanation of these changes in the term structure of municipal bond yields appeals to the notion of "market segmentation." For much of this century commercial banks have been important investors in the market for tax-exempt debt, and banks prefer (other things equal) to invest in securities with short to intermediate maturities. Households, on the other hand, have traditionally preferred longer-term bonds. This description of the municipal bond market certainly fit the data over the years when it was formed: the 1960s and 1970s.

However, as noted above, this picture changed dramatically in the mid 1980s when banks withdrew from investments in municipal securities. Because banks typically hold shorter maturities, the primary impact of this withdrawal was in those maturities. This meant that one or both of two things had to happen. First, municipalities had to reduce their issue of short- to intermediate-term debt; this could be accomplished by reducing capital outlays, by increasing use of tax revenues to finance capital outlays, or by substituting longer-term debt for short- to intermediate-term bonds. Second, some nonbank sectors had to be induced to acquire short- to intermediate-term debt when they would not otherwise have done so. Both of these adjustments require a rise in yields on short- to intermediate-term bonds relative to long-term yields.

The primary adjustment was of the second form: households responded by increasing their ownership of municipal bonds, much of this in the short to intermediate maturities. The shortening of average maturities held by the household sector was aided by several financial innovations that reduced the risks, and increased the liquidity, of municipal bonds. Chief among these was the formation of mutual funds specializing in municipal debt of all maturities, but particularly of short to intermediate maturities. These allowed households with small portfolios to diversify their holdings as well as to gain liquidity by check-writing privileges and by redemption of shares at net asset value. A second innovation was the development of private firms providing municipal bond insurance. While bond insurance had been first provided in the early 1970s, the explosion of the market for it in the 1980s was induced by the growing dominance of households in the municipal bond market.

V. An Econometric Analysis

In this section a model of interest rate ratios will be estimated. The variables to be explained are four interest rate ratios, the three shown in Figure 2 plus the 10-year ratio, for the period June 1970 through December 1989.

The model uses several tax rate variables to capture the effect of changes in tax rate legislation. To represent the personal income tax rate schedule, the model uses the *maximum personal income tax rate* (TMAX), and a measure of *tax rate progressivity* (PROGRSV), defined as the difference between the maximum personal tax rate and the tax rate for an individual with $25,000 of real taxable income. The maximum tax rate employed in defining these variables is the rate paid by those in the highest income bracket. Until 1987, this was also the highest rate levied, but the 1986 Tax Reform Act introduced a bubble in the tax rate schedule, so that the highest-income taxpayers paid less than the maximum tax rate. Thus, for 1988–90 the model uses 28 percent as the maximum tax rate, not the 33 percent bubble rate.

The Traditional View of municipal bond yields predicts that the first tax variable (TMAX) should have a negative coefficient, while the coefficient on the second (PROGRSV) should be positive: a more progressive tax rate schedule, given the maximum rate, should increase municipal bond yields relative to taxable bond yields. Note that because the tax rate data are available annually, the same tax rate is assigned to each month in the year.

This econometric model does not incorporate the New View, for two reasons. First, as noted above, evidence is abundant against the hypothesis that corporate income tax rates dominate the determination of the interest rate ratios. Second, an experiment that included the maximum corporate income tax rate did not support the New View: the corporate income tax rate had the wrong sign and was not statistically significant.

In order to capture the influence of *anticipated*

future tax rates, several measures of the implicit future tax rate were constructed: T_{2-5} is the implicit tax rate for two to five years in the future, T_{5-10} is the implicit tax rate five to ten years out, and T_{5-20} is the implicit tax rate five to 20 years hence. Each is constructed from the yield curve data that were used to construct Figure 2, using the method described in Section I above. These constructed variables are available for every month in the sample. Rather than include all three in the regression for each rate ratio, only the ones that seemed most relevant were included: t_{5-20} in the 20-year regression, t_{5-10} in the 10-year regression, and t_{2-5} in the five-year regression. Anticipated future tax rates were excluded from the one-year regression because the relevant tax rate is known at the time of purchase.

It was argued earlier that the *anticipated variability of bond prices* should affect the interest rate ratio because market discounts on municipal bonds are subject to capital gains taxes, placing them at a disadvantage relative to taxable bonds if bond prices fall, but giving them no advantage if bond prices rise. In order to reflect this, the Ibbotson Associates (1990) data on the monthly rate of change in prices of long-term Treasury bonds were used to construct a volatility index for each month. The result is a variable, called VOLATILE, available for each month.[22]

Three dummy variables were used to capture fixed effects. One, labeled NY, is for the New York City financial crisis, which is assumed to have occurred in the period June 1975 to December 1976. During this period, the yields on lower-rated municipal bonds rose relative to yields on prime grade bonds, but the New York City crisis could have affected prime grade bonds as well, although the direction of effect is not clear: NY could have a positive coefficient if the quality of high-grade bonds was called into question, or it could have a negative coefficient if a flight to quality drove high-grade bond yields down.

A second dummy variable, named TRA86, applies to the period January 1987 through the end of the sample. The 1986 Tax Reform Act had a variety of effects on the municipal bond market other that those that operate through tax rates (which are already captured in TMAX and PROGRSV). The limits on private-activity bonds and the severe limits on other tax shelters should induce a negative coefficient on TRA86, but the elimination of commercial bank deductibility of municipal carrying costs should have a positive effect. While the sign of the coefficient on TRA86 cannot be specified *a priori*, the common view is that the elimination of carrying-cost deductibility dominated the effect.

The third dummy variable, labeled Y86, refers to the 12 months of 1986 and this is introduced to capture any effects of the active and often-changing debate about tax policy during that year.

Estimation of the model was done with Three-Stage Least Squares, using a correction for first-order autocorrelation. Three-Stage Least Squares (3SLS) is a method of joint estimation of a system of equations combining Seemingly Unrelated Regression Equations (SURE) and Two-Stage Least Squares (2SLS). The four interest rate ratios are viewed as a four-equation system because of the potential for omitted variables common to interest rates at all four maturities. The SURE method employs this information on correlations between residuals to derive efficient estimates of the parameters.

The 2SLS aspect of 3SLS was necessary because the variables for anticipated future tax rates are endogenous: they are derived from the term structure of interest rates and, therefore, use the same interest rates that are used in defining the interest rate ratios. In order to eliminate this problem of feedback from the dependent variables to the variables T_{2-5}, T_{5-10} and T_{5-20}, a rather long list of instruments was used.[23]

As noted above, the estimation was done with a correction for first-order autocorrelation. The specific method of estimation involved two steps. First, each of the four equations was estimated separately, using 2SLS with an autocorrelation correction. This gives four autocorrelation coefficients, one for each equation; those autocorrelation coefficients are reported as the variable RHO in Table 1. Second, the variables in each equation were transformed to partial differences using the autocorrelation coefficient estimated for that equation in the first stage, after which the transformed variables were employed in a 3SLS estimation of the four-equation system.

[22] The rate of change in bond prices is Ibbotson's total return on long-term government bonds in each month less the income return due to coupons. The monthly volatility index is the square of the deviation of the bond price change from its sample mean, divided by the sample variance. The variable VOLATILE is the simple average of the volatility measure in the past three months.

[23] The instruments were all of the exogenous variables in the system, including a constant term, as well as the following additional instruments, all available monthly: a time trend, the level of the CPI, the rate of inflation, the civilian unemployment rate, real personal income, the earnings-price ratio for the S&P500, and the three-month Treasury bill rate.

Table 1
Three-Stage Least Squares Regression: Interest Rate Ratios, 1–5–10–20 Year Maturities, June 1970 to December 1989
Dependent Variable (R_M/R_T)

Independent Variable	Maturity			
	20-Year	10-Year	Five-Year	One-Year
CONSTANT	0.3841	0.4636	0.3545	0.3275
	(42.53)	(28.81)	(44.35)	(8.57)
T_{5-20}	−.7004	n.a.	n.a.	n.a.
	(79.85)			
T_{5-10}	n.a.	−.4832	n.a.	n.a.
		(28.51)		
T_{2-5}	n.a.	n.a.	−.7705	n.a.
			(153.49)	
VOLATILE	.0011	.0019	.0014	.0070
	(1.46)	(1.54)	(1.96)	(2.17)
TMAX	−.0024	−.0043	−.0019	−.0083
	(3.27)	(4.01)	(2.69)	(2.73)
PROGRSV	.0017	.0031	.0015	.0071
	(2.42)	(3.10)	(2.38)	(2.47)
NY	−.0010	−.0031	−.0018	−.0089
	(.22)	(.49)	(.43)	(.48)
Y86	.0258	.0475	.0183	.0780
	(4.60)	(5.74)	(3.44)	(3.30)
TRA86	.0115	.0226	.0221	.1019
	(1.86)	(2.50)	(3.75)	(3.92)
RHO	.6088	.5170	.6310	.6023
	(2.83)	(1.80)	(5.47)	(5.41)
$\bar{R}^2$	.9514	.8818	.9526	.3071
DW	2.1845	1.9849	2.1597	2.1134

The method of estimation is 3SLS with correction for first-order autocorrelation; RHO is the autocorrelation coefficient. The $\bar{R}^2$ and DW are for the transformed equations. The instruments are used for the future tax rate variables; see footnote 23 for instrument list. Numbers in parentheses are absolute value of t-statistics, corrected for instrumental variables estimation.

n.a. = not applicable.

The results, reported in Table 1, provide strong support for the insights gained from our discussion of tax legislation. With respect to the fixed effects, we find that the New York City financial crisis played no role: the coefficient is negative in each equation, suggesting that this period was one of lower municipal bond yields, but it is not statistically significant.

The dummy variable Y86 is positive and statistically significant. The very active debate about tax policy in 1986 increased the interest rate ratios because of the uncertainty about future tax rates. The implied increase in the rate ratios in 1986 was about 0.03 for 20-year bonds, 0.05 for 10-year bonds, 0.02 for five-year bonds and 0.08 for one-year bonds. At the 1988–90 averages of Treasury bond yields, these rate ratio increases imply increases in municipal bond yields of 23 basis points (bp), 41 bp, 15 bp, and 62 bp, respectively.[24]

The variable TRA86 shows that the period of effectiveness of the 1986 Tax Reform Act (1987 and after) was also a period of higher interest rate ratios. Like Y86, TRA86 appears to have the greatest impact on one-year bonds (which had an interest rate ratio 0.10 higher after 1986), but it was both statistically and economically significant (roughly 0.01 to 0.02) for other maturities. This is predicted from the elimination of the deduction for commercial bank carrying costs. The municipal bond yield effects of TRA86, evaluated at 1988–90 Treasury bond yields, were 10 bp for 20-year bonds, 20 bp for 10-year bonds, 19 bp for five-year bonds, and 82 bp for one-year bonds.

The tax rate variables are all statistically significant with the signs predicted by theory. According to the estimated coefficients, the reduction in the maximum tax rate (TMAX) from 50 percent to 28 percent after the 1986 Tax Reform Act reduced the interest rate ratios by about 0.05 for 20-year bonds, 0.10 for 10-year bonds, 0.04 for five-year bonds and 0.18 for one-year bonds. The corresponding declines in municipal bond yields, evaluated at 1988–90 Treasury bond yield levels, were 46 bp, 82 bp, 35 bp, and 146 bp, respectively.

