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THE LEVEL AND VOLATILITY OF INTEREST RATES IN THE UNITED STATES: THE ROLES OF EXPECTED INFLATION, REAL RATES, AND TAXES

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ABSTRACT

This paper attempts to demonstrate a need to expand the simple Fisherian view whereby changes in interest rates are explained largely by changes in expected inflation. It presents and tests a model of expected, after-tax real interest rate behavior which, together with a group of explanatory variables suggested by a structural model, takes full account of implications of a broad range of U.S. tax code provisions for behavior of interest rates. Determinants of interest rate volatility are also investigated.

The model and results of empirical testing suggest: (1) why the measured impact on interest rates of changes in anticipated inflation has been below levels anticipated by many investigators; (2) how the measured impact on interest rates of explanatory variables is conditional on tax rates which may change over time; (3) larger than expected fiscal deficits have a moderate positive impact on interest rates (40 basis points per 100 billion annual rise for three-month Treasury bills) while lower than expected money growth may also raise interest rates (as in the second quarter of 1981 when it did so by an estimated 24 basis points); (4) inflation uncertainty produces no significant impact on interest rates due to the econometric effect of including a measure of excess capacity; (5) an unexpected rise in money demand may be responsible for persistently higher interest rates during the first half of 1982 but during most of the 1960-82 period money supply shocks had a more powerful impact on interest rates.

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The Level and Volatility of Interest Rates in the United States: The Roles of Expected Inflation, Real Rates, and Taxes

John H. Makin* and Vito Tanzi

I. Introduction

This paper analyzes the major forces affecting the behavior of interest rates, with particular emphasis on the unusually high levels and variability of rates in recent years. The approach is eclectic in the sense that strong prior views are not allowed to rule out consideration of any possible avenue of investigation that might help to explain unusual interest rate movements.

As Irving Fisher theorized a long time ago, the market interest rate (hereafter, the interest rate) on a security maturing in "t" periods of time is approximately the sum of an expected real rate (hereafter, the real rate) and the level of inflation expected over "t" periods. A change in the level or the volatility of interest rates should thus arise from (a) a change in the level or the volatility of the real rate; (b) a change in the level or the volatility of expected inflation; or (c) a change in the impact that unit changes in either or both of these variables has on interest rates.

In fact, it has been difficult to explain fully the behavior of interest rates for two reasons. First, econometric models estimated

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for a particular sample period have tended to perform poorly outside of the sample period. Second, since both expected inflation and the real rate are unobservable variables, attribution of movements in interest rates to either of these components has depended crucially on the use of proxies to represent their behavior. The latter problem has been highlighted recently, when efforts to slow money growth at a time when actual and expected fiscal deficits are growing, have resulted in higher real rates, slowdowns in economic activity and in currency appreciation. Furthermore, contrary to a considerable body of economic theory, it appears that the real rate may be quite responsive over more than the very short run (say, one quarter) to monetary and fiscal policy actions and/or to fluctuations in economic activity.

The possible relationship between the configuration of monetary and fiscal policy and the real rate has had a significant impact on analysis of costs attributed to measures aimed at controlling inflation (see Makin, 1982b). Based on conventional macroeconomic theory, it would be considered unusual to hear calls for tax increases or cuts in government spending in the midst of a serious recession. Yet such calls have been heard with increasing frequency since the onset of the U.S. recession in the summer of 1981, and, indeed, in the summer of 1982 there was a major tax increase in the United States. The usual arguments for pump-priming measures aimed at ending recessions have become less convincing amid widespread concern that fiscal deficits, both actual and projected, have been responsible for the high real rates that have depressed U.S. expenditure on new plant and equipment, housing, and durables. The possible "crowding-out" of private investment by large government borrowing requirements to finance large fiscal deficits is at the core of the ongoing debate over the effects of a tight-money, loose-fiscal configuration of macropolicy.

Another element to be considered in the investigation of interest rate movements is the role played by taxes. Changes in actual or perceived tax rates on interest income from financial instruments, relative to tax rates on incomes from alternative assets, should affect the relationship between nominal interest rates and real interest rates, given the level of expected inflation. This means that when actual or perceived marginal tax rates change, empirical models estimated over a given sample period may break down outside of that period even when the other variables needed to explain interest rates are identified and accurately predicted.

Empirical investigations of interest rate behavior through the mid-1970s by Tanzi (1980a) and Levi and Makin (1979) suggest that investors tended to adjust interest rates to insulate, to a large extent, real rates from the effects of expected inflation but not of income taxes. This "fiscal illusion" (Tanzi, 1980a) may be expected to have disappeared for several reasons. First, the high rates of inflation in recent years would inevitably make the effect of taxes on real rates obvious to most investors. These effects are far less obvious when inflation is low. Second, these tax effects were discussed in several well-known articles, such as those by Darby (1975), Feldstein (1976), and Tanzi (1976). Third, as inflation rates climbed, a combination of "bracket-creep" and higher interest rates tended to enlarge the absolute gap between before-tax and after-tax real interest income, while simultaneously enhancing the attractiveness of returns on real assets that may be subject to only low capital gains tax rates (and only upon realization) or to no tax at all, as is true for many collectibles and antiques (Tanzi, 1982a and 1982b). As expected inflation rose, expected after-tax real interest rates quickly became negative when allowance was made for taxation of nominal interest earning.

Section II of this paper briefly describes a framework for proximate analysis of interest rate behavior. Section III considers in more detail the role of expected inflation. A theoretical framework for analysis of real rates is developed in Section IV. Section V presents results of some empirical tests. Section VI discusses remaining puzzles concerning behavior of interest rates. Section VII presents some concluding remarks and summarizes suggestions for future investigation.

II. Proximate Sources of Interest Rate Movements

The Fisher equation describing an interest rate, i, in terms of a real rate, r, and expected inflation π is written as 1/

$$i_t = r_t + \pi_t \qquad (1)$$

where the subscript t indicates time. When taxes are considered, the aim is to define as the investor's objective an after-tax real rate, r*, written as

$$r_t^* = i_t(1-\tau) - \pi_t \qquad (2)$$

1/ The interaction term $r_t\pi_t$ is ignored here, since it is relatively small in the United States.

where τ is the perceived marginal tax rate on nominal interest income. Transposing equation (2) to place i_t on the left-hand side,

$$i_t = \left(\frac{1}{1-\tau}\right) [r_t^* + \pi_t] \qquad (3)$$

Equation (3) summarizes the proximate determinants of the interest rate discussed earlier. Movements in i can be decomposed into movements in after-tax real returns, changes in expected inflation, and/or changes in tax rates that alter the impact on i of given changes in r* or π. These three sources of movements in i, together with some modifications that arise from more detailed consideration of determinants of the after-tax real rate, will be explored in turn. It is, however, immediately evident from equation (3) that, for a given level of expected inflation, the provisions of the U.S. Economic Recovery Tax Act of 1981 will elevate observed interest rates, since accelerated depreciation allowances should raise the expected after-tax real returns on investment projects. However, the impact of such a rise in r* would be somewhat diminished by reduced marginal individual income tax rates, particularly in higher tax brackets, which will lower τ.

