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No. 91-6 December 1991

Working Paper Series
Federal Reserve Bank of Boston

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Revised 11/18/91

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Patric H. Hendershott* and Joe Peek**

Abstract

As is widely recognized, real interest rates in the early 1980s were at peaks not witnessed since the late 1920s. Less well perceived is the sharp decline in real interest rates in the middle 1980s to their average levels of the previous quarter century. This paper seeks to identify the underlying determinants of the major movements in real six-month Treasury bill rates. The primary innovation is the development of a new monetary policy proxy that explains much of the real rate movement in the 1980s.

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The authors thank Eric S. Rosengren, Geoffrey M.B. Tootell, James A. Wilcox, participants at seminars at the Reserve Bank of Australia, the University of South Carolina, Penn State University, and the University of Kentucky and two anonymous referees for their helpful comments. Professor Hendershott also thanks the Australian Graduate School of Management of the University of New South Wales for its support while he was in residence as a Fulbright Senior Scholar. This research is part of NBER's program in Financial Markets. The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of Boston, the Board of Governors of the Federal Reserve System, or the National Bureau of Economic Research.

Treasury Bill Rates in the 1970s and 1980s

As is well known, real interest rates in the early 1980s were at peaks not witnessed since the late 1920s (Clarida and Friedman 1983; Hendershott 1986). These rates have generally been attributed to tight monetary policy (Clarida and Friedman), easy fiscal policy (Feldstein 1985), or a combination of the two (Blanchard and Summers 1984 and their discussants). Changes in private saving and investment propensities have been given secondary billing. Less well recognized is that real interest rates declined sharply after 1984.

Movements in ex ante real six-month Treasury bill rates, both pretax and after-tax, are shown in Figure 1 (and precisely defined in the data section). The high pretax real rates in the 1981-85 period and subsequent lower ones are obvious.[1] Equally obvious are the low real rates in the middle 1970s. Those low rates might cause one to view recent real rates as still being high. In fact, though, the average real bill rate in the 1986-88 period equals the average real rate over the previous quarter century. Figure 1 also suggests a strong cyclical pattern in real rates, with the pretax real rate rising by 2 to 3 percentage points from trough to peak over each business cycle (shaded).[2]

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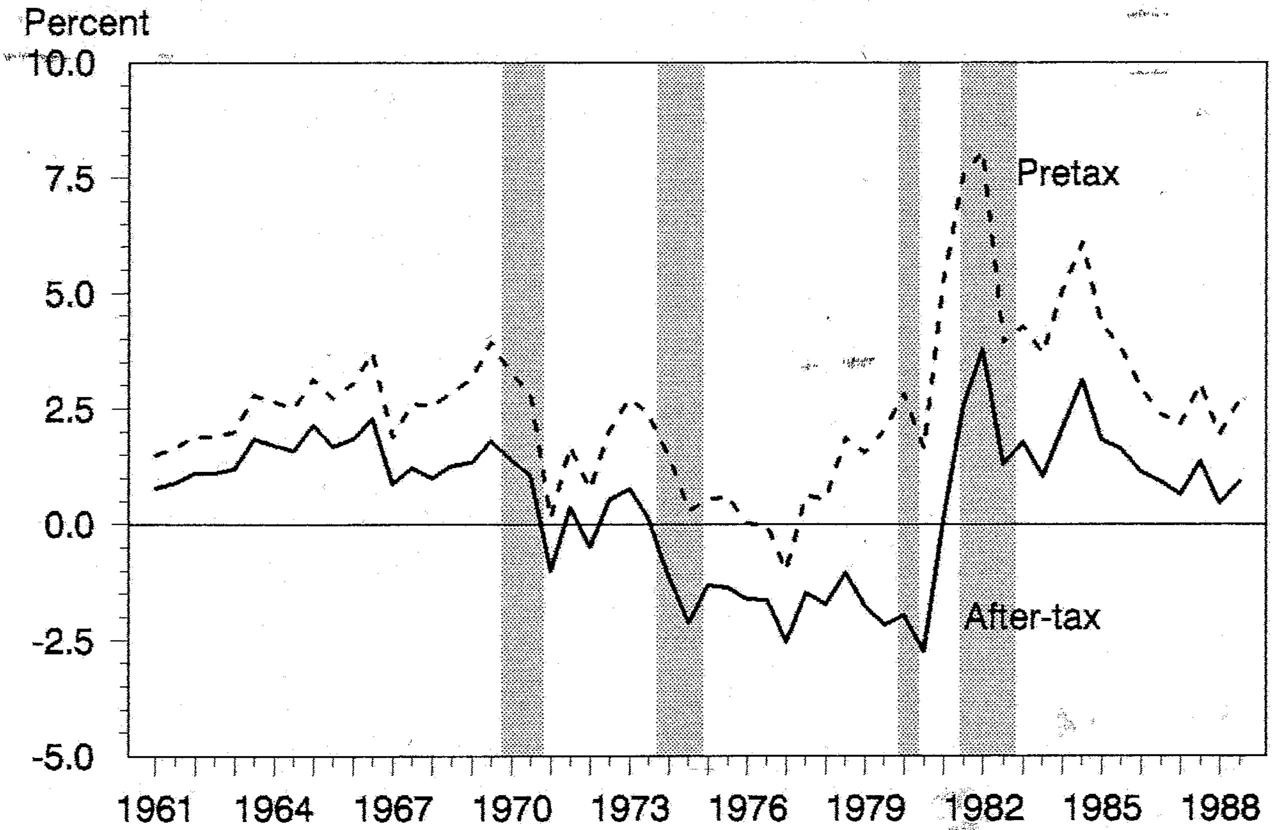
[1] For the 1980-88 period, Drexel Burnham Lambert surveyed "decision-makers" on 10-year inflation expectations. Based upon this series, pretax real 10-year Treasury bond rates have moved roughly like real six-month rates, rising from 2.1 percent in 1980 to 5.8 percent in 1981 to mid-1985 and then falling to 2 percent in late 1986-early 1987, before rising to about 4 percent more recently.