The tax progressivity variable (PROGRSV) also is statistically and economically significant in each equation. The 1986 Tax Reform Act reduced the progressivity variable by 22 percentage points, from 22 percent in 1985 to zero in 1988. This reduced the rate ratios by 0.04 for 20-year bonds, 0.07 for 10-year bonds, 0.03 for five-year bonds and 0.15 for one-year bonds. The corresponding decreases in municipal bond yields are 32 bp, 57 bp, 27 bp, and 120 bp.

In each equation the coefficient on anticipated future tax rates is negative and statistically significant: when the market expects tax rates to be high, the interest rate ratio is reduced as tax-exempt bonds are substituted for taxable bonds. The very high t-statistics attest to the statistical importance of tax

[24] The 1988–90 averages for Treasury bond yields were 8.7 percent for 20 years, 8.6 percent for 10 years, 8.5 percent for five years, and 8.0 percent for one year.

rate anticipations, and the size of the coefficients attests to their economic significance.

In order to assess the economic significance of the 1986 Tax Reform Act, the change in the interest rate ratio between 1982–85 and 1988–90 attributable to changes in statutory tax rates (TMAX and PROGRSV) was calculated, as well as the fixed effect captured in the dummy variable TRA86. The changes in rate ratios were converted to changes in municipal bond yields, using the 1988–90 average values of the four Treasury bond yields.

The results are reported in the top portion of Table 2. These three tax policy variables account for a rise in the municipal bond yields by 25 to 44 bp for the longer maturities, and by a large 107 basis points for the one-year maturity. The primary source of the large increase at the one-year maturity is the TRA86 dummy variable. That this is most important at the short maturity is consistent with the withdrawal of a primary short-term lender—commercial banks—from the tax-exempt debt market.

Table 2
Effects of Tax Policy on Interest Rate Ratios and Municipal Bond Yields, 1982–85/1988–90

Independent Variable	Maturity			
	20-Year	10-Year	Five-Year	One-Year
Tax Policy Variables				
TMAX	+.0528	+.0946	+.0418	+.1826
PROGRSV	−.0361	−.0659	−.0319	−.1509
TRA86	+.0115	+.0226	+.0221	+.1019
Subtotal ratio	+.0282	+.0513	+.0320	+.1336
R_M	+25 bp	+44 bp	+27 bp	+107 bp
Anticipated Tax Rate Variables				
T_{5-20}	−.0123	n.a.	n.a.	n.a.
T_{5-10}	n.a.	−.0076	n.a.	n.a.
T_{2-5}	n.a.	n.a.	+.0616	n.a.
Subtotal ratio	−.0123	−.0076	+.0616	n.a.
R_M	−11 bp	−7 bp	+52 bp	n.a.
Total ratio	+.0159	+.0437	+.0936	+.1336
R_M	+14 bp	+37 bp	+79 bp	+107 bp

Source: Coefficients in Table 1 times average values of variables in 1982–85 and 1988–90. The conversion from interest rate ratios to municipal bond yields is done at the 1988–90 average for Treasury bond yields: 8.75 percent, 8.63 percent, 8.45 percent, and 8.01 percent, respectively.
n.a. = not applicable.
bp = basis points.

Another avenue for tax policy is anticipated tax rates. The bottom portion of Table 2 assesses the effects of the anticipations variables after the Tax Reform Act of 1986. The results suggest only a minor effect of tax rate anticipations for 20-year and 10-year bonds: the implied yield changes are −11 bp and −7 bp, respectively. However, a 52 bp increase occurred in five-year yields in the 1987–89 period. This suggests that in this period tax rates were expected to decline further.

The combined effect of all four tax policy variables (Table 2) is to increase municipal bond yields after the 1986 Tax Reform Act, with the magnitude being greater for shorter maturities. The impacts are greater for shorter-term bonds, ranging from a mild 14-basis-point increase for 20-year bonds to a 107-basis-point increase for one-year bonds.

Bond price volatility (VOLATILE) increases the rate ratios, as the earlier discussion of capital gains taxation suggests. While the t-statistics suggest that this effect is not as reliable as the effect of tax variables, the evidence does support the hypothesis that the more volatile are bond prices (hence the higher the probability of a price decrease), the less desirable are municipal bonds. This is the effect of capital gains taxes on the relative desirability of tax-exempt and taxable bonds when market discounts exist.

Thus, the data provide very strong support for the role of personal income tax legislation, and the elimination of bank deductibility of carrying costs, in affecting interest rate ratios.

VI. Summary

This article reviews the performance and changing structure of the municipal bond market in recent years. It shows that the ratio of yield to maturity on municipal bonds to yields on U.S. Treasury bonds (the interest rate ratio) has varied greatly in the last two decades, that the interest rate ratio is greater for longer maturities, that the yield curve for municipal bonds has sloped upward more rapidly than the yield curve for Treasury bonds, and that the yield curve shapes for municipals and Treasuries became much more similar after the mid 1980s.

Dramatic changes have occurred in the character of municipal bonds outstanding, with private-activity

bonds rapidly gaining market share in the 1970s and early 1980s, and losing market share just as rapidly after the mid 1980s. In addition, major changes in municipal bond ownership occurred, primarily the dramatic withdrawal of commercial banks from the market after the mid 1980s, with households taking the place of banks as the dominant investors.

The paper reviews the main aspects of the Internal Revenue Code that affect the demand for municipal bonds. It argues that municipal bond yields will rise relative to Treasury bond yields when personal income tax rates fall or become more progressive, and that the exposure of municipal bonds to capital gains taxes when market discounts emerge will place municipal bonds at a disadvantage in periods when bond prices are more volatile. Furthermore, it is argued that anticipated future income tax rates will have a strong impact on municipal bond yields.

Recent tax legislation was examined in some detail, particularly the 1986 Tax Reform Act. That Act not only radically revised the income tax rate schedule—moving toward a flat-rate system with few brackets—but it also contained non-tax-rate legislation that dramatically affected bond yields. Of particular importance is the elimination of commercial bank deductions for municipal bond carrying costs, which should raise the interest rate ratio. Offsetting this, perhaps only partially, were the Act's severe restrictions on tax-sheltered investments, which made municipal bonds more attractive.

The paper concludes with an econometric analysis of the interest rate ratio for four maturities: one-year, five-year, 10-year and 20-year bonds. The results of this statistical analysis provide strong support for the importance of tax legislation in general, and for the propositions outlined above about the role of personal income taxes and the 1986 Tax Reform Act. In particular, the analysis finds that both the decrease in the maximum personal income tax rate, and the decline in the progressivity of the tax rate schedule, had effects that were statistically and economically significant, that the 1986 Tax Reform Act had a positive fixed effect on municipal bond yields, and that tax rate anticipations were very important.

While each of these factors was statistically and economically significant, they tended to have offsetting effects. The combined effect of these tax policy variables after 1986 ranged from a small 14-basis-point increase for 20-year bonds to a large 107 bp increase for one-year bonds.

The results also show that the debate during 1986 about the 1986 Tax Reform Act—as opposed to its actual implementation—increased interest rate ratios. This suggests independent evidence for the importance of anticipated future tax rates.

Appendix: The "New View" of Municipal Bond Yields

The "New View" of municipal bond yield determination can be understood in two ways. Fama (1977) argued that corporations, primarily commercial banks, are the marginal investors in municipal bonds. Thus, the DD schedule follows the personal tax rate schedule for low quantities of municipal bonds outstanding; for these quantities, individuals with tax rates between t_{max} and t_c will provide the funds. However, the DD schedule becomes horizontal at a ratio of $(1 - t_c)$: any tendency for the ratio to go above that level will induce banks to enter the market in sufficient volume to restore the ratio to $(1 - t_c)$. Because the volume of municipal bonds outstanding is great enough to fully absorb the funds of high-bracket investors, commercial banks become the marginal investors and the equilibrium rate ratio will be $R_M/R_T = (1 - t_c)$.

Miller's (1977) explanation of the New View is slightly more exotic. According to the stripped-down Miller version, individual investors—and the personal tax rate schedule—determine the demand function, so DD remains the effective demand schedule. But Miller argues that the effective supply schedule for municipal bonds is horizontal at the interest rate ratio $(1 - t_c)$.

In Miller's view, common stocks and municipal bonds are perfect substitutes in investors' portfolios, and common stocks are virtually tax-exempt.[25] As a result, in equilibrium the equality $R_M = R_S$ will hold, where R_S is the yield on common stocks. Because a corporation will choose its debt-equity ratio so as to minimize its cost of capital, if the required return on stocks (R_S) exceeds the after-tax cost of debt (R_T), the corporation will sell bonds; this occurs when $R_S/R_T > (1 - t_c)$. On the other hand, if the cost of equity is less than the after-tax cost of debt, corporations will sell equity; this occurs when $R_S/R_T < (1 - t_c)$. Since all corporations face the same tax rate, all will finance themselves either with debt or with equity unless $R_S/R_T = (1 - t_c)$, in which case each firm will be indifferent; some firms will choose debt, others will choose equity, and still others will finance themselves with both debt and equity. This de-

[25] Because dividend-paying stocks can be held by low-tax sectors (such as pension funds) and capital gains taxes can be deferred, Miller's assumption that common stocks are tax-exempt has some merit.

scribes the equilibrium. Because equity and municipal bonds are (according to Miller) perfect substitutes in investors' portfolios, so $R_S = R_M$, the debt-equity decisions of corporations will ensure that $R_M/R_T = (1 - t_c)$: the interest rate ratio is determined by the corporate income tax rate. In effect, the supply schedule SS is horizontal at the interest rate ratio $(1 - t_c)$. At any higher ratio municipalities will not alter their debt decision, but corporations will sell less equity that, under the Miller assumptions, is equivalent to less tax-exempt debt.

The New View received some empirical support in its early years, a prominent example being the work of Trczinka (1982). However, it fails to fit the 1980s data, as shown by Fortune (1988) who used Trczinka's method, and by Peek and Wilcox (1986), who used a different method. Furthermore, the event analyses by Poterba (1986, 1989) have demonstrated the importance of the personal income tax. A more recent study of the importance of personal income tax rates is Fortune (1991b).

In addition, recent changes in the structure of the market clearly have weakened any validity of the New View. For example, Fama's explanation is based on high commercial bank participation in the municipal bond market, but banks have been notoriously absent from the market for municipal bonds in the 1980s. Also, Miller's explanation is less convincing in the 1980s, when corporations clearly were not balancing debt and equity at the margin, but were apparently at a corner solution, issuing debt in large quantities and retiring equity.

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The Real Estate Cycle and the Economy: Consequences of the Massachusetts Boom of 1984–87

Karl E. Case

Professor of Economics, Wellesley College, and Visiting Scholar, Federal Reserve Bank of Boston. *The author wishes to thank the members of the Harvard Seminar on Urban and Regional Economics and Lynn E. Browne for helpful comments and suggestions. An earlier version of this paper was presented at a session in honor of Benjamin Chinitz at the annual meetings of the Regional Science Association, November 1990.*

The economy of Massachusetts is in a deep recession. In March 1991, the unemployment rate hit 9.7 percent, the second highest in the United States and the worst since 1975.[1] Between the peak of the employment cycle at the end of 1988 and March 1991, the Commonwealth of Massachusetts lost 273,000 jobs, or 8.7 percent of the employment base. By that measure, this recession is much worse than either the 1981–82 recession or the 1975 recession. In the 1981–82 recession, peak to trough, the Commonwealth lost 51,000 jobs, or 1.9 percent of total nonagricultural employment; in 1975, total jobs lost numbered 109,000, or 4.8 percent of the total.