As for interest rate volatility, an expression for the variance of interest rates based on equation (3) is given by

$$\begin{aligned}\sigma_i^2 = {} & [1/(1-\tau)]^2 \, \sigma_{r^*}^2 + [1/(1-\tau)]^2 \, \sigma_\pi^2 \qquad (4) \\ & + 2[1/(1-\tau)]^2 \, \rho_{r^*\pi} \, \sigma_{r^*} \sigma_\pi\end{aligned}$$

where σ_π^2 denotes the variance of anticipated inflation, $\sigma_{r^*}^2$, the variance of the after-tax real rate and $\rho_{r^*\pi}$ is the coefficient of correlation between r^* and π. Notice that, when taxes are ignored as in equation (1), the variance of i is written as

$$\sigma_i^2 = \sigma_{r^*}^2 + \sigma_\pi^2 + 2\rho_{r^*\pi}\,\sigma_{r^*}\sigma_\pi \qquad (5)$$

The effects of considering tax rates are evident when equations (4) and (5) are compared. Ignoring the effects of possible correlation between r^* and π ($\rho_{r^*\pi} = 0$ for now), the volatility of after-tax real rates unambiguously produces <u>more</u> volatility in i, since for any $\tau > 0$ $[1/(1-\tau)]^2 > 1$. [Given $\tau = 0.35$, $[1/(1-\tau)]^2 = 2.37$]. Given an average tax rate of 35 per cent on interest income, a rise of 1 per cent in the variance of the after-tax real rate raises the variance of i by 2.37 times the effect of a rise in the variance of the real rate when taxes are ignored as in equation (5). Furthermore, the higher is τ, the greater will be the volatility of i, <u>ceteris paribus</u>. Of course, this argument assumes that there is no fiscal illusion, so that tax effects are fully recognized by investors. [1] Uncertainty over future tax policy can have a powerful impact on the observed volatility of i. Equation (4) suggests also that the effects of a rise in the variance of expected inflation on the observed variance of i will be magnified.

It will be seen in the detailed discussion of real rates that theoretical considerations (the Mundell-Tobin effect) suggest a negative correlation between expected inflation and the real rate

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[1] Thus if it is true that in the past two to three years fiscal illusion has disappeared, equation (4) would go a long way toward explaining the greater volatility of interest rates that has prevailed in this period relative to earlier periods.

(${}^{\rho}r^{*}_{\pi}$ ½ 0). Strong evidence for this effect is found in Fama and Gibbons (1982) and Makin (1983). Such an effect produces some damping of the effect of changes in the variance of real rates and variance of expected inflation in both tax and nontax cases, but the damping effect is reduced by consideration of tax effects for almost any conceivable value of relevant parameters. 1/

Consideration of the proximate sources of interest rate movements suggests a number of avenues for an explanation of high and volatile interest rates. These include determinants of inflationary expectations, after-tax real rates, and possible changes in actual or perceived marginal tax rates on financial assets and alternative assets.

1/ The effect of a rise in σ_r^{2*} on σ_i^2 (where for convenience $\sigma_r^{2*} \approx \sigma_\pi^2$) is given by

$$\partial\sigma_i^2/\partial\sigma_r^{2*} = \frac{2[1+2\rho_{r^*_\pi}]}{(1-\tau)^2}$$

when tax rates are considered and, ignoring taxes, by

$$\partial\sigma_i^2/\partial\sigma_r^{2*} = 2(1 + \rho_{r^*_\pi}).$$

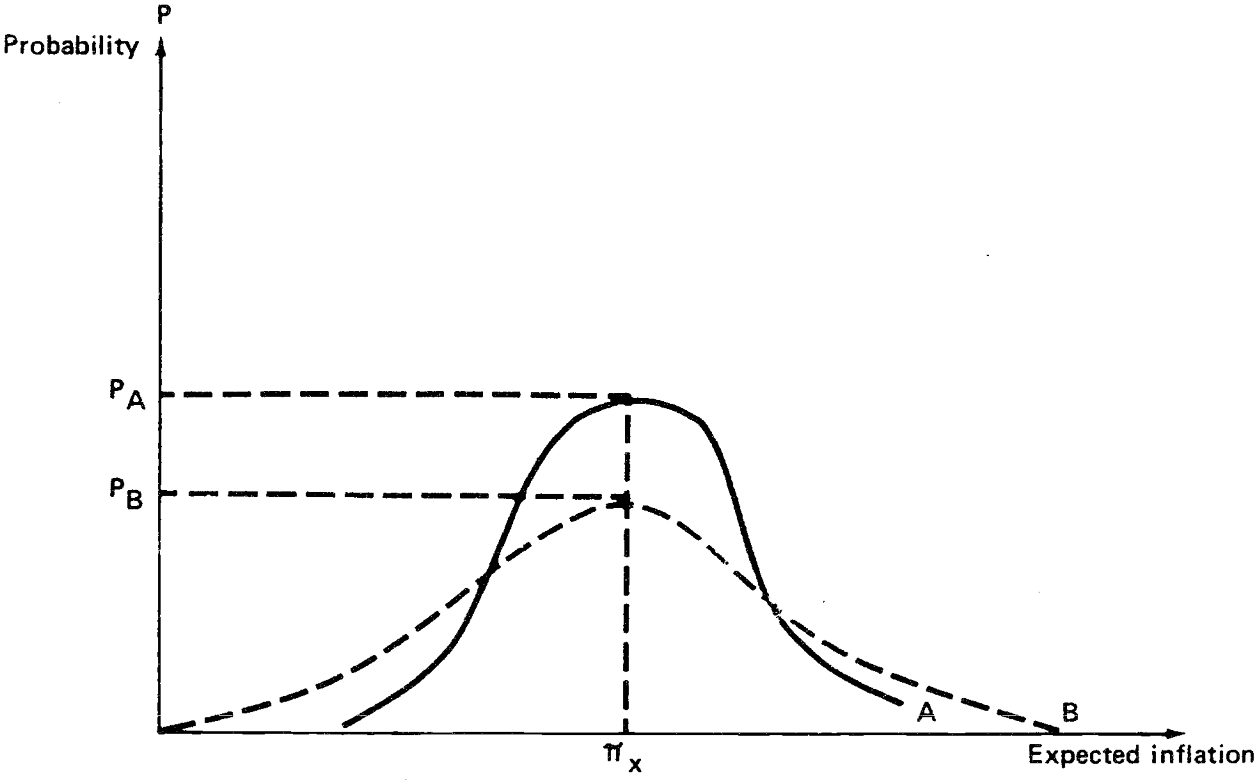
For $\tau = 0.35$; $\rho_{r^*_\pi} = -0.25$; the first of these equations equals 3.55 while the second equals 2.6.

III. Behavior of Expected Inflation

Survey data on inflationary expectations provide a rich source of information on the outlook regarding the level and stability of the value of nominal contracts whose prices determine interest rates. As already discussed, the level of expected inflation is a major determinant of the level of interest rates. Since expectations about inflation are of necessity predictions, it is also relevant to consider the implications for interest rate behavior of the dispersion of such views about their mean value as well as of the symmetry of such dispersion above and below the mean. It is useful to consider the variance and skewness of expected inflation as well as its mean.

The variance across expectations of inflation held by survey respondents may either be taken at face value as an index of the dispersion of views on the outlook for inflation or as a measure of uncertainty about inflation. The latter concept relates to the uncertainty attached to the single-valued forecast given by a respondent who is asked simply to describe his expectation regarding some future price level relative to today's. An individual may give the same response, say π_X shown in Figure 1, at two points in time. However, distribution A in Figure 1 represents a forecast given with more certainty, hence with a higher probability, P_A, attached to π_X than does distribution B. There the probability attached to π_X, which remains as in distribution A the most likely outcome, falls to P_B.