[2] Even the 1966 slowdown, which many at the time viewed as a mini-recession, was accompanied by a decline in real rates. Moreover, between October 1988 (the last point plotted in Figure 1) and April 1990, the pretax real rate rose by 1.5 percentage points before declining almost 2 percentage points by April 1991 in response to the 1990-1991 recession. For earlier

Figure 1
Ex Ante Real Six-Month Treasury Bill Rates



On an after-tax basis, the low rates of the 1970s stand out far more than the high 1980s rates. After-tax real rates were more than a full percentage point below zero throughout the 1974-80 period, while after-tax rates in the 1980s approximated their average value for the 1960s. This paper seeks to identify the underlying determinants of the major movements in both pretax and after-tax real bill rates, pretax because these are the rates most generally referred to and after-tax because these are most relevant to economic activity.

Our innovations to the "standard" pre-1980s model are the addition of investment (Feldstein and Summers' (1978) maximum potential interest rate) and private saving (OPEC) shifters and lagged values of all variables in the economy's expenditure function (to reflect short-term disequilibrium in the goods market). We also develop a new measure of monetary policy because customary empirical measures (for example, the level of the money supply or the acceleration in money growth) do not provide a consistent basis of comparison over time when deposit rate ceilings are removed and new liquid financial claims are introduced. Most of those who attribute high real rates in the 1980s to tight monetary policy do so by default -- monetary policy must be the cause because nothing else seems to explain the high rates -- rather than by relating interest rates to a measure of monetary tightness or ease. With our new measure of monetary policy, we find direct evidence of the important contribution of monetary policy to both the rise in real interest rates in the early 1980s and their subsequent decline.

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empirical evidence on the procyclical pattern in real interest rates, see Hendershott (1986, pp. 45-46) and the references cited therein.

Many of the same factors explain the surge in the early 1980s and the subsequent decline in both before-tax and after-tax real interest rates. A tightening of monetary policy, increased defense purchases, the 1981 Tax Act, the dissipation of the second OPEC shock, and an increase in expected inflation all contributed to the jump in real rates at the beginning of the 1980s. The decline in real rates since then is due to the easing of monetary policy and the reductions in marginal tax rates and investment incentives in the 1986 Tax Act.

This paper is divided into four parts. The model is presented in Section I, and the empirical estimates are reported in Section II. An interpretation of the major shifts in real bill rates, both before- and after-tax, is presented in Section III, and our findings are summarized in Section IV.

I. Derivation of the Estimation Equation

The initial interest-rate model is based on a relatively simple specification of aggregate demand (the IS and LM equations) and aggregate supply. The goods and money market equilibria can be expressed as

$$(1)\quad Y/YN = E(\underset{(-)}{i^*-\pi},\ \underset{(+)}{GOVT},\ \underset{(-)}{NETTAX},\ \underset{(+)}{INCENT},\ \underset{(-)}{OPEC}) \quad \text{and}$$

$$(2)\quad M/P = L(\underset{(+)}{Y},\ \underset{(-)}{i^*},\ \underset{(+)}{RISK},\ \underset{(-)}{OPEC}).$$

Real expenditures relative to full-employment expenditures depend on the after-tax real interest rate, defined as the after-tax nominal rate less the expected inflation rate ($i^*-\pi$); full-employment federal government purchases of goods and services relative to full-employment income (GOVT); full-employment federal taxes less transfers relative to full-employment income (NETTAX); investment tax incentives (INCENT); and OPEC supply shocks (OPEC). Real money demand depends on real income (Y), the after-tax nominal interest rate (i*), default risk on bonds (RISK), and asset demand shifts associated with the OPEC shocks. The presumed partial derivatives of the expenditure and money demand functions with respect to these arguments are indicated in parentheses. The after-tax nominal interest rate is (1-t)i, where t is the marginal tax rate on interest income and i is the pretax nominal rate. Real expenditures equal real income, and real money demand equals real money balances.

Many of the hypothesized responses of planned expenditures in the IS and LM equations are straightforward. Money demand rises with increases in income and in bond default risk, and falls with an increase in the opportunity cost of holding money, the after-tax nominal bond rate. Increases in the after-tax real bond rate and net taxes at full employment are each hypothesized to reduce real expenditures, while increases in full-employment federal government purchases and investment tax incentives are hypothesized to increase real expenditures.[3]

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[3] Changes in government expenditures are often hypothesized to have a larger impact on aggregate demand than changes in tax revenues (the balanced-budget multiplier argument). On the other hand, to the extent government purchases are good substitutes for privately purchased goods, the impact on aggregate demand of government expenditures would be partially offset by a corresponding reduction in private expenditures. Ricardian equivalence hypothesizes that changes in tax revenues financed by changes in government bonds outstanding have no impact on aggregate demand (Barro 1974). Alternatively, to the extent that individuals are liquidity constrained, their marginal propensity to consume out of disposable income would approach unity, allowing tax changes to have substantial effects on aggregate demand. On general measurement issues, see, for example, Eisner (1986) and Kotlikoff (1986).

The OPEC oil shocks shift both the IS and LM curves. An increase in the relative price of energy might reduce the demand for capital, and hence investment, and thus lower the IS curve (Wilcox 1983). Such a shock also would transfer real income to oil-exporting countries. Because the marginal propensity to save of the oil-exporting countries exceeded (at least initially) that of the rest of the world, world saving increased (Sachs 1981; Peek and Wilcox 1983). This would lower the IS curve to the extent that a part of the associated decline in aggregate world expenditures represents a reduction in expenditures on U.S. goods and services. Finally, if the oil-exporting countries desire to maintain a higher proportion of their wealth portfolios in U.S. financial assets than did those that lost wealth (Japan, Europe and the United States), the LM curve will shift downward.

The aggregate supply curve for the economy is given by

$$(3)\quad P/P^e = \underset{(+)}{S}(Y/YN),$$

where P^e is the expected price level for the current period and the equation satisfies the natural rate hypothesis. Assuming that equations (1) to (3) can be specified in terms of the logarithms of Y/YN, M/P and P/P^e (as well as Y in equation (2)), the reduced-form equation for the after-tax nominal interest rate is:

$$(4)\quad i^* = F(\underset{(+)}{\pi}, \underset{(-)}{MYN}, \underset{(+)}{GOVT}, \underset{(-)}{NETTAX}, \underset{(+)}{INCENT}, \underset{(-)}{OPEC}, \underset{(+)}{RISK}),$$

where MYN is equal to $\log(M) - \log(P^e) - a_1\log(YN)$ and a_1 is the income elasticity of money demand.[4] The nominal after-tax interest rate would be

[4] This can be seen with a simple transformation of equation (2) accomplished by subtracting $a_1\log(YN)$ from both sides of the equation to obtain log(Y/YN) as an argument on the right-hand side. Equation (3) is

expected to rise with increases in the expected inflation rate, federal government purchases, investment tax incentives, and bond default risk, and to fall in response to increases in the expected real money supply, net taxes, and real oil prices.[5]

Equations (1) and (2) assume continuous equilibrium in the financial and goods markets. Because financial markets adjust quickly, the economy can plausibly be assumed to be continuously on the LM curve. However, temporary disequilibrium in the goods market can result in the economy being off the long-run IS curve. As a result, shifts in either the IS or LM schedule do not immediately move the economy to the new (i*,Y) equilibrium (Horwich 1964, pp. 525-528). An outward shift of the IS curve moves the economy gradually (along the LM curve) to the higher interest rate/income equilibrium. Thus, lagged values of the IS shifters should enter equation (4).