What makes this downturn all the more painful is that it comes on the heels of a period of unprecedented prosperity. In July of 1987, Massachusetts enjoyed an unemployment rate of 2.4 percent, lowest in the United States. In addition, between 1984 and 1988 personal income rose more rapidly in New England than in any other region of the country (Browne 1989).

What happened? How could a state go from having the lowest unemployment rate in the United States to having the second highest in the space of less than four years?

Clearly no single event caused these problems. Many factors have contributed. Part of the decline is due to a national recession that began in 1990. The national employment decline has been mild, however, with total nonagricultural employment down only 1.5 percent as of April 1991. Some of New England's decline can be traced to cuts in the federal defense budget (Henderson 1990). Certainly the high technology sector has been going through a period of retrenchment after playing an important role in the region's expansion in the early 1980s (Browne 1988; Flynn 1984).

Some claim that the current recession is a natural and inevitable downturn after a prolonged expansion and that the region, with its well-diversified economic base, ultimately will return to a reasonable

growth path (Rosengren 1990). Others claim that the "core" of the economy is structurally unsound, and that the state is likely to experience a prolonged period of stagnation and decline (Moscovitch 1990). The electronic media continue to point to the ongoing fiscal problems of the Commonwealth and to an eroding "business climate" caused in part by recent tax increases.

The thesis of this article is that the dramatic real estate cycle, which began with a housing price boom between 1984 and 1987, was an important element that not only contributed to but also very significantly amplified the economic fortunes and misfortunes of the Commonwealth and the region. The article begins by looking at conditions in the state's economy in 1984. In that year, the state and the region were approaching full employment along a steady but reasonable growth path with a cost structure favorable to continued expansion. Beginning in 1984, real estate prices exploded upwards. The article focuses on the price boom, which triggered a series of economic changes that had serious consequences for the economy.

The dramatic real estate cycle that began with a housing price boom between 1984 and 1987 significantly amplified the economic fortunes and misfortunes of the region.

First, consumer spending increased, leading to expansion in the trade and service sectors. Second, a building boom, fueled by favorable tax laws and a recently deregulated banking sector, sharply increased the supply of residential, commercial, and industrial space. These events created a substantial but temporary increase in the demand for labor. Labor force growth, already slowing as the economy was pressing the limits of higher participation rates (Browne 1988), slowed further as a result of high home prices. A serious labor shortage in 1987 and rising wages in the region were the result. In addition, commercial and office rents in the region nearly doubled between 1984 and 1988. It is well known that the region's banking problems are also deeply rooted in real estate, adding a capital shortage and a serious contraction in the financial sector to the region's list of woes.

By 1987, the basic structure of costs in the region was out of line with the rest of the country. The combination of higher wages, rents, and home prices, a labor shortage, and serious problems in the banking sector (that came later) certainly made the region less attractive for investment. When the "temporary" employment in construction, real estate, finance, trade, and services began to erode as the real estate boom came to an end, the erosion was occurring on the back of an economic base already in decline.

I. The State's Economy in 1984

The state's economy was in very good shape in 1984. Data for that year are presented in Table 1. The unemployment rate was 6.3 percent, down from 12.3 percent a decade earlier and 9.6 percent in mid 1982. The state and the region recovered from the 1982 recession at about the same rate as the country as a whole. Nonagricultural employment in Massachusetts grew at 4.9 percent per year between 1982 and 1984 and at 4.7 percent per year in the United States. During the same period, the labor force grew at a 1.2 percent annual rate in the state, while it grew at 1.5 percent in the country as a whole.

The cost structure in the state in 1984 was favorable to business expansion. Average hourly earnings in manufacturing in Massachusetts were 7.4 percent below the national average, and energy prices were falling. The National Association of Realtors' (NAR) median price of existing single-family homes in the Boston metropolitan area (CMSA) was $82,600 in 1983, just 17.5 percent above the national median. In addition, the rental price of Class A downtown office space was $20 to $22 per square foot per year, just above the national average of $19.75.

[1] The figure dropped sharply to 8.3 percent in April, but the bulk of that change was due to a reduction in the labor force of over 30,000. The rate rebounded to 9.6 percent in May. Figures are from the *New England Economic Indicators* data file.

II. The Great Housing Price Boom

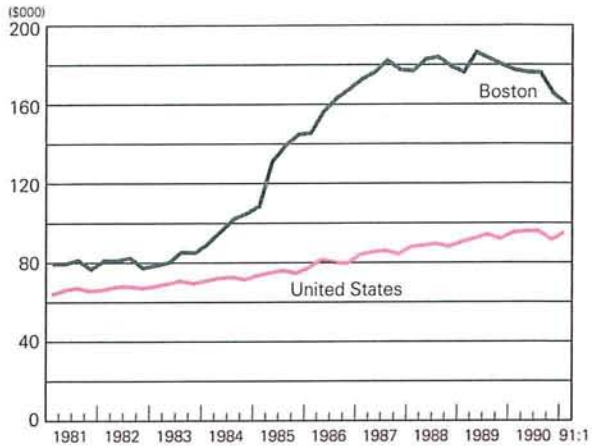
Beginning in early 1984, housing prices began to rise sharply. From $82,600 in 1983, the NAR median in the Boston CMSA jumped to $104,800 by the end of 1984, to $144,800 by the end of 1985, and to $182,200 by the third quarter of 1987, an overall increase of 121 percent. The national median rose from $70,300 to $86,800, an increase of only 23 percent. Figure 1 presents quarterly price data from 1981 to 1991 for existing homes sold in Boston and the United States.[2]

The nature of the boom is debated. Certainly demographics, lower interest rates, and generally favorable economic conditions in the region all played a role. Case (1986) and Case and Shiller (1989), however, argue that fundamentals alone do not explain the boom. Controlling for the combined effects of employment growth, population growth, interest rates, income, construction costs, and a number of other variables, the model in Case (1986) predicted a 15 percent increase in housing prices between 1983 and 1986. Instead, single-family home prices virtually doubled. The argument in Case and Shiller (1988, 1989 and 1990) is that home buyers and sellers were significantly influenced by psychology. That is, reacting to rising prices and generally favorable economic conditions, home buyers paid inflated prices in anticipation of future price increases and capital gains. Whether the boom was speculative in nature or not remains controversial (see Norton 1989), but the cause of the boom is not an important element in the argument below.

Figure 1

Median Price of Existing Single-Family Homes

Boston CMSA and United States- 1981:1 to 1991:1



Source: National Association of Realtors.

Table 1

The Massachusetts and United States Economies in 1984

	Massachusetts	United States
Unemployment Rate[a]	6.3%	8.1%
Annual Percent Change in Nonagricultural Employment (1982–84)[b]	4.9%	4.7%
Annual Percent Change in Civilian Labor Force (1982–84)[b]	1.2%	1.5%
Average Hourly Earnings of Production Workers[c]	$8.50	$9.19
Median Home Price, 1983[d]	$82,600	$70,300
Annual Rent per Square Foot of Class A Office Space, 1984[e]	$20–$22	$19.75

[a]January 1984. U.S. Bureau of Labor Statistics.

[b]Based on change from the 4th quarter 1982 to the 4th quarter 1984, expressed at annual rates.

[c]U.S. Bureau of Labor Statistics, average for all of 1984.

[d]Median sales price of existing single-family homes in the Boston CMSA, National Association of Realtors, *Home Sales*, May 1985.

[e]Based on author's interviews with commercial real estate developers representing a substantial portion of the Boston market and data from The National Real Estate Index, Inc. and The Reis Reports, Inc.

Effects on Demand for Locally Produced Goods and Services

The first consequence of the boom was that homeowners in Massachusetts were better off.

[2] These data are a simple plot of the quarterly NAR median, taken from National Association of Realtors, *Home Sales*, monthly. As part of a current (1991) research project being done at the Federal Reserve Bank of Boston, a total of 25,378 properties that sold more than once between 1980 and 1990 were extracted from a data file containing nearly 400,000 home sales in the Boston CMSA obtained from the *Banker & Tradesman*. These data were used to construct a Weighted Repeat Sales Index (WRS) for Boston as discussed in Case and Shiller (1989). The results show a nominal increase of 155 percent between the end of 1983 and the middle of 1987.

Households fortunate enough to own their units during the boom found themselves with significant accumulations of new equity. It is likely that the additional home equity changed household saving and spending patterns. Some borrowed against their home equity, while others simply saved less, or spent some of their previous savings.

While it is difficult to accurately measure the response, a number of sources of evidence suggest that it was significant. Tabulations from the Survey of Consumer Finances for the period 1983–86 show that for all households in the Northeast (including renters), household assets increased by an average of $57,328. Virtually all of that expansion can be accounted for by the growth in home equity; during the same period, household liquid assets did not increase at all, and household debt increased by an average of $10,267.[3] This suggests a very low savings rate.

Data on home equity loans written by Massachusetts banks and thrifts are available only since 1987. In 1987, total home equity loans held as assets by Massachusetts commercial banks and thrifts were $1.8 billion.[4] By 1989, the figure was over $5 billion.

Theory does not unambiguously predict that increases in home equity will reduce saving and increase spending. A simple life cycle model predicts that an increase in fungible assets would lead to an increase in consumption about 4 or 5 percent as large. That is, the asset would be spread over the owner's lifetime consumption. Over a long period, that would increase real consumption by about the real rate of interest.

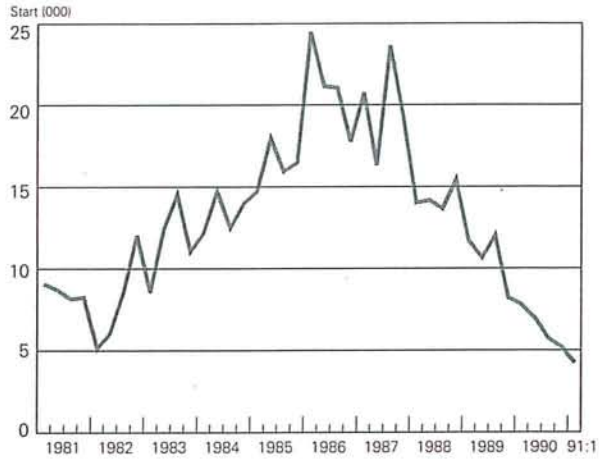
But housing assets are not the same as other assets. First, if housing prices rise, homeowners are affected on both the sources and the uses sides of the income equation. Any increase in equity is matched exactly by an increase in the cost of housing. A buyer who bought before the boom sees her equity increase, but she lives in the same house with the same out-of-pocket monthly expenses as before. If transactions costs were zero, a homeowner might adjust her portfolio, but transactions costs are high. In addition, a price increase makes non-homeowners worse off and could lead to an increase in saving.[5]

To estimate the potential size of the spending effect, consider that the average homeowner living in the Boston area in 1983 found herself with $102,700 in new equity by mid 1987.[6] In 1984 Massachusetts had approximately 2.16 million occupied housing units, and 58 percent of them were owner-occupied. Of these, 718,600 were located in the eastern five counties (the Boston CMSA), leaving 531,400 in the rest of the state.[7] If Boston homeowners accumulated $102,700 each, while homeowners in the rest of the state accumulated half as much, the total comes to $101 billion.