FIGURE 1



Uncertainty about inflation both across survey respondents and by individual investors may be linked as follows. If investors form their own expectations regarding inflation by sampling the outlook of forecasters, as does the Livingston survey of inflationary expectations, they will be more uncertain as to the outlook for inflation as they discover an increase in the dispersion of outlooks across forecasters. Based on this reasoning, we shall employ the variance of the Livingston survey of inflationary expectations as a measure of the uncertainty about inflation.

The sign of the impact of changes in inflation uncertainty on observable interest rates is not clear. It operates through an impact on the equilibrium after-tax real rate which adjusts to equilibrate real saving and investment. 1/ A rise in uncertainty about inflation will cause risk-averse investors, contracting to pay money to finance projects, to reduce investment because of elevated uncertainty surrounding the real value of contractual payments. Cukierman and Wachtel (1982) have shown that relative price uncertainty tends to rise with inflation uncertainty; this result, in turn, will reduce real investment, which after all represents a commitment to a given expected set of relative prices. Downward pressure on real investment schedule will, *ceteris paribus*, cause the expected after-tax real rate to fall. At the same time, however, on the other side of the market, risk-averse savers contracting to receive dollars, will, because of elevated uncertainty regarding the real value of contractual receipts, reduce the supply of

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1/ This discussion is drawn from Makin (1983).

funds at given levels of income and real balances. This will, *ceteris paribus*, cause the expected after-tax real rate to rise. The net impact on the expected after-tax real rate of the negative shift in real investment and real saving schedules is uncertain. If the negative impact on investment dominates, higher uncertainty about inflation depresses the equilibrium after-tax real rate and thereby the nominal rate. The reverse holds true if the negative impact of uncertainty about inflation on saving dominates. Results reported below, although statistically weak, suggest that higher uncertainty about inflation tends to depress short-term nominal interest rates, suggesting that the negative impact on investment dominates the negative impact on saving. 1/

1/ Hartman and Makin (1982) employ a utility-maximizing framework in a two-period model to develop an alternative rationale for the proposition that uncertainty about inflation has a negative impact on the nominal rate. The approach yields a definition of the after-tax real rate:

$$r_t^* = i_t(1-\tau) - \pi_t + \sigma^2 \qquad (2a)$$

which implies:

$$i_t = (\frac{1}{1-\tau})[\lambda_0 + (1-\lambda_1)\pi_t - \lambda_2(m_t - {}_{t-1}m_t') \qquad (10a)$$

$$- (1+\lambda_3)\ \sigma_t^2 + \lambda_4 X_t - \Theta\lambda_2 \text{ time} + V_t]$$

In equation (10a) the coefficient on σ_t^2 is negative even if λ_3 is negative and less than unity in absolute value with the impact of τ^2 on saving dominating that on investment. In short, though the expectation of a negative impact of σ^2 on i is enhanced, it may not be due to the impact on savings versus investment but rather to the alternative definition of the after-tax real rate given by equation (2a).

It is also possible that the asymmetry (skewness) of views about the outlook for inflation may affect the level of interest rates. Suppose that the probability distribution for a typical respondent X is as described by A in Figure 2; in other words, the respondent considers π_X as the most likely outcome, but he also considers that outcomes that imply expectations lower than π_X are more likely than those implying expectations higher than π_X. Assume that while the most likely outcome remains π_X, the shape of the probability distribution changes from A to B, from negatively skewed to positively skewed, so that outcomes implying inflation higher than π_X become more likely. Although the reply that the respondent will give to the pollster would remain unchanged (and equal to π_X), his attitude as a lender or borrower would certainly change. As a lender, he will now expect to receive a higher rate of interest to compensate him for the higher risk. As a borrower, he will be willing to pay a higher rate. The net effect will be an increase in the market rate of interest. Therefore, given the average level and variance of expected inflation, the more positively skewed are such expectations the higher is the rate of interest likely to be. [1/]

Since 1981, two important considerations have been paramount in the minds of sophisticated investors. First, as the money supply was being expanded at a slower pace, the expectation was for the rate of inflation to fall. Second, as a growing fiscal deficit loomed large on the horizon, one significant probability was that the Federal Reserve would, at some

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[1/] See also Fama (1976).

point, reverse its policy in order to accommodate the fiscal deficit with monetary expansion. Under these circumstances, it seems safe to assume that, for many observers, while the point estimate of inflation (π_x in Figure 2) was falling, that fall was accompanied by a positive change in the skewness of the probability distribution describing expected inflation represented by the change from A to B. As a consequence, a lower observed π might not be accompanied by as great a fall in the nominal rate of interest, as we would have expected. Therefore, this effect would be reflected in a higher real rate. Unfortunately, we do not have data that would permit an empirical verification of this effect, and it will have to be left in the realm of theoretical speculation. 1/

While we do not have information about the skewness of the probability distribution for each of the respondents in the Livingston sample, we do have information about the variance across survey respondents on expected inflation. Table 1 reports the mean level and standard deviation of inflation forecasts from 1973 through the end of 1981 in the Livingston survey. The December 1981 forecast, of course, covers the first half of 1982. The steady rise of the mean until mid-1980 is consistent with steady upward pressure on the level of interest rates until that time. After that time, and particularly during 1981, the 3.5 per cent drop in the mean level of expected inflation clearly suggests that, if real (after-tax) rates had remained constant, by December 1981 short-term interest rates should have been between about 3.5 per cent and 5.5 per

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1/ Furthermore, the argument is likely to be more important for financial assets of longer maturity than for those of short maturity.

FIGURE 2

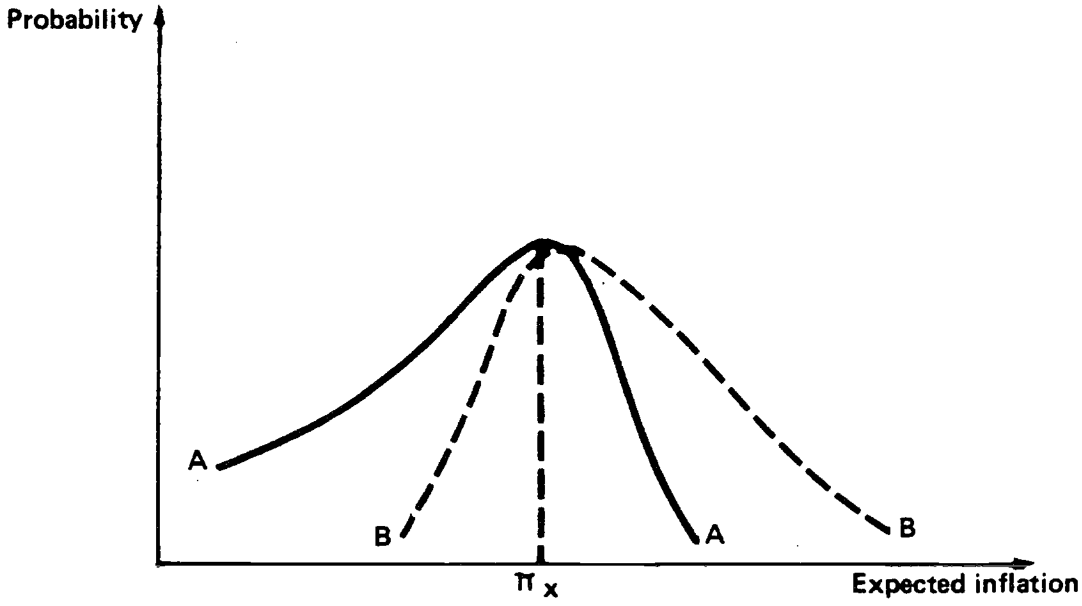


Table 1. Mean and Standard Deviation of Six-Month Consumer Price Index Forecasts

		Standard Deviation	
Date	Mean	Cross-section	Over time
July 1973	4.00	1.31	
December 1973	5.17	2.10	
June 1974	7.12	2.38	
December 1974	7.70	2.32	1.34 (June 1973 to December 1975)
June 1975	5.64	2.12	
December 1975	5.84	1.38	
June 1976	5.30	1.30	
December 1976	5.23	1.81	
June 1977	5.92	1.36	
December 1977	5.99	1.23	0.66 (June 1976 to December 1978)
June 1978	6.40	1.57	
December 1978	6.97	1.75	
June 1979	8.31	2.35	
December 1979	10.14	2.37	
June 1980	10.67	2.57	1.46 (June 1979 to December 1981)
December 1980	10.51	2.58	
June 1981	8.86	2.83	
December 1981	6.96	2.21	