In contrast, when the LM curve shifts, the interest rate overshoots the new equilibrium. For example, an easing of monetary policy causes the interest rate initially to decline sharply with little change in income and then to rise (along the new LM curve) with income to the new equilibrium. The overshoot and reversal can be captured by including the difference between the

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substituted into (2) to eliminate log(P), and the resulting equation is combined with (1) to eliminate log(Y/YN).

[5] In the equations estimated below, the sign of the RISK coefficient could well be negative rather than positive. The RISK measure is intended to capture a flight to safety, or quality, by portfolio investors when default risk increases. In the simple two-asset case in the model, that flight would be from bonds subject to default to money. However, once we move to real world data with different types and qualities of bonds, it must be recognized that this flight will be not only to money but to default-free Treasury issues as well. Because our dependent variable is the six-month Treasury bill yield, an increase in RISK would tend to put downward pressure on this interest rate, other things equal.

current growth rate of the money supply and its recent average growth rate (MACC) as an argument in the IS curve and thus as a regressor in equation (4) (Peek and Wilcox 1986). If this accelerated growth rate is maintained, MACC gradually reverts to zero and the overshooting of the interest rate decline is eliminated. We would expect the coefficient on MACC to be negative.

The revised interest rate equation is thus:

$$(5)\quad i^* = F(\underset{(-)}{MYN}, \underset{(-)}{MACC}, \underset{(+)}{RISK}; \text{ current and lagged values of: } \underset{(+)}{\pi}, \underset{(+)}{GOVT}, \underset{(-)}{NETTAX}, \underset{(+)}{INCENT}, \underset{(-)}{OPEC})$$

II. Bill Rate Equations

A. The Basic Data

The interest rate equation estimates are based on semiannual observations corresponding to the frequency of the Livingston survey data on expected inflation rates. April and October monthly averages of daily secondary market six-month Treasury bill rates are taken from the Federal Reserve Bulletin and have been converted from a discount basis to an investment yield. The six-month Livingston expected inflation rate series was provided by the Federal Reserve Bank of Philadelphia.[6] This measure of expected inflation has two advantages over mechanical formulations: it is a truly ex ante expectation, and it reflects whatever sophistication agents use to process information. The tax rate on interest income is an average marginal tax rate constructed from data contained in annual editions of

[6] The Livingston survey data actually represent eight- and fourteen-month rather than six- and twelve-month inflation expectations. The timing of the interest rate data has been selected to correspond with the approximate date at which respondents form their expectations.

Statistics of Income, Individual Income Tax Returns as described in Peek and Wilcox (1983). The tax rate used for the October observation is an average of the rate for the current year and the subsequent year.

We use full-employment government purchases and net taxes as our fiscal policy proxies for two reasons. First, separate variables for purchases and for taxes-net-of-transfers, rather than a deficit measure, allow for different impacts of these components (see footnote 3). Second, full-employment measures eliminate the endogenous business cycle element in expenditures and revenues. We base our full-employment measures on the cyclically adjusted deficit series (the middle-expansion trend variant) constructed by the Bureau of Economic Analysis (BEA). Because federal government expenditures rather than purchases have been cyclically adjusted, and transfers rather than purchases account for the bulk of the adjustment, we use as our measure of GOVT the logarithm of the ratio obtained by dividing BEA actual federal government purchases of goods and services by BEA middle-expansion trend GNP. NETTAX is constructed as the logarithm of the ratio obtained by dividing actual federal government purchases less the BEA cyclically adjusted federal government budget deficit by BEA middle-expansion GNP. Because our observations are semiannual rather than quarterly, we use the average of the first and previous fourth quarters to correspond to the April interest rate observation and the average of the second and third quarters for the October observation.

The OPEC proxy is measured as the current account surplus of oil exporting countries, taken from International Financial Statistics, divided by middle-expansion GNP. Because these data are not available prior to 1970, the 1960s values are constructed from net export data. Following the two sharp oil price increases in the 1970s, oil-exporting countries did not immediately purchase imports with their rapidly growing export receipts, causing a temporary surge in their current account surplus. Because this surplus is highly correlated with the relative price of oil, it is also employed as a proxy for the OPEC relative price effect.

MYN is calculated as the logarithm of: the narrowly defined nominal money supply (M1) for the quarter immediately preceding the interest rate observation (that is, first- and third-quarter values), divided by the product of the expected price level (for April and October) based on the Livingston survey data and BEA middle-expansion trend GNP raised to the 0.75 power.[7] MACC is calculated as the growth rate of nominal M1 during the previous six months relative to its growth rate during the previous three years (as in Wilcox 1983). Alternative measures of MYN and MACC based on the M2 definition of the money supply were also considered. Because the results were so similar, the M2 specifications have not been reported in the tables.

INCENT is an updated series for the maximum potential net return from Feldstein and Jung (1987).[8] RISK is calculated as the difference between Moody's Baa and Aaa bond yields divided by the Aaa yield, in each case averaged over the previous six months.

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[7] Because the Livingston survey asks respondents for the price level expected for the subsequent June and December, we applied the six-month expected inflation rate from the October survey to the actual price level for that October to obtain the April expected price level. A similar calculation produced the October observation. The 0.75 value for the long-run income elasticity of money demand is consistent with much of the literature (e.g., Goldfeld 1973).

[8] This series was originally developed by Feldstein and Summers (1978). We thank Joosung Jung for supplying a revised and updated series.