Figure 2

Housing Starts: Boston

1981:1 to 1991:1



Source: F.W.Dodge.

In addition, the value of raw land, rental property, and commercial property appreciated at comparable rates. While the ownership of land and rental property is probably local, commercial and industrial property is just as likely to be held by corporations and out-of-state owners. A conservative estimate of

[3] Federal Reserve tabulations.

[4] Board of Governors of the Federal Reserve System, Call Report data.

[5] The impact of home equity on saving behavior was investigated empirically by Skinner (1989) using the Panel Study of Income Dynamics. Skinner's results are mixed. In one set of equations he finds that a 23 percent increase in market value of housing predicts a 1.4 percent increase in consumption. In a second set of equations, he finds no effect. Sheiner (1990) finds little evidence that renters' behavior is significantly affected by housing price increases.

[6] Only the median price is published by the National Association of Realtors for the Boston area. Based on national data, the mean price rose 2.6 percent faster than the median. Thus, an estimate of the average increase is $100,100 × 1.026, or $102,700.

[7] U.S. Bureau of the Census, *State and City Data Book*, 1987.

the increase in value of the locally held portion is $60 billion.

If wealth holders spent just 2 percent of the added value per year, that would have resulted in an annual increase in consumption of $3.25 billion. Total state income in 1987 was $100 billion and employment was just about 3 million. A consumption effect of that size could account for nearly 100,000 added jobs. The labor market will be discussed in more detail below.

The Building Boom and Home Sales

When real estate prices rise sharply, a building boom is likely to follow, and one did in Massachusetts. The most dramatic swing occurred between 1985 and 1987. Housing starts in the five eastern counties of Massachusetts are shown in Figure 2. The high interest rates of 1981 caused a drop during the recession of 1982 to about 5,000 per year. By 1984, starts had risen to a sustainable 12,000 to 14,000. But a sharp upturn began in 1985, peaking in the first quarter of 1986 and again in the third quarter of 1987 at an annual rate of nearly 24,000 starts. In Massachusetts in December of 1986, permits were issued for 4,100 new housing units *in a single month.*

Sales of existing homes, shown in Figure 3, followed a very similar pattern. After a reasonable recovery from the recession of 1982, sales of existing homes (including condominiums and cooperatives) hit 66,000 in Massachusetts in 1984. By the end of 1985, the figure hit 90,000, and it peaked at over 100,000 in 1987.

The building boom was fueled by a recently deregulated and fiercely competitive banking sector. In 1984, total real estate loans held as assets by Massachusetts banks and thrifts totaled $13.7 billion, or 38.4 percent of loan assets. By 1988 the figure had grown to $59.9 billion, or 60 percent of total loan assets. Between 1984 and 1988, 72 percent of all bank lending in Massachusetts was for real estate. While real estate lending increased nationwide during the decade, the increase was twice as large in New England. The sharp increase after 1984 is clearly visible in Figure 4.

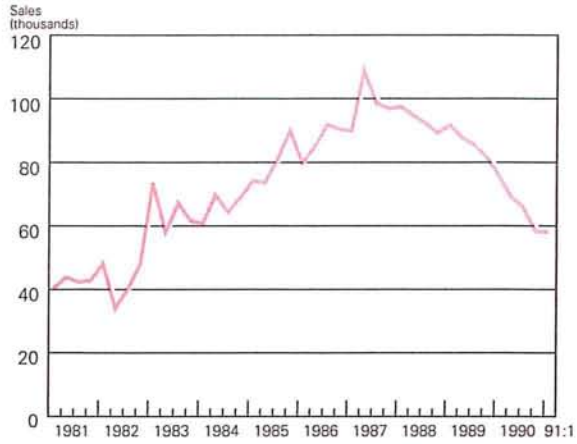
Effects on the Demand for Labor

All of this had a significant impact on the demand for labor in the state. The most dramatic effect was in the construction sector, where employment in Massachusetts rose from 90,900 at the beginning of

Figure 3

Sales of Existing Homes[a]

Boston-1981:1 to 1991:1



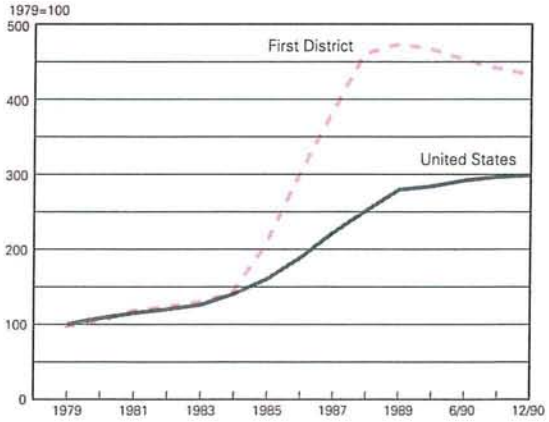
[a] Single-family, condo, and co-op.

Source: National Association of Realtors.

Figure 4

Real Estate Lending by Commercial and Savings Banks

First District versus United States 1979 to 1990



Note: The sharp increase in First District real estate lending from 1984 to 1987 is due in part to an increase in the number of FDIC-insured institutions.

Source: Call Report data for FDIC-insured institutions.

1984 to 142,800 at the end of 1987, an increase of 57.1 percent.

Next in terms of relative increase was the finance, insurance, and real estate industry (FIRE). FIRE employment rose 27.1 percent during the same period, from 175,700 to 223,000. Nationally during the same period, FIRE employment increased by only 18.4 percent.

It is impossible to say precisely what percentage of this increase in FIRE employment was due to the real estate boom, but it is clear that much of it was. Outstanding real estate loans on the books of banks and thrifts expanded by $46.2 billion during the period; as mentioned above, this was 72 percent of all new lending. Certainly a good deal of the added employment in the financial sector was due to the real estate boom.

And, naturally, real estate employment expanded significantly as well. Consider just real estate agents. Aggregate commissions on sales of existing single-family homes and condominiums came to approximately $387 million in 1984; in 1987 the figure was $1.23 billion.[8] If the average agent makes $45,000, the difference is enough to support nearly 19,000 new real estate agents.

Spending on locally produced goods and services affected the labor market through the trade and service sectors. Overall, trade and services combined account for more than one-half of the jobs in the state and in the region. Trade employment in Massachusetts grew by 88,000 (13.7 percent) between 1984 and 1987 while service employment grew by 144,000 (19.6 percent).

Adding the four sectors together (construction, FIRE, trade, and services) the total number of new jobs created between January 1984 and December 1987 was 331,000. While it is impossible to pinpoint exactly how many of these jobs would have been created had the real estate boom not happened, it seems clear that the boom had a significant impact on the demand for labor between 1984 and 1987.

Effects on the Supply of Labor

While the housing price boom had a significant and positive effect on the demand for labor in the state and the region, it also contributed to a slowdown in the growth of the labor force. Between 1982 and 1984, the labor force in Massachusetts was growing at about 1.2 percent per year, while in the nation it was growing at 1.5 percent per year. However, between 1984 and 1987, while the national labor force growth rate increased to 1.8 percent, it dropped to 0.5 percent in Massachusetts.

Browne (1989) shows that much of the expansion of the New England labor force in the early 1980s resulted from increased participation rather than inmigration. Increased participation can increase labor supply only up to a limit, and those limits were being approached in the mid 1980s. Nonetheless, all regions have a steady flow of inmigrants and outmigrants, and evidence strongly suggests that housing prices had an effect on this flow in New England.

The boom had a significant impact on the demand for labor between 1984 and 1987.

Numerous accounts of the effects of high housing prices on local labor supply have appeared recently in the press.[9] Some interesting anecdotal evidence is presented in a *Harvard Business Review* article by Drier, Schwartz and Greiner (1988). Drier and his colleagues interviewed a number of executives at Massachusetts corporations to determine whether high home prices presented a serious problem with recruiting. Drier presents a convincing argument that housing prices were an important deterrent, although the evidence is not systematic.

A new paper by Gabriel (1991) uses Internal Revenue Service data on place-to-place migration flows, published information on the nine Census regions, and household data from the Current Population Survey to estimate a logistic model of regional migration. Gabriel concludes (pp. 19–21):

> Estimates of the model suggest that quality-adjusted house price differentials are important determinants of household moves and operate to offset some of the added incentive to migrate to regions characterized by tight labor markets. . . . For both sample periods, relative housing prices and mortgage servicing costs deter migration from lower cost to higher cost regions.

[8] According to the National Association of Realtors (*Home Sales*, various issues), 66,000 existing single-family units were sold in 1984 at an average price of $97,750. In 1987, there were 100,500 sales at an average price of $203,781. New home sales are not included, but would increase the number.

[9] See, for example, "Jobless Aren't Migrating to Boom Areas," *Wall Street Journal* (February 21, 1989).

The current analysis attempted to isolate the effect of high home prices on labor force growth empirically, using monthly time series data from 1980:1 to 1990:8 (128 observations). Three specifications were tried, and the results of all three are presented in Table 2.

The models all assume that labor force participation is driven by three economic variables: wages, local housing prices, and the likelihood of finding a job. Wages are measured by average hourly earnings; housing prices are measured by a repeat sales index constructed for Boston; the likelihood of finding a job is proxied by the unemployment rate. In equation 1, the coefficient on the unemployment rate is negative but insignificant, and the coefficient on house prices is negative and significant. The coefficient on average hourly earnings is positive and alone explains 85 percent of the variation.

In order to wash out the demographic trend component from labor force growth, the monthly

Table 2
Analysis of Labor Force Growth: 1980–90

Variable	Description	Source	
LABFRC	Massachusetts labor force (thousands)	*New England Economic Indicators* data file; U.S. Bureau of Labor Statistics (BLS)	
HOUSE	WRS index of single-family home prices, constructed from *Banker & Tradesman* transactions file	Case and Shiller (1990)	
AHEMASS	Average hourly earnings of production workers in Mass.	*Indicators* file; BLS .	
URMASS	Unemployment rate—Mass.	*Indicators* file; BLS	
AHEUS	Average hourly earnings of production workers—U.S.	*Indicators* file; BLS	
URUS	Unemployment rate—U.S.	*Indicators* file; BLS	
Equation 1: Dependent Variable — LABFRC			
	Independent Variables	*Coefficient*	*T-Statistic*
	Constant	2409.6	81.3
	URMASS	−.0869	−0.04
	AHEMASS	78.6	14.2
	HOUSE	−.0321	−2.7
	Adjusted R^2: .917		
Equation 2: Dependent Variable — LABFRC			
	Independent Variables	*Coefficient*	*T-Statistic*
	Constant	2886.9	533.3
	TIME	2.43	33.3
	Adjusted R^2: .917		
Equation 3: Dependent Variable — Residual From Equation 2			
	Independent Variables	*Coefficient*	*T-Statistic*
	Constant	−130.5	4.3
	URMASS	−0.863	−0.3
	AHEMASS	25.9	4.6
	HOUSE	−0.048	−4.1
	Adjusted R^2: .149		
Equation 4: Dependent Variable — Residual From Equation 2			
	Independent Variables	*Coefficient*	*T-Statistic*
	Constant	−190.1	2.4
	URMASS/URUS	−35.94	−1.7
	AHEMASS/AHEUS	309.4	2.7
	HOUSE/AHEMASS	−0.372	−3.2
	Adjusted R^2: .061		

series was regressed on TIME in a first stage, equation 2. Then, in equations 3 and 4, the residual from the time trend regression was regressed on two sets of explanatory variables. In equation 3, the same variables used in equation 1 were included. The result is similar. Unemployment has the correct sign, but is insignificant. Average hourly earnings remains positive and significant, and house price remains negative and significant.