Source: Livingston Survey Data at Annual Rates.

cent below the levels of December 1980. In fact, the rate on six-month Treasury bills fell by about 2.5 per cent over that period, implying that after-tax real rates rose considerably during 1981. Overall, the behavior of the level of anticipated inflation suggests that, ceteris paribus, interest rates should have come down during 1981 by more than they actually did. Further, the rise in rates early in 1982 would be somewhat at variance with the slowing of actual inflation rates and appearance of further survey data suggesting a drop in longer-term expected inflation. 1/

Table 1 also suggests that the volatility of expected inflation over time has been considerably higher since mid-1979 than during the period of comparable length from mid-1976 through the end of 1978. The standard deviation of expected inflation rates during the later period was 1.46 per cent, or more than twice the level of 0.66 per cent for the earlier period. This rise may well have contributed to the rise in the volatility of interest rates since 1979. The rise in the volatility of expected inflation likely reflects the rise in the volatility of U.S. money growth rates since October 1979, when new operating procedures were adopted by the Federal Reserve Board.

1/ During February 1982, Manufacturer's Hanover Trust reported a drop since late 1981 of about 2 per cent in expected inflation over the coming five years from the 9 per cent range to the 7 per cent range.

In the second half of 1982 rates on short-term Treasury bills fell to a level broadly consistent with a tax-adjusted Fisher hypothesis.

It is also clear from Table 1 that cross-sectional uncertainty about expected inflation has risen steadily since 1977. This phenomenon, as discussed above, may be linked to a rise or fall in after-tax real rates.

IV. Behavior of the Expected Real Interest Rate

A strict version of the Fisherian relationship between interest rates and inflation assumes that the rate of interest rises *pari passu* with the rate of inflation. In other words, it assumes that the real rate of interest is constant. This version received a strong boost when a particularly influential study by Fama (1975) failed to reject the joint hypothesis of constancy of the real rate and rationality of inflation forecasts. A later study by Nelson and Schwert (1977) argued that Fama's test of that joint hypothesis was not sufficiently powerful. After applying more powerful tests, these authors concluded that the data permitted rejection of the constant real rate hypothesis. Mishkin (1981) argued that Fama's failure to reject constancy of the real rate might alternatively be viewed as an artifact of the sample period he employed (first quarter 1953 through second quarter 1973).

The recent behavior of interest rates is difficult to explain without recourse to the hypothesis that the real rate has fluctuated considerably. A relevant question then becomes how to explain movements in the real rate. Those movements have been substantial, particularly since 1979 (see Figure 3).

Studies by Levi and Makin (1979), Makin (1982b), Mishkin (1981), Peek (1981), Tanzi (1980a), and others have singled out many factors that may cause, at least in the short run, changes in the after-tax real rate of interest. Among these, the following deserve specific mention: (a) expected inflation itself; (b) the stage of the business cycle; (c) unanticipated changes in the fiscal deficit; (d) taxes; (e) unanticipated changes in the money supply; and (f) uncertainty about the level of inflation.

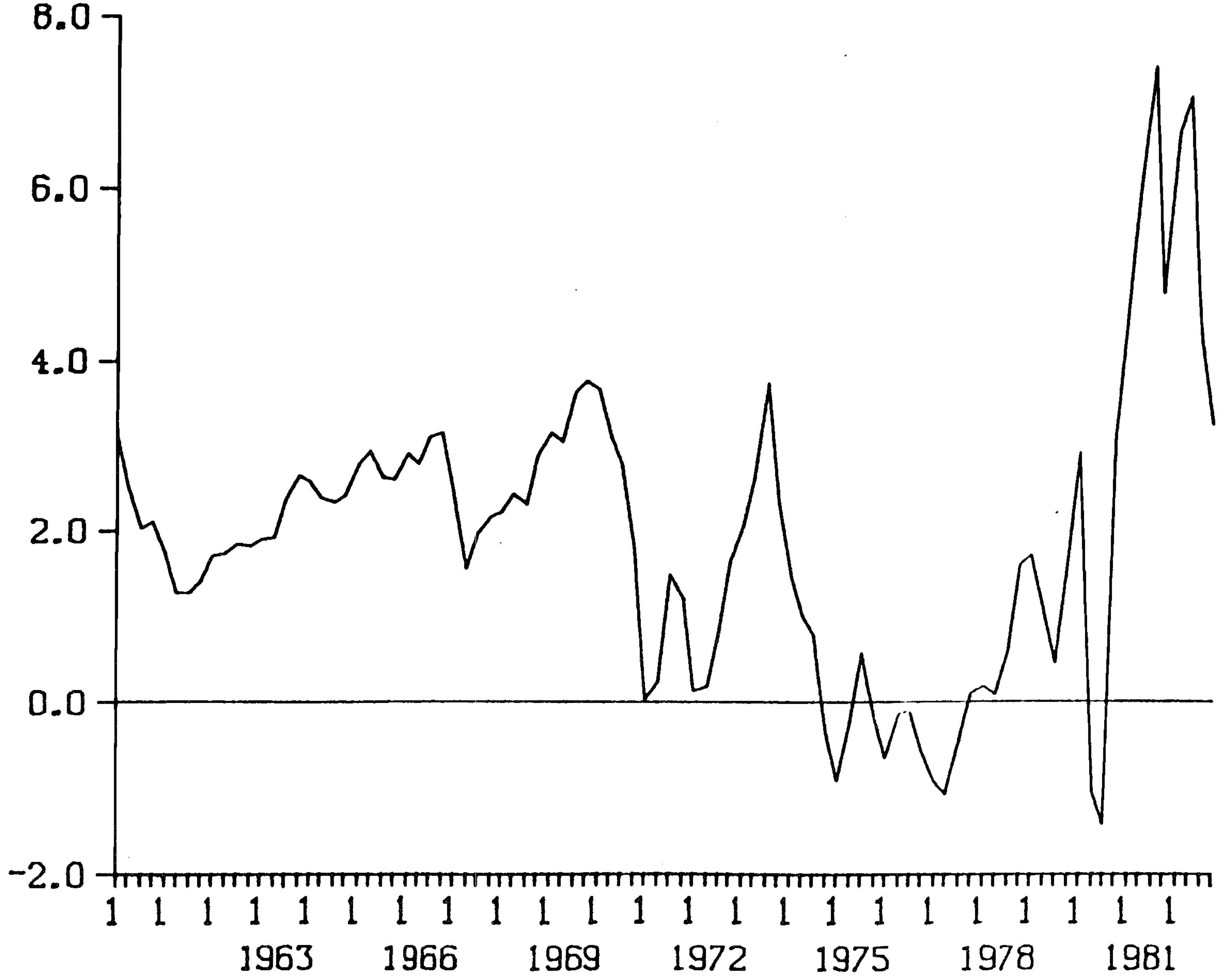
We have speculated above on ways in which uncertainty about inflation might affect the after-tax real rate. And we have already discussed the way in which taxes should play a role, at the same time advancing the hypothesis that up to the mid-1970s there was too little tax effect because of a "fiscal illusion," but that this illusion has progressively disappeared. This disappearance would, of course, be translated into an increase in the impact of changes in expected inflation on nominal interest rates.