B. Preliminary Estimation

Table 1 contains preliminary estimates of the after-tax bill rate equations. The estimation method is two-stage least squares to address the errors-in-variables problem arising from the use of the Livingston survey expected inflation rate series.[9] The first two rows of Table 1 contain alternative estimates of the "standard" specification -- equation (4) without INCENT and RISK but augmented with MACC (for example, Wilcox 1983). Row 1 contains the results for the 1961:04-1979:04 period. All of the explanatory variables have the predicted sign with the exception of MYN, and all except GOVT and NETTAX are statistically significant. The positive coefficient on MYN is consistent with the findings of much of the previous empirical literature (for example, Peek and Wilcox 1983) and could be caused by the money demand puzzles of the 1970s. Similarly, the insignificance of the estimated coefficients on the fiscal policy variables is not surprising given the mixed evidence from previous studies regarding fiscal policy effects (for example, Evans 1985; Makin 1983; Congressional Budget Office 1984).

This specification does an excellent job of explaining movements in the after-tax bill rate for the 1961-79 period. However, the specification is unable to forecast the sharp rise in after-tax real interest rates in the early 1980s. The difference between actual and fitted after-tax real interest rates exceeds 1 percentage point only once through mid-1980; in contrast, the

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[9] The instrument list includes current and lagged values of each of the explanatory variables (with the exception of π because its current and lagged values are the variables being instrumented), a time trend and the time trend squared. The estimated values of both the coefficients and their t-statistics are essentially the same as those obtained using ordinary least squares estimation.

Table 1
Preliminary After-Tax Bill Rate Equations
Estimation Method: TSLS (standard errors in parentheses)

	Period	CONST	π	OPEC	GOVT	NETTAX	MACC	MYN	RISK	INCENT	π_{-1}	$OPEC_{-1}$	$GOVT_{-1}$	$NETTAX_{-1}$	$INCENT_{-1}$	$\bar{R}^2$	SEE	DW
1.	1961-79	-3.98	1.041	-.041	14.73	-19.32	-.153	10.26								.804	.533	1.60
		(1.44)	(.140)	(.016)	(14.37)	(12.95)	(.055)	(2.96)										
2.	1961-88	.39	.573	-.026	43.24	16.04	-.127	-8.47								.832	.780	1.14
		(1.51)	(.152)	(.023)	(17.32)	(10.33)	(.036)	(1.68)										
3.	1961-88	.66	.478	-.008	44.60	18.26	-.099	-8.82	-10.86	.238						.878	.663	1.34
		(3.05)	(.209)	(.026)	(14.74)	(9.15)	(.031)	(2.57)	(4.48)	(.196)								
4.	1961-88	-1.14	-.024	.068	3.52	-16.53	-.095	-7.69	-11.09	.456	.617	-.085	53.59	27.61	-.157	.909	.573	1.38
		(3.49)	(.245)	(.034)	(27.56)	(15.85)	(.029)	(3.39)	(4.84)	(.185)	(.243)	(.029)	(29.68)	(13.96)	(.223)			

difference between the actual and forecasted rates rises to 7.3 percentage points in early 1982 and does not fall below 2 percentage points until 1987.

Further evidence of the breakdown of the relationship when the 1980s are included is given in row 2 of Table 1. When the sample period is extended through 1988:10, the standard error of the equation rises sharply, the Durbin-Watson statistic declines, and all but the estimated coefficient on MACC change dramatically.[10] While the full-sample equation fits the 1980s better, the improved fit comes at the expense of the 1970s, where the equation underpredicts the early 1970s and overpredicts the low rates of the second half of the 1970s.

Row 3 adds both RISK and INCENT as explanatory variables. The equation's estimated standard error is reduced by 15 percent, with RISK accounting for most of the improvement and the INCENT coefficient not being statistically significantly different from zero.

The final row in Table 1 adds a single lagged value of each IS shifter to the specification, cutting the equation standard error by 14 percent.[11] For four of the five IS shifters, the largest part of their impact comes with a one-period lag (INCENT being the exception). Only NETTAX has a sum of coefficients on its current and lagged values different from that predicted.

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[10] The extended sample period includes the imposition and termination of credit controls in 1980. When dummy variables were included for the two 1980 observations, neither was statistically significant and the other estimated coefficients were little affected.

[11] An F-test was used to determine the number of sets of lagged terms to include, with the maximum considered being three. The method advocated by Startz (1983) was used to calculate the F-test statistic appropriate for linear hypothesis tests for two-stage least squares estimation. In all but one instance (Table 1, row 8), zero coefficients on the first set of lagged regressors could be rejected at the 5 percent level while zero coefficients on the second and third sets of lags could not be rejected.

With respect to the monetary variables, both MACC and MYN have negative, statistically significant estimated coefficients as predicted. However, based on their estimated coefficients in this equation, restrictive monetary policy accounts for only one-eighth of the sharp increase in real interest rates in the early 1980s, a surprisingly small role given the widespread attribution of high 1980s interest rates to a restrictive monetary policy.

C. Measures of Monetary Policy

The creation of new interest-bearing deposit accounts and the deregulation of deposit interest rate ceilings in the late 1970s and early 1980s distorted measures of the money supply and shifted the money demand function (Simpson 1984). Much evidence suggests that the impacts of MYN and MACC might be different in the 1980s than in the 1970s. (See, for example, Friedman 1988.) Moreover, the information contained in these measures might need to be supplemented to account for the shifting relationship between money demand and any particular measure of the money supply.

Our alternative proxy for the stance of monetary policy is based on the behavior of the six-month Treasury bill rate, which the Federal Reserve can control over short periods, relative to that of the five-year Treasury bond rate, over which the Federal Reserve has decidedly less control. In general, one might posit the slope of the term structure (R6/R60, the ratio of the six- to the 60-month Treasury rates) to be a function of the slope of the expected inflation rate structure ($\pi6/\pi60$, the ratio of the six- to the 60-month expected inflation rates) and the ratio of short- to long-term real interest rates. The latter, in turn, should be greater the larger are current federal purchases (GOVT) relative to expected long-run purchases (GOVT60), the lower are full-employment net taxes (NETTAX) relative to expected long-run net taxes

(NETTAX60), the stronger is the economy currently relative to its long-term trend (Y/YN), and the tighter is current monetary policy. We also include RISK. An increase in RISK would reflect an increase in default risk that would cause a "flight to quality." It is expected that such a flight would be more toward Treasury bills than Treasury bonds, lowering R6/R60.