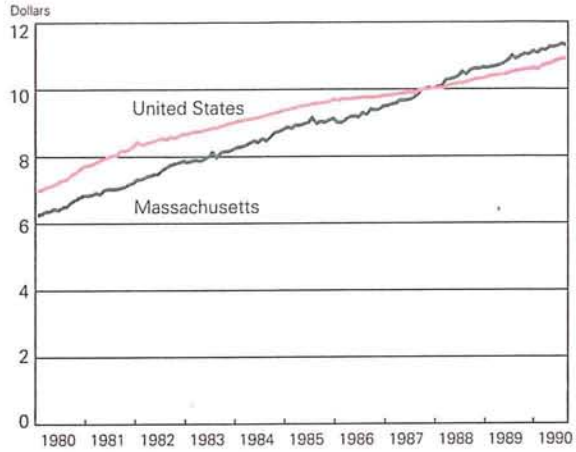
In the final specification (equation 4), unemployment in Massachusetts is measured relative to U.S. unemployment, earnings are measured as a percentage of the U.S. average, and house prices are measured relative to earnings. The results are consistent with the notion that unemployment and high home prices discourage entry into the labor force, while higher wages encourage entry.

While this analysis is preliminary and suggestive, it does add some weight to the argument that the slower growth in the New England labor force after 1984 was at least in part due to high home prices.

Figure 5

Average Hourly Earnings in Manufacturing

United States and Massachusetts



Source: U.S. Bureau of Economic Analysis; *New England Economic Indicators* data file.

Effects on Wages

The above analysis argues that the housing price boom from 1984 to 1987 caused an increase in the demand for labor and probably contributed to a decrease in the rate of growth of the labor supply. These factors together produced two effects that damaged the competitive position of the region: they drove the unemployment rate to all-time low levels and created a severe labor shortage, and they drove wages up sharply.

Figure 5 shows average hourly earnings for production workers in manufacturing in Massachusetts and in the United States since 1980. Massachusetts wages were 7.5 percent below the nation as a whole until 1984, when wages in the state began to rise. The difference steadily narrowed until the two were about the same in November of 1987. Since that time, Massachusetts wages have continued to rise, to the point where they were 4 percent above the national figure at the end of 1990.

Effects on the Supply of Credit

Finally, the real estate cycle has clearly had a significant impact on the supply of credit and the condition of the region's financial institutions. While hard numbers are difficult to obtain, the condition of the region's financial institutions has deteriorated dramatically as a result of bad real estate loans. An extreme example is the case of Bank of New England, which was taken over by the Federal Deposit Insurance Corporation in 1990. The bank lost well in excess of $2 billion, and 90 percent of its losses were in real estate. Literally hundreds of banks and S&Ls are currently under the watchful eye of federal regulators. As a result of bad capital positions and harsh regulatory standards, the volume of credit available for growing companies has been sharply cut.

It must be pointed out that the "credit crunch" is very difficult to document. Some claim that tougher credit standards are simply the natural result of the downturn, and that tougher standards are clearly justified on the basis of the slower economy. What is undeniable, however, is that the real estate cycle, whatever its cause, has inflicted serious damage on the region's financial institutions, and very few have been spared.

III. The State's Economy in 1987

Table 3 shows the position of the state's economy in 1987. Compared to the initial position described in

Table 1, conditions had changed significantly. First of all, a labor shortage is clearly evident. The unemployment rate in the state stood at 2.4 percent. The labor shortage had produced wages above the national average by 1987. Housing prices in 1987 were more than twice the national average. Finally, Class A downtown office rents by 1987 stood at $37 to $40 per square foot per year, nearly double the U.S. average. All four of these factors have been found to have a negative effect on regional growth rates.[10]

The Give-Back: 1987 to 1991

By late 1987, the real estate market began to turn. Single-family home prices stopped rising around the middle of that year (Figure 1). By late in the same year, home sales and housing starts peaked and started a protracted decline. Between 1987 and 1991, home sales dropped from a peak of over 105,000 to an annual rate of 58,600 in the first quarter of 1991 (Figure 3). During the same period, housing starts fell to an annual rate of 4,220, the lowest level in the past quarter century (Figure 2). Finally, between 1987 and 1991, office rents dropped sharply, to the point that they are about where they were in 1984. Class A office space in downtown Boston was available at $22 to $24 per foot in 1991.

By the spring of 1991, the resulting declines in employment were dramatic. Construction employment dropped by 48 percent from its peak of 147,200 in early 1988 to 76,800, a loss of over 70,000 jobs. This left construction employment more than 15 percent below its 1984 levels. Total jobs lost by 1991 in other nonmanufacturing sectors include 92,400 in wholesale and retail trade, 34,700 in the service sector, and 14,000 in finance insurance and real estate. Thus, of the 331,000 jobs added between 1984 and 1987 in these three sectors plus the construction sector, over 211,000 were lost between 1987 and 1991. How much of this decline is directly linked to events in the real estate market is impossible to say, but the real estate decline certainly played a role.

Table 3
The Massachusetts and United States Economies in 1987

	Massachusetts	United States
Unemployment Rate[a]	2.4%	6.1%
Annual Percent Change in Nonagricultural Employment (1984–87)[b]	2.2%	2.6%
Annual Percent Change in Civilian Labor Force (1984–87)[b]	.5%	1.8%
Average Hourly Earnings of Production Workers[c]	$10.04	$10.00
Median Home Price, 1987[d]	$177,200	$85,600
Annual Rent per Square Foot of Class A Office Space, 1987[e]	$37–$40	$22.23

[a]July 1987. U.S. Bureau of Labor Statistics.

[b]Based on change from the 4th quarter 1984 to the 4th quarter 1987, expressed at annual rates.

[c]U.S. Bureau of Labor Statistics, average for November 1987, the first month that the Mass. figure rose above the national figure. The wage rate in Massachusetts was 4 percent higher than the national wage rate at the end of 1990.

[d]Median sales price of existing single-family homes in the Boston CMSA for the year 1987, National Association of Realtors, *Home Sales*, October 1988.

[e]See Table 1.

IV. Conclusion

Clearly, the real estate cycle is not the only story behind the current deep recession in Massachusetts and New England. Declines in defense spending, retrenchment in the high technology sector, and a national recession have all contributed. Manufacturing employment in the state began to decline back in 1984, long before the real estate boom had any discernible impact. Nonetheless, there is strong evidence that the real estate cycle amplified the business cycle significantly, both on the way up and on the way down. Not only is the region giving back jobs that were added directly because of the real estate boom, the boom did serious damage to the cost structure of the region, making it less attractive to both existing firms and potential new entrants to the region.

In many ways Massachusetts in 1991 is back to where it was in 1984. But in 1984, the unemployment rate was dropping and the economy was on an upswing. Today, the unemployment rate appears to have leveled off just shy of 10 percent, and the road to recovery looks very long. Much of the reason for this change in fortunes lay hidden in what we thought was evidence of great success: the great real estate boom of 1984–87.

[10] The output of the DRI Regional Forecasting Service shows that housing prices, wage rates, and labor availability are all very significant determinants of regional and state employment growth rates.

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Infrastructure and Regional Economic Performance: Comment

Robert Eisner

William R. Kenan Professor of Economics, Northwestern University.
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Widely disparate results have flowed from various attempts to analyze the impact of public investment in tangible infrastructure. Charles Hulten purports to see estimates of "much larger elasticities [of output] with respect to public capital (often exceeding the corresponding private elasticity)" in time series than in analyses of state data (Hulten 1990, p. 105). The substantial body of data for 48 states over the years 1970 to 1986 put together by Munnell and her associate offers a unique opportunity to reveal divergences of estimates from the same data set.[1] Results from overall regressions, pooled cross sections, and pooled time series of these data do indeed reveal sharp differences, but in quite the opposite direction from those suggested by Hulten.

Munnell reports the results of what may be called "overall" regressions, where the observation vectors consist of differences from the means of public and private capital stock, labor, and output series for all 48 states for all 17 years. Regressions on these vectors thus combine cross-section and time-series variance and covariance. In fact, though, as we shall note, it is the cross sections that dominate.

On the basis of her overall regressions, Munnell reports that private capital, labor, and public capital all contribute to state output and that unemployment, even given the number of workers in nonagricultural employment, reduces it. In unconstrained Cobb-Douglas (log-linear) regressions (Munnell 1990a, Table 5), Munnell finds elasticities of state output of 0.31 to private capital, 0.59 to labor, and 0.15 to public capital, all with huge, significant t-statistics. In log-linear regressions breaking down public capital, Munnell finds similar significant positive elasticities for two of its components—0.06 for highways and 0.12 for water and sewer systems—but only a small, not significant coefficient of 0.01 for "other state and local capital, primarily buildings" (Munnell 1990a, Table 6). And breaking down her observation set into four regions, she reports uniformly positive but varying elasticities of output to public

capital—0.07 for the Northeast, 0.12 for North Central states, a very high 0.36 for the South, and 0.08 for the West (Munnell 1990a, Table 7).

Munnell also reports results of estimates of translog production functions (Munnell 1990a, Table 9). They yield similar positive elasticities for public capital, 0.16 as the coefficient of the log of public capital, but positive coefficients for the squared terms, suggesting increasing returns to scale for factors greater than their means, particularly for private capital and labor. And finally, the results show negative coefficients for the cross-product terms involving private capital, suggesting that both public capital and labor are substitutes for private capital.

Munnell's results essentially are replicated here in corresponding Tables 5A, 6A, 7A and 9A.[2] In Table 5B, however, pooled time series regressions give strikingly different results. The observation vectors here involve differences for each state from the mean of all its own observations. The variance and covariance are thus exclusively over time; differences between states play no part. In these time series the private capital and labor coefficients are in the usually expected range, 0.292 and 0.768, respectively. The public capital coefficient, however, is virtually zero in the unconstrained regression, indeed (not significantly) negative, −0.026. Where the coefficients of private capital and labor are constrained to sum to unity, a significantly positive coefficient for public capital again is found. In view of the results of the unconstrained regression, however, that would appear to entail public capital proxying for private capital (with which it is correlated) to bring forth the increasing returns that are evident here, as elsewhere.