Also operating on the measured impact of expected inflation on the nominal interest rate is the well-known Mundell-Tobin effect. Under the Mundell-Tobin effect, the real rate can be affected by changes in expected inflation. A rise in expected inflation causes a shift out of money balances and into real capital, thereby depressing the marginal product of capital and the equilibrium real rate. This is the "Tobin Effect." Mundell (1963) describes a similar phenomenon whereby a rise in anticipated inflation depresses equilibrium real cash balances, in turn elevating the steady-state level of flow saving owing to the real

Figure 3

EXPECTED REAL RETURN ON 3-MONTH TREASURY BILLS: 1960-82

(Quarterly Averages Less Livingston Survey Estimate of Expected Inflation)



balance effect. Equilibrium is restored by means of a lower real interest rate, which elevates the level of investment until it equals the higher level of saving. This effect, operating as it does on the steady-state rate of saving, is not expected to be subsequently reversed in the absence of a further change in the rate of expected inflation.

The impact of the Mundell-Tobin effect on the relationship between expected inflation and nominal rates of taxes can best be understood with the aid of a structural model that determines the equilibrium value of the after-tax real rate. This approach also helps to clarify the role of uncertainty about inflation, money surprises, and surprise fiscal deficits in determining the level of observable, nominal interest rates. The structural model presented here, which extends the model developed in Makin (1983), yields a reduced-form equation for the after-tax real rate. The resulting expression for the after-tax real rate can then be substituted into a Fisher equation describing the observable nominal rate in terms of the after-tax real rate and expected inflation.

The structural equations are expressed in the familiar IS-LM format with some modifications, along with an expression for real income (output) in terms of a distributed lag on money surprises as derived by Blinder and Fischer (1981). The log of nonincome-induced expenditure is written as

$$I_t = \alpha_0 - \alpha_1 r_t^* - \alpha_2 \sigma_t^2 + \alpha_3 X_t - \alpha_4 \pi_t \qquad (6)$$

$$+ \alpha_5 \, GAP_t + e_{1_t} \quad (\alpha_i, \; i=1 \ldots 5 > 0)$$

where

I_t = log of nonincome-induced expenditure

r_t^* = expected, after-tax, real interest rate

σ_t^2 = a measure of inflation uncertainty

X_t = log of an exogenous expenditure shift

π_t = expected inflation

GAP_t = [(actual real GNP - potential real GNP)/(potential real GNP)]

e_{1_t} = an error term, normally distributed with zero mean (All error terms, e_i ($i=1,\ldots,4$) take this form)

Equation (6) describes nonincome-induced expenditure. As such, it is negatively tied to the after-tax real rate and to uncertainty about inflation and positively affected by any real exogenous shock to expenditure that is unrelated to other right-hand variables in equation (6). Expected inflation produces a negative impact on investment owing to the depressing impact on corporate profits arising from historic cost depreciation rules noted by Feldstein (1976) and Summers (1978). 1/ GAP is a measure of capacity utilization, or the stage of the business cycle, first employed by Tanzi (1980a). As GAP rises so does pressure on existing capacity, signaling a need for more investment. In effect, GAP captures an accelerator effect on investment.

1/ The depressing impact on corporate profits of actual inflation may be offset by a reduction in the real value of corporate debt only to the extent that actual inflation is unanticipated. But expected inflation will not result in a lower value of corporate debt, since it will be reflected in a higher nominal interest rate demanded by lenders and paid by borrowers in the face of an anticipated depreciation of money against commodities. It will, however, depress expected after-tax profits under existing depreciation rules.

The log of the sum of real saving, taxes and imports is written as:

$$Z_t = \gamma_0 + \gamma_1 y_t - \gamma_2(m_t - p_t) - \gamma_3\sigma_t^2 + e_2 \quad (\gamma_1, \gamma_2, \gamma_3 > 0) \quad (7)$$

where

Z_t = log of real saving

y_t = log of real income (output)

$(m_t - p_t)$ = log of real money balances

Equilibrium in the money sector is written as

$$(m_t - p_t) = \beta_0 + \beta_1 y_t - \beta_2(1-\tau)i_t + e_{3_t} \qquad (8)$$

Equation (8) takes the after-tax nominal interest rate as the opportunity cost of holding money.

The supply side of the model represents real income (output) as

$$y_t = y_{n_t} + \sum_{i-0}^{n} \phi_i(m_i - {}_{i-1}m_i^e) + e_{4_t} \qquad (9)$$

where

y_{n_t} = log of natural output, written as $\Theta_0 + \Theta_1$ time

$(m_i - {}_{i-1}m_i^e)$ = surprise money growth measured as the difference between the log of the current money supply and the log of the anticipated (as of t-1 for t) money supply

Finally, the Fisher equation is written as equation (3):

$$i_t = \left(\frac{1}{1-\tau}\right)[r_t^* + \pi_t]$$

where

i_t = nominal interest rate

τ = marginal tax rate on interest income

Equations (6) through (9) and equation (3) can now be used to solve for r_t^*. Setting equation (6) equal to equation (7), substituting from equation (8) for real balances and from equation (9) for real output, and substituting the resulting expression for r_t^* into equation (3) yields a reduced-form equation for the nominal interest rate in terms of a constant term, expected inflation, money surprises, uncertainty about inflation, exogenous demand disturbances, GAP, time, and an error term. 1/

$$i_t = \left(\frac{1}{1-\tau}\right) [\lambda_0 + (1-\lambda_1)\pi_t - \lambda_2 \sum_{i=0}^{n} \phi_i(m_i - {}_{i-1}m_i^e)$$

$$- \lambda_3\sigma_t^2 + \lambda_4 X_t + \lambda_5 GAP_t - \Theta_1\lambda_2 \text{ time} + V_t] \qquad (10)$$

$$\lambda_0 = [(\alpha_0 - \gamma_0 + \gamma_2\beta_0 - \Theta_0(\gamma_1 - \gamma_2\beta))/$$

$$(\alpha_1 + (\alpha_1 + \alpha_2\beta_2)]$$

$$\lambda_1 = [(\alpha_4 + \gamma_2\beta_2)/(\alpha_1 + \gamma_2\beta_2)] \quad (0 < \lambda_1 < 1)$$

$$\lambda_2 = [(\gamma_1 - \gamma_2\beta_1)/(\alpha_1 + \gamma_2\beta_2)] \qquad \lambda_2 > 0 \text{ 2/}$$

$$\lambda_3 = [(\alpha_2 - \gamma_3)/(\alpha_1 + \gamma_2\beta_2)] \qquad \lambda_3 \overset{>}{\underset{<}{-}} 0$$

1/ It is assumed that money surprises are independent of the error term in equation (10).