Because we are interested in the impact of monetary policy on the six-month interest rate, it is useful to write:

$$(6)\ R6/R60 = \Phi(\underset{(+)}{\pi 6/\pi 60},\ \underset{(+)}{GOVT},\ \underset{(-)}{GOVT60},\ \underset{(-)}{NETTAX},\ \underset{(+)}{NETTAX60},\ \underset{(-)}{Y/YN},\ \underset{(-)}{RISK}) + MP,$$

where MP is the impact of monetary policy. Solving for MP,

$$(7)\ MP = R6/R60 - \Phi().$$

That is, MP can be computed residually after the estimation of the Φ function. In the actual estimation of equation (6), standard monetary variables (a component of MP) would be included in the equation along with the arguments in $\Phi()$. MP would then be measured as the estimated contribution of the monetary variables and the equation's residual. The fact that MP is measured with error must be taken into account in the estimation of the interest rate equations below.

For the rate ratio, we use the six-month bill rate divided by the five-year rate, both on an investment yield basis, for April and October of each year. The five-year rate is the constant maturity series from the Federal Reserve Bulletin.[12] Unfortunately, a five-year expected inflation

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[12] We used the five- rather than 10- or 20-year Treasury rates for two reasons. First, the data on longer-term Treasuries are contaminated because only deep discount bonds existed between 1966 and 1975 (Cook and Hendershott

rate is unavailable, but a one-year rate is obtainable from the Livingston survey. Thus we use the ratio of six-month and one-year expected inflation rates (denoted $\pi6/\pi12$) as our proxy for $\pi6/\pi60$.[13] We use the logarithm of actual GNP divided by BEA middle-expansion trend GNP for Y/YN.

Empirically, we proxy the expected future GOVT and NETTAX variables by their actual values during the two years beyond the current period (GOVT24 and NETTAX24). A two-year rather than five-year horizon is employed, both because sufficient actual future values of these two variables are unavailable for the final observations in our sample and because the longer the horizon, the less likely are actual government purchases and full-employment net taxes to serve as adequate proxies for their expected values, owing to major unanticipated changes in fiscal policy. The latter factor is particularly important for the sequence of tax law changes in the 1980s, some of which reversed the thrust of prior changes. For the same reason, projections of future values based upon today's tax law and expenditure programs are likely to be inappropriate.

Table 2 presents the results for alternative specifications of the rate ratio equation. The two-stage least squares estimation method is used to address the errors-in-variables problem introduced by our measures of $\pi6/\pi12$, GOVT24 and NETTAX24. The instruments include current and lagged values of the remaining explanatory variables, a time trend and the time trend squared. The equation in row 1 is estimated only through April 1979 to avoid possible

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1978). Second, only short-term expected inflation series are available prior to 1980.

[13] Using the decision-makers' five-year and 10-year expected inflation rates, we can construct measures of $\pi6/\pi60$ and $\pi6/\pi120$ for the 1980s. For the 1980:10-1988:10 period, the simple correlation of $\pi6/\pi12$ with both $\pi6/\pi60$ and $\pi6/\pi120$ is 0.87, suggesting that $\pi6/\pi12$ may not be a bad proxy for longer horizons.

Table 2
Interest Rate Ratio (6 Month to 5 Year) Equations
Estimation Method: TSLS (standard errors in parentheses)

	Period	CONST	$\pi 6/\pi 12$	Y/YN	GOVT	GOVT24	NETTAX	NETTAX24	RISK	MYN	MACC	MYN80	MACC80	$\bar{R}^2$	SEE	DW
1.	1961-79	.55	1.067	3.94	-5.42	-.136	-.842	.234	-.209	.438	-.013			.737	.0626	2.05
		(.99)	(.607)	(1.07)	(4.09)	(.249)	(2.002)	(.294)	(.764)	(.339)	(.008)					
2.	1961-88	1.54	.503	2.13	-1.40	-.162	-.318	.382	-1.177	-.489	-.019	.137	.025	.686	.0676	1.52
		(.79)	(.458)	(.90)	(3.04)	(.294)	(2.139)	(.207)	(.659)	(.149)	(.009)	(.211)	(.008)			

contamination of the estimated coefficients by the changing monetary relationships associated with the October 1979 change in Federal Reserve operating procedures and the acceleration of the ongoing financial deregulation and innovation in the early 1980s. MYN and GOVT have estimated coefficients with signs opposite those predicted, although neither coefficient is statistically significant. Among the four fiscal policy coefficients, only that on GOVT is as large as its estimated standard error. This may be related to the general problems associated with the fiscal policy measures discussed above (see footnote 3).

Row 2 contains the estimates for the full 1961:04-1988:10 period. To allow for a changing impact of M1 in the 1980s owing to deregulation, MYN and MACC are entered for the entire period and again for the 1980s only (MYN80 and MACC80 are equal to MYN and MACC during the 1979:10-1988:10 subperiod and zero otherwise). MYN and MACC both have the predicted negative sign and are statistically significant; the positive and statistically significant MACC80 coefficient indicates an offsetting impact on the rate ratio in the 1980s. This would be consistent with our hypothesis of a deteriorating relationship between measures of M1 and other economic variables (including interest rates). The fiscal policy proxies are again statistically insignificant. On the other hand, extending the sample period substantially changes the values of many of the estimated coefficients.

Substituting the first eight terms of row 1 in Table 2 into equation (7) for $\Phi()$, we can compute the MP series for the entire 1961:04-88:10 period.[14]

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[14] If the MACC component of equation (6) were not included in MP, only the size and interpretation of the MACC estimated coefficient in the interest rate equation that includes MP as an explanatory variable would be altered. The overall fit of the equation would be unaffected.

An MP proxy based on the second row of Table 2 has been computed in the same way. The two MP variables are plotted in Figure 2. Even though the short- and long-sample coefficient estimates differ substantially, both tell essentially the same, plausible story. They suggest an easing of monetary policy after the 1966 credit crunch, a tightening leading to the 1969 credit crunch, a return to monetary ease, a tightening prior to the 1974-75 recession, and a subsequent easing of policy. These proxies indicate that monetary policy was tightening well before October 1979 and that a dramatic easing of monetary policy began in 1983. The long-sample proxy is, however, less volatile than the short-sample proxy and indicates a generally tighter monetary policy stance in the 1970s and 1980s relative to the 1960s.