What is going on becomes clearer in Table 5C, which offers the pooled cross-section results. These observation vectors involve differences for each state for each year from the mean of observations of all states for that year. The variance and covariance underlying the regressions are thus pure cross section, involving only differences between states. The coefficients in Table 5C are very similar to the results of replicating Munnell's overall regressions. The public capital coefficient (elasticity), in particular, is a highly significant 0.165 in the cross section versus 0.155 in the overall regression.

Similar comparisons of regional regressions are offered in Tables 7A, 7B, and 7C. The time series regression of Table 7B again shows non-significant and, in fact, small negative coefficients for public capital, except in the West, where the coefficient is a significantly positive 0.121. The cross-section results of Table 7C show somewhat higher coefficients for public capital than do the overall regressions of Table 7A in all the regions other than the West, where the coefficient is close to zero.

Finally, turning to the translog production functions shown in Tables 9A, 9B and 9C, it must first be noted that the coefficient of the public capital term is again virtually zero in Table 9B's time series. Further, the positive coefficients of the squared terms, as in the overall and cross-section regressions of Tables 9A and 9C, offer evidence of increasing returns, particularly in labor and public capital. But the time series suggest that public capital is a substitute for both private capital and labor. Unemployment, by the way, has a negative coefficient in almost all regressions, a finding not without interesting policy implications.

The regressions reported in Table E1 show the results of a more direct examination of the role of public capital in distributed-lag investment functions. They show the characteristic accelerator role for investment along with differences between sums of coefficients in time series (0.721) and cross sections (0.825), reported in firm data long ago (Eisner 1978, among others). Little evidence is shown of a role for public capital except, perhaps, the negative coefficient (−0.070) in the time series. This would seem to suggest that public capital is a substitute for private investment, perhaps making it more productive, so that less of it is needed for any given increase in output.

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[1] Editor's note: This article comments on research by Alicia H. Munnell with the assistance of Leah M. Cook. Their results were published in a paper, "How Does Public Infrastructure Affect Regional Economic Performance?" that appeared in the September/October 1990 *New England Economic Review* and in the proceedings of this Bank's economic conference No. 34, entitled *Is There a Shortfall in Public Capital Investment?* The paper explores the impact of the stock of public capital on economic activity at the state and regional level. Munnell concludes that those states that have invested in infrastructure tend to have greater output, more private investment, and higher employment growth. The Munnell tables referred to are reproduced at the end of this article, along with Eisner's results.

[2] Our one major discrepancy is with regard to Durbin-Watson (D-W) statistics, which are of uncertain meaning in this combination of cross section and time series. In fact the statistic must surely depend on the order of the observations. I took the 17 observations for each state in turn, and got very low D-W statistics. The fact that Munnell reports D-Ws close to 2 suggests to me that her regression program took first the 48 different state observations for one year and then 48 state observations for the next year, and so forth. (This is correct—Ed.) Also contributing to my very low D-Ws is the nature of the pooled regression. Since regression planes differ by states, each state's residuals from the pooled regression will be particularly autocorrelated.

Conclusion

Where does all this leave the ongoing debate on the role of public capital? First, it is clear, on the one hand, that those states that have more capital have greater output, even after taking into account both their amounts of labor (nonagricultural employment) and private capital. On the other hand, no evidence was found that states that have more public capital one year than another have more output during the year with more public capital.[3] This latter finding is hardly any comfort to those who would argue that increasing public capital will increase output and income. But it is also hardly surprising. In the first place, who would reasonably expect that adding a new sewer system or a new highway to a state's public capital stock at the beginning of a year would add to the state's output that year?[4] If the additions affect conventional output, the impact would rather be expected with considerable and possibly variable lags.

Furthermore, a large part of the output of public capital—the environmental benefits of water and sewage systems, the time savings of better transportation, the pleasures of public parks, and the greater comforts of public buildings—are not included in conventional measures of output or gross state product. They may make significant contributions in other measures such as Nordhaus and Tobin's MEW (measure of economic welfare) or Eisner's TISA (total incomes system of accounts), or in broader measures still.

The cross-section results do indicate a significant and substantial association between public capital and state output. Serious questions remain, however, as to which is cause and which is effect. Does public capital contribute to more output? Or do states that have greater output and income, as a consequence of having more private capital and labor, tend to acquire more public capital, perhaps for all of the nonmeasured benefits suggested above?

[3] This inference is supported by the results of regressions in first differences (Table 5D). The coefficient of public capital is virtually zero but the coefficients of private capital are also close to zero, indeed slightly negative (−0.032 with a t-statistic of 1.407 in the overall regression), and results were little different in the pooled cross sections and time series.

[4] It must be said that introducing lags of up to six years failed to uncover a significantly positive sum of coefficients for public capital in time series regressions. The variations of public capital over time, simply enough, do not account for any of the variance of state output over time beyond that explained by private capital, nonagricultural employment, and the rate of unemployment.

The Tables

Table 5

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), 48 States, 1970–86 (Munnell Table)

Equation for Output (lnQ)										$\bar{R}^2$	SE	DW
					Private Capital Only							
1) No Constraint:	lnMFP	+	alnK	+	blnL	+	dU%			.992	.092	2.0
	6.75		.36		.69		−.006					
	(69.2)		(38.0)		(82.4)		(4.0)					
2) a + b = 1:	lnMFP	+	a(lnK − lnL)	+	lnL	+	dU%			.990	.103	2.1
	7.32		.30		1.0*		−.002					
	(74.2)		(31.9)				(1.0)					
					Including Public Capital							
3) No Constraint:	lnMFP	+	alnK	+	blnL	+	clnG	+	dU%	.993	.088	1.9
	5.75		.31		.59		.15		−.007			
	(39.7)		(30.1)		(43.2)		(9.0)		(4.7)			
4) a + b = 1:	lnMFP	+	a(lnK − lnL)	+	lnL	+	clnG	+	dU%	.992	.090	2.0
	6.33		.34		1.0*		.06		−.007			
	(59.6)		(39.6)				(15.9)		(4.6)			
5) a + b + c = 1:	lnMFP	+	a(lnK − lnL)	+	lnL	+	c(lnG − lnL)	+	dU%	.990	.102	2.0
	6.82		.27		1.0*		.08		−.002			
	(45.8)		(23.3)				(4.4)		(1.0)			

Note: Q = gross state product; MFP = the level of technology; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\bar{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

*Constrained to equal 1.

Table 5A

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), 48 States, 1970–86 (Replication of Table 5, Munnell)

Equation for Output (lnQ)										$\hat{R}^2$	SE	DW
			Private Capital Only									
1) No Constraint:	α	+	alnK	+	blnL	+	dU%					
	1.948		.355		.695		−.006			.992	.092	.176
	(39.792)		(38.054)		(82.424)		(4.093)					
2) a + b = 1	α	+	a(lnK − lnL)	+	lnL	+	dU%					
	2.472		.299		1.0*		−.002			.555	.103	.174
	(70.407)		(31.891)				(1.038)					
			Including Public Capital									
3) No Constraint:	α	+	alnK	+	blnL	+	clnG	+	dU%			
	1.643		.309		.594		.155		−.007	.993	.088	.180
	(28.536)		(30.100)		(43.203)		(9.036)		(4.754)			
4) a + b = 1:	α	+	a(lnK − lnL)	+	lnL	+	clnG	+	dU%			
	1.793		.343		1.0*		.057		−.007	.660	.090	.177
	(34.084)		(39.662)				(15.887)		(4.619)			
5) a + b + c = 1:	α	+	a(lnK − lnL)	+	lnL	+	c(lnG − lnL)	+	dU%			
	2.352		.269		1.0*		.084		−.002	.564	.102	.179
	(53.230)		(23.344)				(4.390)		(1.036)			

Note: Q = gross state product; α = intercept; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

*Constrained to equal 1.

Table 5B

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), 48 States, 1970–86, Time Series

Equation for Output (lnQ)								$\hat{R}^2$	SE	DW
			Private Capital Only							
1) No Constraint:	alnK	+	blnL	+	dU%					
	.288		.756		−.006			.999	.038	.608
	(11.655)		(27.869)		(6.233)					
2) a + b = 1:	a(lnK − lnL)	+	lnL	+	dU%					
	.295		1.0*		−.005			.937	.039	.669
	(11.807)				(5.542)					
			Including Public Capital							
3) No Constraint:	alnK	+	blnL	+	clnG	+	dU%			
	.292		.768		−.026		−.005	.999	.038	.613
	(11.625)		(25.527)		(.902)		(5.358)			
4) a + b = 1:	a(lnK − lnL)	+	lnL	+	clnG	+	dU%			
	.282		1.0*		.050		−.006	.938	.038	.617
	(11.276)				(3.473)		(6.415)			
5) a + b + c = 1:	a(lnK − lnL)	+	lnL	+	c(lnG − lnL)	+	dU%			
	.302		1.0*		−.076		−.004	.938	.038	.643
	(12.182)				(3.999)		(4.852)			

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

*Constrained to equal 1.

Table 5C

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), 48 States, 1970–86, Cross Sections

Equation for Output (lnQ)									$\hat{R}^2$	SE	DW
				Private Capital Only							
1) No Constraint:	alnK	+	blnL	+	dU%						
	.355		.694		−.004				.992	.092	.161
	(37.875)		(82.160)		(2.195)						
2) a + b = 1:	a(lnK − lnL)	+	lnL	+	dU%						
	.299		1.0*		.0005				.560	.102	.152
	(31.889)				(.236)						
				Including Public Capital							
3) No Constraint:	alnK	+	blnL	+	clnG	+	dU%				
	.304		.589		.165		−.006		.993	.087	.154
	(29.073)		(42.743)		(9.421)		(3.422)				
4) a + b = 1:	a(lnK − lnL)	+	lnL	+	clnG	+	dU%				
	.342		1.0*		.056		−.005		.663	.089	.159
	(39.557)				(15.676)		(2.848)				
5) a + b + c = 1:	a(lnK − lnL)	+	lnL	+	c(lnG − lnL)	+	dU%				
	.263		1.0*		.098		−.0003		.572	.101	.148
	(22.486)				(4.997)		(.141)				

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

*Constrained to equal 1.

Table 5D

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), 48 States, 1970–86, First Differences

Equation for Output (lnQ)											$\hat{R}^2$	SE	DW
					Private Capital Only								
1) No Constraint:	α	+	alnK	+	blnL	+	dU%						
	.011		−.033		.830		−.006				.690	.021	1.766
	(8.287)		(1.449)		(23.273)		(8.215)						
2) a + b = 1:	α	+	a(lnK − lnL)	+	lnL	+	dU%						
	.033		−.215		1.0*		−.014				.505	.026	1.438
	(33.849)		(8.040)				(18.447)						
					Including Public Capital								
3) No Constraint:	α	+	alnK	+	blnL	+	clnG	+	dU%				
	.011		−.032		.831		−.007		−.006		.690	.021	1.766
	(7.763)		(1.407)		(22.491)		(.144)		(7.862)				
4) a + b = 1:	α	+	a(lnK − lnL)	+	lnL	+	clnG	+	dU%				
	.027		−.219		1.0*		.305		−.015		.525	.026	1.517
	(19.403)		(8.352)				(5.684)		(19.303)				
5) a + b + c = 1:	α	+	a(lnK − lnL)	+	lnL	+	c(lnG − lnL)	+	dU%				
	.028		−.096		1.0*		−.491		−.009		.587	.024	1.420
	(29.920)		(3.672)				(12.313)		(9.910)				

Note: Q = gross state product; α = intercept; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 768. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

*Constrained to equal 1.