2/ λ_2 is positive, since γ_1, the elasticity of real saving plus imports with respect to real income, is unity, given a constant ratio of saving plus taxes and imports to income, while β_1, the elasticity of demand for real balances with respect to real income, and λ_2, the (elasticity) real balance effect on saving plus imports, are both fractions.

$$\lambda_4 = [\alpha_3/(\alpha_1+\gamma_2\beta_2)] \qquad \lambda_4 > 0$$

$$\lambda_5 = [\alpha_5/(\alpha_1+\gamma_2\beta_2)] \qquad \lambda_5 > 0$$

$$V_t = [(e_{1_t} - e_{2_t} + \gamma_2 e_{3_t} - \gamma_1 e_{4_t})/\alpha_1+\gamma_2\beta_2)]$$

The coefficients on the interest rate equation (10) are functions of the underlying structural parameters defined in equations (3) and (6) through (9). It is useful to note that the measured impact upon nominal interest of each of the explanatory variables in equation (10) also depends upon the effective marginal tax rate, τ, on interest incomes. While the underlying structural parameters are unidentified (they cannot be measured based on empirical estimation of equation (10)) this framework is still useful for three reasons. First, it shows clearly why it may be that even with nonzero tax rates applied to interest incomes, the measured coefficient on expected inflation will be less than $[1/(1-\tau)]$ and may even be less than unity. Second, it clearly shows that the measured impact on interest rates of all explanatory variables is conditional on the tax rate, τ. Since that rate may vary over time, it suggests a reason for changes over time in the fit of many interest rate equations. Finally, the derivation of equation (10) makes clear the theoretical basis for a negative relationship between expected inflation and the expected after-tax real rate. 1/

The impact of expected inflation on the nominal interest rate reflects a combination of four factors: (a) the Fisher effect, whereby the nominal interest rate rises by the full amount of a rise in expected

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1/ This phenomenon may also arise in open economies where inventory behavior results in inertia of commodity prices. See Criswell (1983).

inflation; (b) the tax effect, whereby the nominal interest rate must rise by more than the rise in expected inflation to maintain a constant expected after-tax real return; (c) the Mundell-Tobin effect, captured in equations (7) and (8), whereby a rise in expected inflation depresses equilibrium real cash balances, in turn elevating the steady-state level of flow saving owing to the real balance effect, with equilibrium being restored by means of a lower after-tax real interest rate, which raises investment to the higher level of saving; and (d) the Feldstein-Summers effect, whereby a rise in anticipated inflation depresses expected after-tax profits and causes investment to fall. In sum, tax effects move the coefficient above unity, while the Mundell effect and the Feldstein-Summers effect both push it below unity. Typical parameter values for τ and λ_1 indicate an expected value of 0.75 for the coefficient describing the impact of expected inflation on the nominal interest rate. 1/ Even though tax effects by themselves tend to push the coefficient above unity, the combined depressing impact of the Mundell effect and the Feldstein-Summers effect may result in a net impact below unity. The general equilibrium approach employed here resolves the apparent "mystery" regarding a less than unitary impact of expected inflation on interest rates when taxes are considered.

The hypothesized negative impact of money surprises on the real rate arises from their positive impact on real income which, in turn, elevates real saving and requires a drop in the real rate to produce

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1/ Parameter values which make $\partial i/\partial \pi = 0.75$ are $\alpha_1 = 0.5$; $\alpha_4 = 0.2$; $\gamma_2 = 0.2$; $\beta_2 = 0.5$; $\tau = 0.33$.

an equilibrating rise in real investment. This effect outweighs the simultaneous upward pressure on the real rate that results from excess demand for real balances associated with elevated real income. (See footnote above, p. 20). The effect of money suprises may be contemporaneous or it may persist over a number of periods owing either to stickiness or, more rigorously, to attempts to restore desired inventory stocks. (See Blinder and Fischer (1981).)

It is important to distinguish between the real income impact of a money surprise described here and an expectations effect like that reported by Mishkin (1982). Mishkin reports a positive relationship between quarterly money surprises and end-of-period short-term interest rates. The result arises, in Mishkin's view, from a positive impact of a money surprise on expected inflation. In contrast, this study employs period-average short-term rates as a dependent variable in order to capture the real income impact under way during the quarter, before comparison of an actual with an anticipated money supply gives rise to an expectations effect. A fuller discussion of Mishkin's results and their relationship with results obtained here is contained in Makin (1982c). An alternative liquidity rationale for a negative relationship between money surprises and short-term rates is discussed in Makin (1982b) and Khan (1980).

The impact of uncertainty about inflation on the equilibrium, after-tax real rate is ambiguous as discussed earlier. The negative impact of uncertainty about inflation on real investment is measured by α_2 in equation (6). The negative impact on real saving of uncertainty about inflation is measured by γ_3 in equation (7). The ambiguous impact on the interest rate is given by λ_3 in equation (10).

The impact of exogenous shifts in aggregate demand on the after-tax real rate is unambiguously positive. If there is an exogenous upward shift in aggregate demand, the after-tax real rate must rise to "crowd out" private investment in order to restore commodity market equilibrium. The model represented by equations (6) through (10) makes it clear that tests of the possible impact of fiscal deficits on interest rates cannot be conducted by inserting a measure of the actual fiscal deficit directly into an interest rate equation. Since tax proceeds rise with income, the built-in portion of deficits is endogenous and typically countercyclical. Interest rates are typically procyclical; therefore, the coefficient on the actual deficit (measured as a positive number) term in the interest rate equation will be downwardly biased and possibly negative. 1/

Expected future deficits have been identified by some as a source of higher interest rates. However, such effects ought to be confined to long-term rates. Measurement of the impact of expected future deficits on long-term rates is confounded by the cyclical biases just discussed, together with the fact that few actual time series on anything like a comprehensive measure of expected future deficits exist before

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1/ This is confirmed by results reported in Section V. For a thorough discussion of government deficits and aggregate demand, see Feldstein (1982).

1980. Some analysts contend that the impact on interest rates of fiscal deficits arises only from their impact on longer run inflationary expectations. Others suggest that expected "crowding out" that large fiscal deficits imply for credit markets will raise real rates and thereby raise nominal rates. But for all of these longer-run concepts, measurement presents a serious difficulty.

One way to avoid these difficulties is to test the impact on interest rates of unanticipated movements in the fiscal deficit. 1/ This approach purges the deficit of its systematic component which, as noted above, tends to bias downward its measured impact on interest rates. Further, given period-average short-term rates as the dependent variable, as with money surprises, it is possible to capture the impact on interest rates of higher-than-expected sales of government securities during the quarter. This impact should occur before the end of the quarter, when comparison of an actual with an anticipated fiscal deficit may give rise to an expectations effect. More specifically, a surprise increase in the deficit may cause market participants to expect higher money growth and therefore higher inflation. But if this expectations effect is already captured in the expected inflation term, the surprise deficit will appear to have no additional explanatory power. The use of a period-average interest rate as a dependent variable, as noted, avoids this problem of apparent redundancy of fiscal deficits in an interest

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1/ Another way could be to use the full employment budget surplus. This was tried in place of the unanticipated deficit for which results are reported below. The full employment budget surplus did not enter significantly into the estimated interest rate equation.

rate equation. We expect that a surprise deficit will raise the period-average interest rate.

Once a measure is obtained of the impact on interest rates of a surprise intraquarter rise in the fiscal deficit, expressed in terms of basis points per billion per quarter, some idea of the cumulative effect over a year of a rise in predicted deficits can be obtained. The presumption is that if forecast fiscal deficits over a year rise by, say, $100 billion, the instant impact on interest rates is equivalent to the present discounted compound impact of $25 billion per quarter in fiscal deficit surprises over the coming year. Based on estimates to be reported below, a $100 billion rise in the estimated annual deficit distributed as a surprise of $25 billion per quarter over four quarters would raise three-month Treasury bill rates by 40 basis points.