D. Final Estimates of the Bill Rate Equation

Table 3 presents further estimates of the after-tax bill rate equations. Row 1 adds our short-sample monetary policy proxy to the regressors in row 4 of Table 1. Because MP is measured with error, an instrument for it must be added to the previous instrument list. The MP instrument was constructed by arranging the 56 semiannual MP values according to magnitude and collecting them into seven groups of eight. The rank, one through seven, of each group is used as the value of the instrumental variable for each observation in the group. Such an instrument is constructed for each of the alternative monetary policy proxies.

Comparing row 1 in Table 3 with row 4 in Table 1, including the short-sample monetary policy proxy lowers the equation standard error by 12 percent, raises the Durbin-Watson statistic, and, by reducing its estimated impact by nearly 60 percent, eliminates the statistical significance of MYN. Here, the fitted rate deviates as much as a percentage point from the actual only in

Figure 2
Monetary Policy Proxies Based on M1

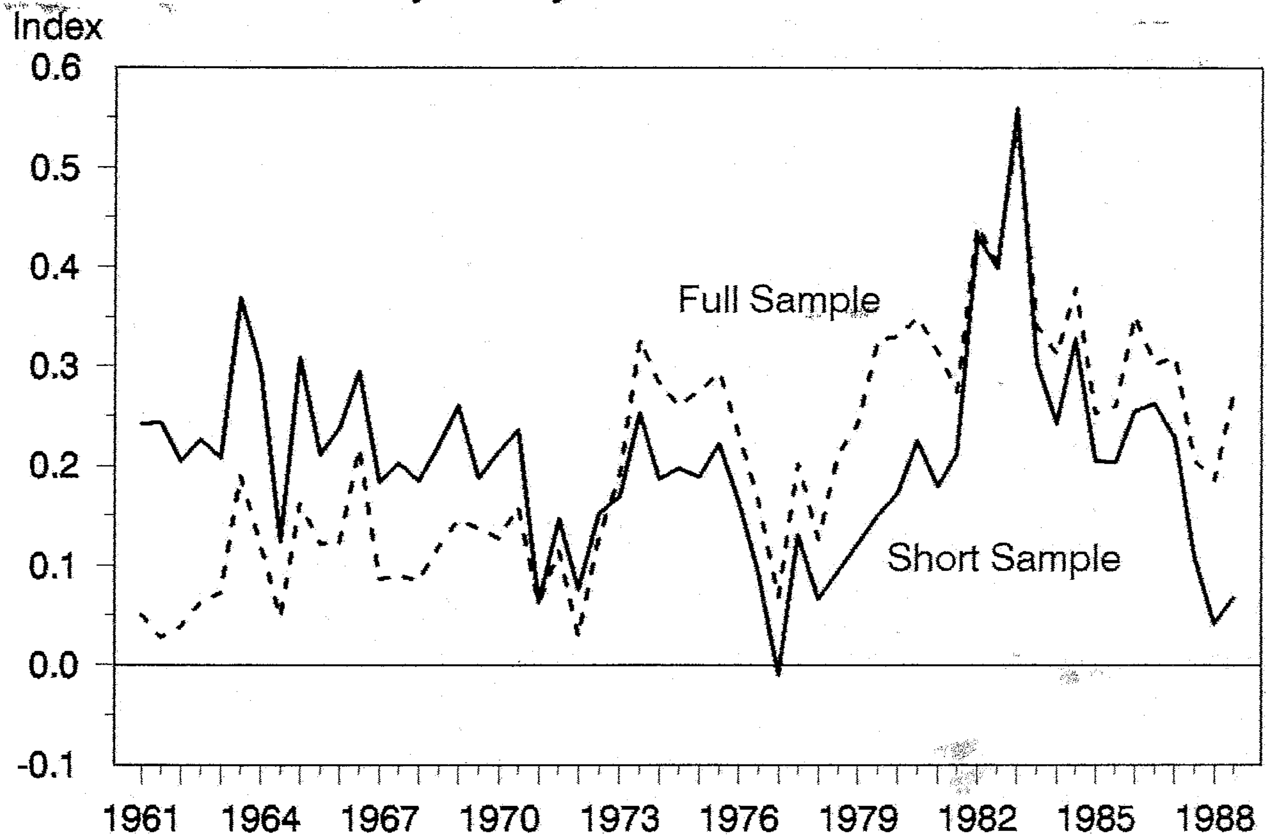

Table 3
After-Tax Treasury Bill Rate Equations, 1961-88
Estimation Method: TSLS (standard errors in parentheses)

	MP Proxy	CONST	π	π_{-1}	OPEC	$OPEC_{-1}$	GOVT	$GOVT_{-1}$	NETTAX	$NETTAX_{-1}$	INCENT	$INCENT_{-1}$	RISK	MACC	MYN	MP	ρ	$\bar{R}^2$	SEE	DW
1.	Short	-1.10	.214	.558	.014	-.048	-1.07	46.01	-17.73	11.76	.369	-.204	-12.34	-.112	-3.33	4.76		.930	.504	1.52
	Sample	(2.87)	(.226)	(.213)	(.035)	(.027)	(24.30)	(26.23)	(13.95)	(13.18)	(.161)	(.190)	(4.00)	(.026)	(3.29)	(1.34)				
2.	Long	1.80	.132	.469	.005	-.035	18.72	26.04	-5.43	17.80	.335	-.306	-14.47	-.091	-4.80	5.61		.935	.485	1.41
	Sample	(3.00)	(.212)	(.209)	(.033)	(.027)	(23.60)	(25.94)	(13.68)	(12.06)	(.158)	(.191)	(4.14)	(.025)	(2.96)	(1.30)				
3.	Long	1.39	.066	.496	.022	-.041	15.48	34.53	-13.64	20.66	.378	-.260	-15.62	-.075	-4.98	4.90	.343	.939	.462	1.88
	Sample	(2.95)	(.193)	(.211)	(.032)	(.027)	(24.16)	(27.92)	(13.73)	(11.20)	(.157)	(.168)	(3.60)	(.026)	(2.87)	(1.31)	(.165)			

April and October of 1981. The MP coefficient has the predicted sign and a t-statistic of 3.56 (compared to only -1.01 for MYN). Although each individual coefficient is not of the predicted sign, when the coefficients on the current and lagged IS-shifter variables are combined, all variables have the predicted effect. When the equation was re-estimated with a first-order autoregressive error correction, the coefficient on the autoregressive term was not statistically significant.