Table 6

Output as a Function of Private Capital (K), Labor (L), and Disaggregated Public Capital (H, WS, O), 48 States, 1970–86 (Munnell Table)

Equation for Output (lnQ)													$\hat{R}^2$	SE	DW
				State and Local Capital											
lnMFP	+	alnK	+	blnL	+	clnH	+	dlnWS	+	elnO	+	fU%			
5.72		.31		.55		.06		.12		.01		−.007	.993	.085	1.9
(42.0)		(28.1)		(35.4)		(3.8)		(9.6)		(.7)		(5.2)			

Note: Q = gross state product; MFP = the level of technology; K = private capital stock; L = employment on nonagricultural payrolls; H = stock of highways; WS = stock of water and sewer systems; O = other state and local public capital, primarily buildings; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

Table 6A

Output as a Function of Private Capital (K), Labor (L), and Disaggregated Public Capital (H, WS, O), 48 States, 1970–86 (Replication of Table 6, Munnell)

Equation for Output (lnQ)													$\hat{R}^2$	SE	DW
				State and Local Capital											
lnMFP	+	alnK	+	blnL	+	clnH	+	dlnWS	+	elnO	+	fU%			
1.926		.312		.550		.059		.119		.009		−.007	.993	.085	.188
(36.684)		(28.142)		(35.380)		(3.821)		(9.597)		(.692)		(5.255)			

Note: Q = gross state product; MFP = the level of technology; K = private capital stock; L = employment on nonagricultural payrolls; H = stock of highways; WS = stock of water and sewer systems; O = other state and local public capital, primarily buildings; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

Table 6B

Output as a Function of Private Capital (K), Labor (L), and Disaggregated Public Capital (H, WS, O), 48 States, 1970–86, Time Series

Equation for Output (lnQ)											$\hat{R}^2$	SE	DW
				State and Local Capital									
alnK	+	blnL	+	clnH	+	dlnWS	+	elnO	+	fU%			
.235		.801		.077		.079		−.115		−.005	.999	.037	.627
(8.966)		(26.923)		(2.457)		(5.245)		(6.325)		(5.287)			

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; H = stock of highways; WS = stock of water and sewer systems; O = other state and local public capital, primarily buildings; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

Table 6C

Output as a Function of Private Capital (K), Labor (L), and Disaggregated Public Capital (H, WS, O), 48 States, 1970–86, Cross Section

Equation for Output (lnQ)											$\hat{R}^2$	SE	DW
				State and Local Capital									
alnK	+	blnL	+	clnH	+	dlnWS	+	elnO	+	fU%			
.309		.548		.064		.116		.011		−.006	.993	.085	.162
(26.634)		(35.341)		(3.913)		(9.302)		(.895)		(3.229)			

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; H = stock of highways; WS = stock of water and sewer systems; O = other state and local public capital, primarily buildings; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 816. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

Table 7

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), Four Regions, 1970–86 (Munnell Table)

Equation for Output (lnQ)										$\bar{R}^2$	SE	DW	n
					Private Capital Only								
	lnMFP	+	alnK	+	blnL	+	dU%						
Northeast	9.31		.11		.95		−.01			.997	.068	1.5	153
	(28.2)		(3.3)		(28.9)		(3.2)						
North Central	6.90		.34		.72		−.003			.998	.048	2.0	204
	(27.9)		(14.2)		(41.2)		(1.8)						
South	6.03		.42		.62		−.01			.983	.098	1.7	272
	(31.1)		(22.4)		(30.3)		(4.7)						
West	4.92		.54		.58		−.02			.997	.058	1.7	187
	(31.6)		(36.9)		(51.4)		(7.9)						
					Including Public Capital								
	lnMFP	+	alnK	+	blnL	+	clnG	+	dU%				
Northeast	8.83		.09		.90		.07		−.01	.997	.067	1.5	153
	(22.7)		(2.7)		(22.2)		(2.3)		(3.7)				
North Central	5.68		.34		.62		.12		−.004	.998	.046	2.0	204
	(15.8)		(15.1)		(22.3)		(4.5)		(2.6)				
South	3.15		.38		.36		.36		−.02	.988	.082	1.7	272
	(10.1)		(22.8)		(12.0)		(10.8)		(6.8)				
West	4.53		.51		.53		.08		−.02	.997	.056	2.0	187
	(23.4)		(28.0)		(28.7)		(3.2)		(8.4)				

Note: Q = gross state product; MFP = the level of technology; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses. $\bar{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic; n = number of observations.

Table 7A

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), Four Regions, 1970–86 (Replication of Table 7, Munnell)

Equation for Output (lnQ)										$\bar{R}^2$	SE	DW	n
					Private Capital Only								
	α	+	alnK	+	blnL	+	dU%						
Northeast	2.722		.109		.953		−.010			.997	.068	.14	153
	(25.097)		(3.302)		(28.847)		(3.239)						
North Central	1.892		.337		.724		−.003			.998	.048	.49	204
	(14.431)		(14.259)		(41.252)		(1.859)						
South	1.762		.424		.618		−.012			.983	.098	.07	272
	(19.034)		(22.379)		(30.315)		(4.661)						
West	.932		.541		.577		−.019			.997	.058	.33	187
	(10.689)		(36.923)		(51.441)		(7.913)						
					Including Public Capital								
	α	+	alnK	+	blnL	+	clnG	+	dU%				
Northeast	2.616		.090		.898		.073		−.012	.997	.067	.15	153
	(22.413)		(2.672)		(22.195)		(2.282)		(3.785)				
North Central	1.371		.342		.624		.120		−.005	.998	.046	.51	204
	(8.018)		(15.133)		(22.328)		(4.482)		(2.588)				
South	.688		.375		.356		.356		−.015	.988	.082	.10	272
	(5.455)		(22.808)		(11.987)		(10.782)		(6.807)				
West	.874		.506		.530		.079		−.019	.997	.056	.33	187
	(10.059)		(28.052)		(28.738)		(3.208)		(8.447)				

Note: Q = gross state product; α = intercept; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses. $\bar{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic; n = number of observations.

Table 7B

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), Four Regions, 1970–86, Time Series

Equation for Output (lnQ)								$\hat{R}^2$	SE	DW	n
				Private Capital Only							
	alnK	+	blnL	+	dU%						
Northeast	.201		1.058		−.007			.999	.034	.51	153
	(3.910)		(16.416)		(3.720)						
North Central	.138		.925		−.001			.999	.034	.80	204
	(2.600)		(13.959)		(.715)						
South	.452		.543		−.005			.997	.040	.42	272
	(8.928)		(9.299)		(2.993)						
West	.148		.842		−.005			.999	.029	.52	187
	(4.210)		(24.778)		(3.261)						
				Including Public Capital							
	alnK	+	blnL	+	clnG	+	dU%				
Northeast	.210		1.078		−.058		−.006	.999	.034	.52	153
	(4.025)		(15.961)		(.995)		(2.715)				
North Central	.141		.932		−.016		−.001	.999	.034	.80	204
	(2.584)		(13.122)		(.258)		(.632)				
South	.464		.560		−.044		−.004	.997	.040	.43	272
	(8.768)		(8.957)		(.770)		(2.615)				
West	.137		.780		.121		−.007	.999	.029	.57	187
	(3.969)		(19.949)		(2.962)		(4.266)				

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic; n = number of observations.

Table 7C

Output as a Function of Private Capital (K), Labor (L), and Public Capital (G), Four Regions, 1970–86, Cross Section

Equation for Output (lnQ)								$\hat{R}^2$	SE	DW	n
				Private Capital Only							
	alnK	+	blnL	+	dU%						
Northeast	.072		.987		−.004			.998	.063	.08	153
	(2.284)		(31.331)		(.862)						
North Central	.341		.712		.004			.998	.044	.37	204
	(15.281)		(42.220)		(1.521)						
South	.429		.608		−.017			.982	.099	.06	272
	(21.977)		(28.058)		(4.222)						
West	.556		.569		−.016			.997	.056	.25	187
	(37.476)		(49.871)		(5.383)						
				Including Public Capital							
	alnK	+	blnL	+	clnG	+	dU%				
Northeast	.025		.892		.139		−.008	.998	.058	.08	153
	(.819)		(25.099)		(4.694)		(1.690)				
North Central	.345		.607		.127		.003	.998	.041	.38	204
	(16.565)		(23.801)		(5.286)		(1.215)				
South	.380		.318		.383		−.024	.988	.080	.11	272
	(23.288)		(10.438)		(11.629)		(7.205)				
West	.537		.549		.036		−.018	.997	.056	.25	187
	(25.121)		(27.558)		(1.217)		(5.489)				

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic; n = number of observations.

Table 9

Output (lnQ) and Translog Production Function, 48 States, 1970–86 (Munnell Table)

Equations for Output (ln Q):

Including Aggregate Public Capital	Coefficient (t-Statistic)	Disaggregating Public Capital	Coefficient (t-Statistic)
$\ln K-\overline{\ln K}$	.22	$\ln K-\overline{\ln K}$	.21
	(18.9)		(16.1)
$\ln L-\overline{\ln L}$	.69	$\ln L-\overline{\ln L}$	.67
	(37.5)		(35.7)
$\ln G-\overline{\ln G}$	.16	$\ln H-\overline{\ln H}$	.04
	(9.1)		(2.7)
		$\ln WS-\overline{\ln WS}$	.15
			(10.9)
		$\ln O-\overline{\ln O}$	−.02
			(1.1)
$(\ln K-\overline{\ln K})^2$	.27	$(\ln K-\overline{\ln K})^2$	.27
	(11.7)		(10.3)
$(\ln L-\overline{\ln L})^2$	.13	$(\ln L-\overline{\ln L})^2$	.17
	(3.2)		(3.1)
$(\ln G-\overline{\ln G})^2$	.03	$(\ln H-\overline{\ln H})^2$	.02
	(.5)		(.3)
		$(\ln WS-\overline{\ln WS})^2$	.01
			(.4)
		$(\ln O-\overline{\ln O})^2$	.09
			(3.9)
$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.39	$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.35
	(9.8)		(7.9)
$(\ln K-\overline{\ln K})(\ln G-\overline{\ln G})$	−.14	$(\ln K-\overline{\ln K})(\ln H-\overline{\ln H})$	−.10
	(2.1)		(1.6)
$(\ln L-\overline{\ln L})(\ln G-\overline{\ln G})$	.12	$(\ln K-\overline{\ln K})(\ln WS-\overline{\ln WS})$	.08
	(1.4)		(2.1)
		$(\ln K-\overline{\ln K})(\ln O-\overline{\ln O})$	−.20
			(4.4)
		$(\ln L-\overline{\ln L})(\ln H-\overline{\ln H})$	.11
			(2.0)
		$(\ln L-\overline{\ln L})(\ln WS-\overline{\ln WS})$	−.05
			(.6)
		$(\ln L-\overline{\ln L})(\ln O-\overline{\ln O})$	−.04
			(0.8)
U%	−.006	U%	−.006
	(4.7)		(5.2)
intercept	11.0	intercept	11.0
	(1190.3)		(1168.1)
$\hat{R}^2$	.995	$\hat{R}^2$	.996
DW	1.7	DW	1.7

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; H = stock of highways; WS = stock of water and sewer systems; O = other state and local capital, primarily buildings; and U% = state unemployment rate; overbar denotes mean; t-statistics in parentheses; number of observations = 816.