The GAP variable, as defined above, is positively related to the interest rate. A rise in GAP or pressure on capacity produces an accelerated effect on investment, which, ceteris paribus, requires a higher expected after-tax real rate to maintain equilibrium [Tanzi, 1980a].

After consideration of all these factors, it is clear from equation (10) that regression of nominal interest on a constant, a surprise deficit, a money surprise, GAP, a measure of uncertainty about inflation, and expected inflation ought to (a) test the hypothesized positive impact on the after-tax real interest rate of an exogenous shock to aggregate demand (measured by an unanticipated deficit); (b) test the hypothesized negative impact of a money surprise on the after-tax real rate by checking to see if the coefficient on the surprise is significantly less than zero; 1/ (c) test the hypothesized negative impact of expected inflation on after-tax real interest by checking to see if the coefficient on expected inflation is significantly below $[1/(1-\tau)]$; (d) measure the net impact of uncertainty about inflation on the after-tax real rate; and (e) test the impact of GAP on the after-tax real rate. Contemporaneous and lagged money surprises may depress the real interest rate insofar as they elevate real output above its natural level.

V. Some Empirical Tests

A report on some empirical tests that attempt to incorporate several of the above hypotheses are reported below. These tests, however, will not be able to capture some of those hypotheses, such as, for example, the disappearance of fiscal illusion. As a prelude to those tests it is, perhaps, useful to report some results on the simplest possible test

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1/ Besides Mishkin's (1982) expectations effect, some investigators, including Grossman (1981), Engel and Frankel (1982), and Roley (1982), have found a short-run "policy expectations effect," whereby a positive difference between a consensus forecast and the announced weekly number on the money supply causes short-run interest rates to rise. The result is seen to follow from an anticipated tightening of Federal Reserve policy in response to excessive money growth.

This finding, like Mishkin's, is not inconsistent with a finding that, prior to operation of an expectations effect, when an actual money number materializes which can be compared with a forecast, an income or liquidity effect occasioned by money growth above its anticipated path will depress interest rates. The dependent variable in the "policy expectations effect" studies is the change in three-month Treasury bill yields from 3:30 p.m. to 5:00 p.m. on Friday afternoon, precisely in order to isolate a pure expectations effect. Detection of an income or liquidity effect in these studies would require regressing the average interest rate from 5:00 p.m on Friday of the previous week to 3:30 p.m. on the current Friday on the current Friday's money surprise. A negative interest impact via an income or liquidity effect ought to lead the money surprise. These issues are discussed further in Makin (1982c).

for the Fisherian relationship, such as that reflected in an equation of the type $i_t = r_t + \beta\pi_t$, where all the symbols have the same meaning as above. The results obtained are of some interest.

(a) The worst period for a test of this simple Fisherian relationship insofar as proximity to one of the coefficients on expected inflation is concerned is between the late 1950s and the mid-1970s. For this period, the coefficient of expected inflation, β, is below 0.70. 1/

(b) If one keeps, say, 1958 as the initial period and extends the period beyond 1975 to 1981, β rises to well over 0.80.

(c) If one keeps the terminal year at 1981 but moves the initial year beyond 1958, the coefficient of π changes little up to the mid-1960s, but then it starts rising. For the period after 1970, the coefficient of π is significant and substantially exceeds unity, which is consistent with what one would expect from the partial equilibrium framework with taxes.

(d) The results are about the same whether one uses 3-month, 6-month, or 12-month Treasury bills.

These findings from estimating the basic Fisher equation suggest that either security markets do not fully reflect changes in anticipated inflation or significant movements in the after-tax real rate have, in varying degrees over separate subperiods, distorted inferences drawn from estimating the basic Fisher equation. 2/ In the light of the theory

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1/ This was a period of accelerating inflation.

2/ They may also indicate that it is not just the rate of inflation but the change in that rate that may be significant. For example, the Mundell-Tobin effect may be tied to accelerating inflation rather than to the rate of inflation itself.

of interest rate behavior developed in Section IV, the latter possibility seems most likely. 1/

Results of estimating interest rate equations suggested by equation (10) in Section IV are presented in Table 2. Particular attention is given to implications of proper modeling of residuals made possible by the use of transfer function procedures discussed in Box and Jenkins (1970). An attempt is made to check for the possible atrophy since 1979 of fiscal illusion.

The fit of the equation for the full period (equation (2.1) in Table 2) is displayed in Figure 4. Actual and predicted values listed in Table 3 indicate that the model tracks interest rates well within the sample period. Use of the transfer function procedure implies that the goodness of fit reflects explanatory power both of the independent variables employed and of the past history of interest rates. 2/

Initial estimation of the equations just described resulted in heteroscedastic error terms. A Park-Glejser test strongly supported the hypothesis that error variances grew over time. Therefore, in all results reported here, variables have been divided by the positively trended series on expected inflation to adjust for heteroscedasticity.

1/ Summers (1982) has argued, however, that nominal interest rates do not adjust by the full amount implied by the Fisher hypothesis modified to allow for marginal tax rates on interest earnings. His results based on both pre- and post-World War II data arise from equations that employ actual inflation rates in place of expected inflation and that generally do not include variables to control for movements in the expected real rate.

2/ Estimation employing OLS with adjustment for serial correlation of residuals yields nearly identical results. This is not surprising since this procedure is nearly equivalent to a transfer function with an AR (1) noise model and equations in Table 2 are estimated employing an ARMA (1,1) model.

Table 2. Interest Rate Equations: Various Time Periods 1/

Dependent Variable (Three-month Treasury Bill Rate)	Constant	Expected Inflation 2/	Money Surprise 3/	Surprise Deficit 4/	Inflation Uncertainty	GAP 5/	Sample Period 6/
				Full Period			
(2.1)	2.859	0.746	-0.044	0.004	-0.006	0.134	1960.I-1981.IV
	(13.84)	(6.46)	(6.94)	(2.88)	(0.04)	(4.01)	
				Subperiods			
(2.2)	3.001	0.661	-0.046	0.005	-0.055	0.150	1960.I-1975.IV
	(13.34)	(5.06)	(6.91)	(2.41)	(0.49)	(4.24)	
(2.3)	2.976	0.664	-0.046	0.004	-0.055	0.148	1960.I-1979.III
	(15.58)	(6.37)	(7.59)	(2.61)	(0.41)	(4.81)	
(2.4)	2.948	0.691	-0.046	-0.004	-0.029	0.146	1960.I-1980.IV
	(15.46)	(6.64)	(7.42)	(2.82)	(0.21)	(4.66)	

1/ All equations are estimated as transfer functions. Residuals are modeled by an ARMA (1,1) model (t statistics, which are shown in parentheses, are all above 5.0). White noise test significance levels for the first 24 residuals are (2.1) through (2.4): 0.49, 0.21, 0.11, 0.26.

2/ Anticipated inflation is based on Livingston survey data on six-month expected inflation. Interpolation is employed to obtain a quarterly series.

3/ Money surprises are measured as residuals from an ARMA (0,8) model of money (M1) growth. For a full discussion of this procedure and of alternatives, see Makin (1983).

4/ Surprise deficits are measured as residuals from a univariate time-series model of the government finance deficit measured in billions of U.S. dollars at an annual rate (line 80 of the U.S. country pages in the Fund's International Financial Statistics).