Row 2 replaces the short-sample monetary policy proxy with the long-sample proxy. The equation standard error is further reduced, although the Durbin-Watson statistic rises less than was the case for row 1. The MP variable has the predicted sign and is statistically significant and MYN again loses its statistical significance. The estimated impacts of the explanatory variables are quite similar to those in row 1 except that the net effect of NETTAX is now positive. When the equation is re-estimated with a first-order autoregressive error correction (row 3), its estimated value is 0.343 and is statistically significant. However, the estimated impacts of the explanatory variables are little affected. To avoid the possibility of contamination of the MP proxies by events in the 1980s, the estimates of row 1, rather than those of row 2 or 3, are used in the next section of the paper to explain the major shifts in the real after-tax and pretax bill rates.

Much of the previous empirical literature has focused on the pretax, rather than the after-tax, real interest rate. To test whether financial markets determine before- or after-tax interest rates, we specify the after-tax nominal interest rate as $(1-\theta t)i$ and obtain a nonlinear equation explaining the pretax nominal interest rate by dividing all explanatory variables in the after-tax rate equation by $(1-\theta t)$. A value of one for θ

would be consistent with financial markets determining the after-tax interest rate, and a value of zero would be consistent with markets determining the pretax rate. For the equation corresponding to row 1 of Table 3, the estimated value of θ was 1.40 with a standard error of 0.35, clearly rejecting the hypothesis that $\theta = 0$.[15] We take this as evidence that financial markets determine the after-tax, rather than the pretax, Treasury bill rate.[16]

III. Determinants of Major Shifts in Real Bill Rates

After-tax real rates varied widely over the 1961-88 period, falling from 1.4 percent in the 1960s to -1.6 percent in the middle and late 1970s, jumping to 2.25 percent in the early 1980s, and then receding to 1 percent during the 1986-88 period. Pretax real six-month Treasury bill rates averaged 2.5 percent over the entire 1961-88 period. Moreover, they averaged 2.6 percent during the initial 1961-70 years and 2.5 percent over the last six observations (86:04-88:10). In the intervening years, however, real rates swung violently, averaging only 0.2 percent in the middle 1970s but then rising to 2.0 percent in 1979-80 and 5.5 percent in 1981-84. This section unravels the contributions of our explanatory variables to these wide swings in real rates.

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[15] This test was developed by Peek and Wilcox (1984). They also obtain a point estimate of $\theta = 1.4$ in a specification using the Livingston survey data.

[16] For comparison purposes, we explained the pretax bill rate by re-estimating the after-tax bill rate equations with $t = 0$. These estimates, not reported in the tables, tell much the same story as their after-tax counterparts (given that the dependent variable is roughly 40 percent greater, the coefficients would be expected to be comparably larger than those in Table 3).

A. After-Tax Real Rates

The first row of Table 4 contains average rates for the real after-tax six-month Treasury bill rate at each of the peak and trough periods mentioned above. Row 2 lists the change in the after-tax real rate between these periods. The remaining rows list the contributions of changes in monetary policy (MP, MYN and MACC), fiscal policy (GOVT, NETTAX and INCENT), private saving (OPEC), bond default risk (RISK) and expected inflation (π) to the changes in the real after-tax rate. These contributions are based on the coefficient estimates in row 1 of Table 3. The impact of expected inflation arises largely because the sum of the coefficients on π and π_{-1} (0.77) is less than unity (higher expected inflation lowers the after-tax real rate). The last row in the table is the error in the equation. Note that this error is always less than 8 percent of the change in the real after-tax rate.

The 3 percentage point decline in the after-tax real rate from the 1960s to the mid-1970s is attributable to three factors, contractionary fiscal policy and increases in both private saving and expected inflation. The latter two factors were, in fact, largely due to the same single cause: the first OPEC shock. GOVT accounted for the full fiscal policy effect. Monetary policy played no role in the decrease (and, in fact, tightened somewhat). The real after-tax rate fell another half point in 1979-80, in spite of a restrictive monetary policy, owing to the sharp rise in inflation.

After-tax real rates then jumped by over 4 percentage points in 1981-84, primarily as a result of a further tightening of monetary policy and the decrease in expected inflation. A decrease in private saving and an expansionary fiscal policy (split almost evenly between GOVT and INCENT) each

Table 4
Decomposition of Major Shifts in After-Tax Real Rates

	1961:04-70:10		74:04-78:10		79:04-80:10		81:10-84:10		86:04-88:10
After-Tax Real 6-Month Treasury Bill Rate	1.42		-1.59		-2.15		2.24		0.97
Change		-3.01		-0.56		4.39		-1.27	
Contributions of Changes in:									
Monetary Policy (MACC, MYN, MP)		0.31		0.61		1.22		-1.41	
Fiscal Policy (GOVT, NETTAX, INCENT)		-1.20		-0.13		0.56		0.09	
Private Saving Shifts (OPEC)		-0.86		0.02		0.54		0.21	
Risk		-0.12		0.18		-0.21		0.04	
Expected Inflation		-0.98		-1.24		1.95		-0.22	
Unidentified Factors		-0.16		0.00		0.33		0.02	

contributed one-half percentage point. Most of the increase in the real after-tax rate from its low in the middle and late 1970s to the 1981-84 period can be traced to a single source, the onset of the second OPEC shock. The resultant acceleration in inflation caused the restrictive monetary policy, contributed to the election of Ronald Reagan and his program of expansionary fiscal policy, and led to the disinflation that occurred simultaneously with the decrease in private saving as the second OPEC shock unwound. The decline in after-tax real rates from their early 1980s peak can be attributed solely to a substantial easing of monetary policy.

The subperiods in Table 4 were chosen based on values of the real after-tax interest rate. However, major shifts in the contributing factors can occur within subperiods, and thus changes in the subperiod averages in the table can understate the importance of short-term movements in the contributions. For example, because monetary policy was still tight at the beginning of the 1974-78 subperiod before easing substantially in 1976, the table understates the shift in monetary policy from 1976-77 to the early 1980s. By our measure, monetary policy raised real after-tax interest rates by 114 basis points between 1976:10-1977:04 and 1979:04-1980:10, almost double the contribution shown in Table 4 between the longer 1974:04-1978:10 subperiod and 1979:04-1980:10. In any case, monetary policy appears to have tightened well before the sharp increase in the after-tax real interest rate. However, the impact of sharply higher inflation (the nominal after-tax rate rises less than one-for-one with increases in the expected inflation rate), rising bond default risk, and the temporary increase in private saving associated with the second OPEC shock kept the real rate declining through 1980. The sharp jump in real rates occurred only with the combination of further tightening of monetary policy, the collapse of the inflation rate, and the quick reversal of the temporary swelling of OPEC surpluses.