Table 9A

Output (lnQ) and Translog Production Function, 48 States, 1970–86 (Replication of Table 9, Munnell)

Equations for Output (ln Q):

Including Aggregate Public Capital	Coefficient	Disaggregating Public Capital	Coefficient
$\ln K-\overline{\ln K}$	.256	$\ln K-\overline{\ln K}$	.259
	(25.582)		(24.726)
$\ln L-\overline{\ln L}$	.671	$\ln L-\overline{\ln L}$	.668
	(46.566)		(41.047)
$\ln G-\overline{\ln G}$	.132	$\ln H-\overline{\ln H}$	.020
	(8.151)		(1.415)
		$\ln WS-\overline{\ln WS}$	.120
			(11.006)
		$\ln O-\overline{\ln O}$	−.024
			(1.685)
$(\ln K-\overline{\ln K})^2$	.269	$(\ln K-\overline{\ln K})^2$	.270
	(11.661)		(10.325)
$(\ln L-\overline{\ln L})^2$	.125	$(\ln L-\overline{\ln L})^2$	.169
	(3.240)		(3.101)
$(\ln G-\overline{\ln G})^2$	.027	$(\ln H-\overline{\ln H})^2$	.017
	(.464)		(.350)
		$(\ln WS-\overline{\ln WS})^2$	.014
			(.432)
		$(\ln O-\overline{\ln O})^2$	.093
			(3.904)
$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.387	$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.351
	(9.822)		(7.887)
$(\ln K-\overline{\ln K})(\ln G-\overline{\ln G})$	−.143	$(\ln K-\overline{\ln K})(\ln H-\overline{\ln H})$	−.095
	(2.053)		(1.583)
$(\ln L-\overline{\ln L})(\ln G-\overline{\ln G})$	.122	$(\ln K-\overline{\ln K})(\ln WS-\overline{\ln WS})$	.083
	(1.402)		(2.125)
		$(\ln K-\overline{\ln K})(\ln O-\overline{\ln O})$	−.200
			(4.355)
		$(\ln L-\overline{\ln L})(\ln H-\overline{\ln H})$	.105
			(1.973)
		$(\ln L-\overline{\ln L})(\ln WS-\overline{\ln WS})$	−.049
			(.639)
		$(\ln L-\overline{\ln L})(\ln O-\overline{\ln O})$	−.038
			(0.756)
U%	−.006	U%	−.006
	(4.717)		(5.231)
intercept	10.504	intercept	10.494
	(1148.738)		(1160.292)
$\hat{R}^2$	.995	$\hat{R}^2$	.996
DW	.236	DW	.263

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; H = stock of highways; WS = stock of water and sewer systems; O = other state and local capital, primarily buildings; and U% = state unemployment rate; overbar denotes mean; t-statistics in parentheses; number of observations = 816.

Table 9B

Output (lnQ) and Translog Production Function, 48 States, 1970–86, Time Series

Equations for Output (ln Q):

Including Aggregate Public Capital	Coefficient (t-Statistic)	Disaggregating Public Capital	Coefficient (t-Statistic)
$\ln K-\overline{\ln K}$	.209	$\ln K-\overline{\ln K}$	.150
	(8.015)		(5.562)
$\ln L-\overline{\ln L}$	.851	$\ln L-\overline{\ln L}$	.864
	(27.416)		(28.216)
$\ln G-\overline{\ln G}$	−.007	$\ln H-\overline{\ln H}$	.083
	(.234)		(2.337)
		$\ln WS-\overline{\ln WS}$	.071
			(4.754)
		$\ln O-\overline{\ln O}$	−.081
			(4.629)
$(\ln K-\overline{\ln K})^2$	.386	$(\ln K-\overline{\ln K})^2$	−.282
	(1.209)		(0.785)
$(\ln L-\overline{\ln L})^2$	1.210	$(\ln L-\overline{\ln L})^2$	.726
	(3.405)		(1.997)
$(\ln G-\overline{\ln G})^2$	1.254	$(\ln H-\overline{\ln H})^2$	1.601
	(3.622)		(5.947)
		$(\ln WS-\overline{\ln WS})^2$	−.097
			(.908)
		$(\ln O-\overline{\ln O})^2$	.180
			(1.355)
$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.020	$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.679
	(.034)		(1.062)
$(\ln K-\overline{\ln K})(\ln G-\overline{\ln G})$	−1.360	$(\ln K-\overline{\ln K})(\ln H-\overline{\ln H})$	−1.970
	(2.571)		(3.310)
$(\ln L-\overline{\ln L})(\ln G-\overline{\ln G})$	−1.425	$(\ln K-\overline{\ln K})(\ln WS-\overline{\ln WS})$	.846
	(2.725)		(3.012)
		$(\ln K-\overline{\ln K})(\ln O-\overline{\ln O})$	−.514
			(1.492)
		$(\ln L-\overline{\ln L})(\ln H-\overline{\ln H})$	−.249
			(.370)
		$(\ln L-\overline{\ln L})(\ln WS-\overline{\ln WS})$	−.606
			(2.238)
		$(\ln L-\overline{\ln L})(\ln O-\overline{\ln O})$	−.104
			(0.279)
U%	−.003	U%	−.003
	(2.996)		(2.735)
$\bar{R}^2$	.999	$\bar{R}^2$	.999
DW	.639	DW	.676

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; H = stock of highways; WS = stock of water and sewer systems; O = other state and local capital, primarily buildings; and U% = state unemployment rate; overbar denotes mean; t-statistics in parentheses; number of observations = 816.

Table 9C

Output (lnQ) and Translog Production Function, 48 States, 1970–86, Cross Section

Equations for Output (ln Q):

Including Aggregate Public Capital	Coefficient (t-Statistic)	Disaggregating Public Capital	Coefficient (t-Statistic)
$\ln K-\overline{\ln K}$	.236	$\ln K-\overline{\ln K}$	.220
	(24.057)		(20.484)
$\ln L-\overline{\ln L}$	.670	$\ln L-\overline{\ln L}$	.690
	(48.636)		(45.366)
$\ln G-\overline{\ln G}$	.151	$\ln H-\overline{\ln H}$	.057
	(9.743)		(3.833)
		$\ln WS-\overline{\ln WS}$	.110
			(10.689)
		$\ln O-\overline{\ln O}$	−.034
			(2.528)
$(\ln K-\overline{\ln K})^2$	.341	$(\ln K-\overline{\ln K})^2$	.396
	(14.157)		(13.385)
$(\ln L-\overline{\ln L})^2$	.006	$(\ln L-\overline{\ln L})^2$	.188
	(.167)		(3.540)
$(\ln G-\overline{\ln G})^2$	−.072	$(\ln H-\overline{\ln H})^2$	−.035
	(1.290)		(.658)
		$(\ln WS-\overline{\ln WS})^2$	.070
			(2.222)
		$(\ln O-\overline{\ln O})^2$	.085
			(3.860)
$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.428	$(\ln K-\overline{\ln K})(\ln L-\overline{\ln L})$	−.466
	(11.333)		(11.010)
$(\ln K-\overline{\ln K})(\ln G-\overline{\ln G})$	−.246	$(\ln K-\overline{\ln K})(\ln H-\overline{\ln H})$	−.293
	(3.477)		(4.283)
$(\ln L-\overline{\ln L})(\ln G-\overline{\ln G})$	.408	$(\ln K-\overline{\ln K})(\ln WS-\overline{\ln WS})$	.205
	(4.868)		(5.349)
		$(\ln K-\overline{\ln K})(\ln O-\overline{\ln O})$	−.291
			(6.750)
		$(\ln L-\overline{\ln L})(\ln H-\overline{\ln H})$	.377
			(6.887)
		$(\ln L-\overline{\ln L})(\ln WS-\overline{\ln WS})$	−.289
			(3.624)
		$(\ln L-\overline{\ln L})(\ln O-\overline{\ln O})$	.064
			(1.329)
U%	−.005	U%	−.004
	(3.352)		(2.832)
$\bar{R}^2$	.996	$\bar{R}^2$	.996
DW	.182	DW	.231

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; H = stock of highways; WS = stock of water and sewer systems; O = other state and local capital, primarily buildings; and U% = state unemployment rate; overbar denotes mean; t-statistics in parentheses; number of observations = 816.

Table E1

Net Private Investment as a Function of Four Lagged Changes in Output and of Labor and Public Capital, 48 States, 1975–86

$$dlnK = b_0 + \sum_{j=1}^{4} b_j\, dlnQ_{-j} + b_5 lnL_{-1} + b_6 lnG_{-1} + U\%_{-1}$$

	Overall	Time Series	Cross Section
b_0 (Constant)	.008	.012	—
	(2.862)	(3.665)	
b_1 ($dlnQ_{-1}$)	.239	.229	.303
	(5.583)	(5.226)	(5.051)
b_2 ($dlnQ_{-2}$)	.178	.162	.175
	(4.030)	(3.491)	(2.786)
b_3 ($dlnQ_{-3}$)	.261	.238	.308
	(6.090)	(5.416)	(4.910)
b_4 ($dlnQ_{-4}$)	.112	.092	.039
	(2.675)	(2.213)	(.623)
$\sum_{j=1}^{4} b_j$ (Σ $dlnQ_{-j}$)	.798	.721	.825
	(8.901)	(7.523)	(8.711)
b_5 ($dlnL_{-1}$)	.003	.024	.004
	(.453)	(.849)	(.585)
b_6 ($dlnG_{-1}$)	−.002	−.070	−.002
	(.222)	(1.746)	(.298)
b_7 ($U\%_{-1}$)	−.0003	−.0003	−.0007
	(.410)	(.227)	(.887)
$\hat{R}^2$	.199	.205	.181
SE	.035	.034	.034
DW	2.125	2.139	2.155

Note: Q = gross state product; K = private capital stock; L = employment on nonagricultural payrolls; G = stock of state and local public capital; and U% = state unemployment rate; t-statistics in parentheses; number of observations = 576. $\hat{R}^2$ = adjusted coefficient of determination; SE = standard error of estimate; DW = Durbin-Watson statistic.

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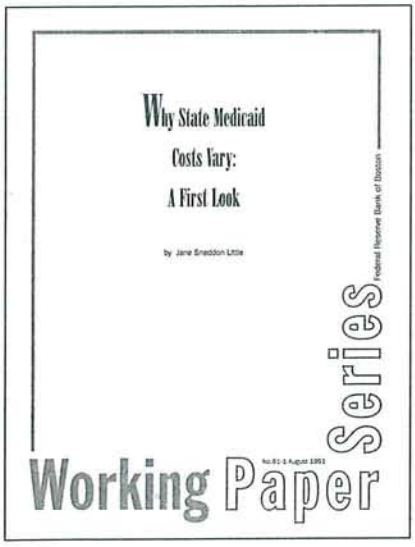

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