B. Pretax Real Rates

Table 5 is similar to Table 4 except that changes in the pretax real six-month bill rate are now attributed to our explanatory variables. The periods correspond to those in Table 4 except for single half-year shifts in the starting/ending dates, to correspond more closely to observed pretax real interest rate peaks and troughs. The contributions of the variables are calculated by unwinding the after-tax equation and including the explicit tax rate contribution with GOVT, NETTAX, and INCENT in the fiscal policy category.[17] Here our "fit" is not so tight, as would be expected because we did not directly explain the pretax rate. Two of the four "unidentified factors" contributions are almost one-fifth of the observed changes in pretax rates.

The decline in the pretax real rate from the 1960s to the mid-1970s is less than the decline in the after-tax real rate because the increase in expected inflation raises the former but lowers the latter. The 2.4 percentage point decline is more than accounted for by the first OPEC shock and the decline in government spending.

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[17] The impact of the variables on the pretax real rate is obtained from the after-tax equation in the following way. The estimated equation is:

$$(1-t)i = a_1\pi + a_2\pi_{-1} + Z,$$

where Z reflects all other variables including the residual. Differencing obtains,

$$(1-t)\Delta i - i_{-1}\Delta t = a_1\Delta\pi + a_2\Delta\pi_{-1} + \Delta Z.$$

Solving for the change in the real rate,

$$\Delta i - \Delta\pi = [a_1\Delta\pi + a_2\Delta\pi_{-1} + \Delta Z + i_{-1}\Delta t]/(1-t) - \Delta\pi.$$

Table 5
Decomposition of Major Shifts in Pretax Real Rates

	1961:04-70:10		74:10-78:04		78:10-80:10		81:04-84:10		86:04-88:10
Pretax Real 6-Month Treasury Bill Rate	2.63		0.20		1.99		5.49		2.53
Change		-2.43		1.79		3.50		-2.96	
Contributions of Changes in:									
Monetary Policy (MACC, MYN, MP)		0.47		0.69		1.81		-1.73	
Fiscal Policy (GOVT, NETTAX, INCENT, t)		-1.39		0.10		0.25		-0.78	
Private Saving Shifts (OPEC)		-1.40		0.40		0.41		0.45	
Risk		-0.38		0.60		-0.45		0.08	
Expected Inflation		0.69		-0.18		0.86		-0.80	
Unidentified Factors		-0.42		0.18		0.62		-0.18	

The rise in the real rate to more normal levels in 1979-80 was due to a restrictive monetary policy, a decline in private saving resulting from the unwinding of the first OPEC shock, and declining bond default risk. The further jump to extraordinarily high levels in 1981-84 is attributable to a further tightening of monetary policy, with additional contributions from expansionary fiscal policy in the form of increased defense spending and investment tax incentives, a decrease in private saving, and declining inflation.[18] As was the case with after-tax rates, most of the increase in real rates from the lows in the middle of the 1970s to the highs in 1981-84 can be attributed to the direct and indirect effects of the second OPEC shock.

Much of the decline in pretax real rates from their peak can, like the decline in after-tax rates, be tied to a decline in inflation and the resultant easing of monetary policy. In addition, the cut in marginal tax rates alone accounts for almost a third of the decline in pretax real rates between 1981-84 and 1986-88.

IV. Summary

We have attempted to uncover the sources of the major changes in real Treasury bill rates, both before-tax and after-tax, since the middle 1970s. Two major changes have occurred in both -- a jump in the early 1980s and a partial reversal since then. But pretax and after-tax rates do not always move together. Most clearly, pretax real rates rose by nearly 2 percentage

[18] When π is falling so rapidly that the average value of π_{-1} significantly exceeds that of π, the decline in inflation can temporarily raise the pretax rate.

points from the mid-1970s to 1979-80, while after-tax rates fell by another one-half percentage point before leaping in 1981-82.

Differences in the movements in these rates stem from different responses to changes in tax rates and expected inflation. Because financial markets determine after-tax rates, these rates are independent of tax rate changes; a reduction in the tax rate causes the pretax rate to rise sufficiently to leave the after-tax rate unchanged. Thus bracket creep in the 1960s and 1970s tended to put upward pressure on pretax real rates, while the large tax rate reductions in the 1980s made an important contribution to the recent decline in real rates.

The impact of changes in expected inflation is more complicated. We estimate the long-run response of the after-tax nominal rate to expected inflation ($\partial i^*/\partial\pi$) to be 0.77. The response of the after-tax real rate is thus 0.77 - 1 = -0.23. Because the response of the pretax real rate is $\partial(i-\pi)/\partial\pi = 0.77/(1 - t)$ and t has averaged 0.29, the average pretax real rate response has been 0.08. However, the immediate response of the pretax real rate is negative because most of the response of nominal rates to increases in expected inflation occurs with a one-period lag.

The other factors estimated to affect real six-month Treasury bill rates are monetary and fiscal policy, OPEC shocks, and bond default risk. Changes in each of these affect pre- and post-tax rates the same way, although the impacts on pretax rates are about 40 percent greater than those on after-tax rates (because 1/(1-t) averages about 1.4). Fiscal policy has had its impact on interest rates through changes in government purchases, marginal tax rates, and investment incentives, but not through changes in full-employment taxes net of transfers.

A key to understanding pretax real interest rates in the last quarter century is recognizing that rates in much of the 1970s were extraordinarily low owing largely to the two OPEC oil shocks, which decreased investment demand and increased world saving by transferring wealth from the high-consuming developed countries to OPEC. Tight money, expansionary fiscal policy, and high inflation contributed to the subsequent sharp rise in real rates, with the eventual decline of OPEC surpluses following the second OPEC shock prolonging this period of higher real rates.

Although standard measures of monetary policy do not indicate an important role for monetary policy in the early 1980s' jump in real interest rates, our monetary policy proxy makes such a role apparent. By our measure, monetary policy began to tighten in 1977 simultaneously with the upturn in pretax real rates, but well before the upturn in after-tax real rates. From April 1977 to April 1983, the tightening of monetary policy accounts for a 4½ percentage point rise in pretax real interest rates. The subsequent loosening of monetary policy explains a 3 percentage point decline from then to October 1988. It is noteworthy that by 1986-88, real rates had returned to their average levels during the 1960s.

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