5/ GAP is calculated from quarterly data on U.S. real GNP capacity estimated by the Council of Economic Advisors and actual U.S. real GNP.

6/ The "time" variable in equation (10) is captured by the "noise model" of residuals estimated simultaneously with the coefficients on explanatory variables in the interest rate equation employing the transfer function estimation procedure.

Figure 4

3-MONTH TREASURY BILL RATE

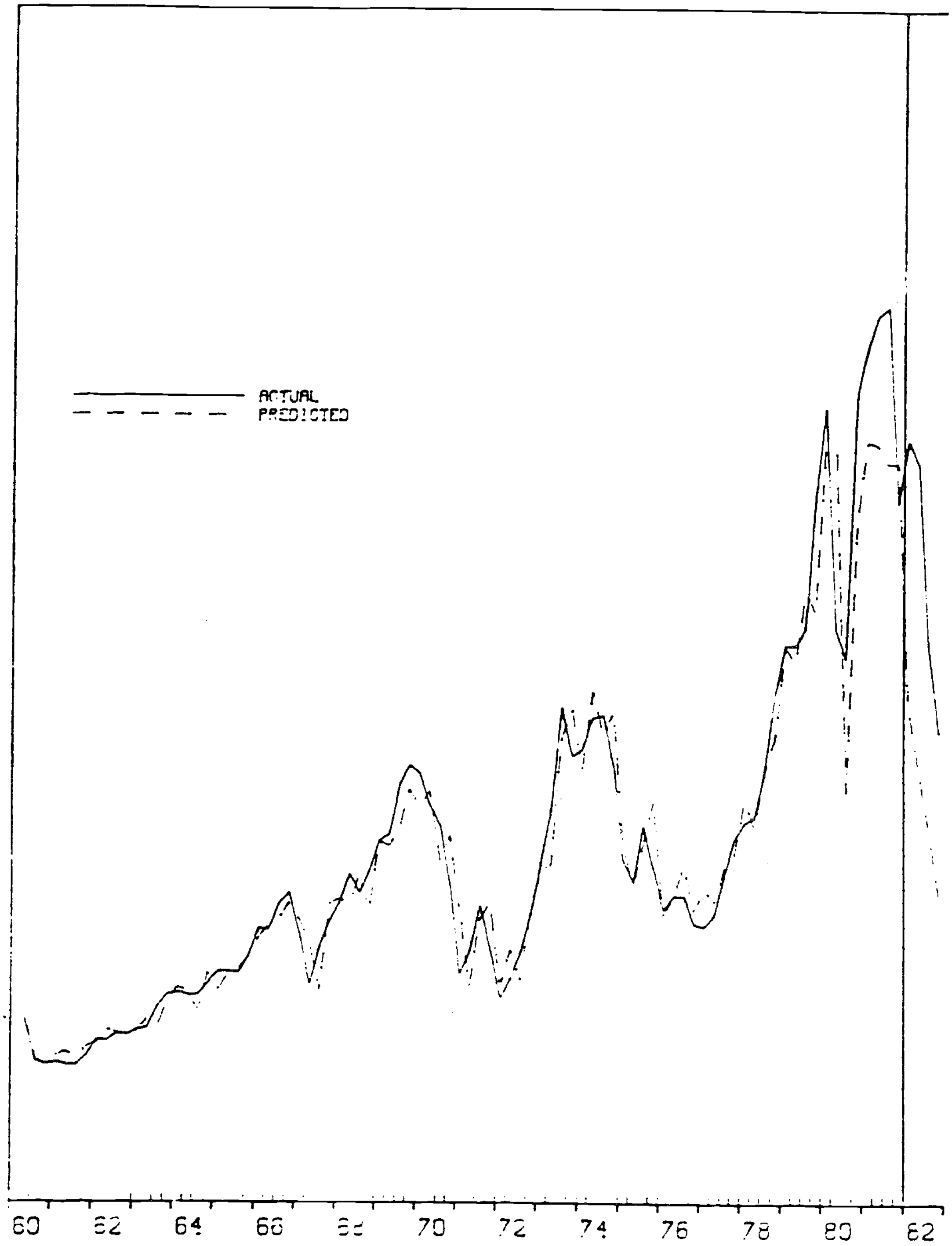

Table 3. Actual Versus Predicted Values of the Three-Month Treasury Bill Rate 1/

		Actual	Predicted
1960	Q1	3.87	
1960	Q2	2.99	3.06
1960	Q3	2.36	2.45
1960	Q4	2.31	2.29
1961	Q1	2.35	2.48
1961	Q2	2.30	2.54
1961	Q3	2.30	2.43
1961	Q4	2.46	2.63
1962	Q1	2.72	2.71
1962	Q2	2.71	2.92
1962	Q3	2.84	2.86
1962	Q4	2.81	2.74
1963	Q1	2.91	2.10
1963	Q2	2.94	3.09
1963	Q3	3.29	2.97
1963	Q4	3.50	3.40
1964	Q1	3.53	3.63
1964	Q2	3.48	3.56
1964	Q3	3.50	3.25
1964	Q4	3.68	3.88
1965	Q1	3.89	3.59
1965	Q2	3.87	3.87
1965	Q3	3.86	3.95
1965	Q4	4.16	4.18
1966	Q1	4.60	4.48
1966	Q2	4.58	4.68
1966	Q3	5.03	4.79
1966	Q4	5.20	5.05
1967	Q1	4.51	4.77
1967	Q2	3.66	4.40
1967	Q3	4.29	3.57
1967	Q4	4.74	5.04
1968	Q1	5.04	5.13
1968	Q2	5.51	5.03
1968	Q3	5.20	5.54
1968	Q4	5.58	4.93
1969	Q1	6.09	6.09
1969	Q2	6.19	6.01
1969	Q3	7.01	6.30
1969	Q4	7.35	6.96
1970	Q1	7.21	6.66
1970	Q2	6.67	6.94
1970	Q3	6.33	5.76
1970	Q4	5.35	6.19
1971	Q1	3.84	4.94
1971	Q2	4.24	3.65
1971	Q3	5.00	4.81
1971	Q4	4.23	5.07
1972	Q1	3.44	3.65
1972	Q2	3.77	4.28
1972	Q3	4.22	3.75
1972	Q4	4.86	4.99
1973	Q1	5.70	5.67
1973	Q2	6.60	5.70
1973	Q3	8.32	7.82
1973	Q4	7.50	8.31
1974	Q1	7.62	7.26
1974	Q2	8.15	8.61
1974	Q3	8.19	7.84
1974	Q4	7.36	8.27
1975	Q1	5.75	6.07
1975	Q2	5.39	5.36
1975	Q3	6.33	6.03
1975	Q4	5.63	6.77
1976	Q1	4.92	4.85
1976	Q2	5.16	5.17
1976	Q3	5.15	5.68
1976	Q4	4.67	4.91
1977	Q1	4.63	5.30
1977	Q2	4.84	5.06
1977	Q3	5.50	5.65
1977	Q4	6.11	5.85
1978	Q1	6.39	6.78
1978	Q2	6.48	6.33
1978	Q3	7.31	7.27
1978	Q4	8.57	7.84
1979	Q1	9.38	9.37
1979	Q2	9.[illegible]	9.11
1979	Q3	9.67	10.29
1979	Q4	11.84	9.95
1980	Q1	13.35	12.71
1980	Q2	9.62	12.71
1980	Q3	9.15	6.91
1980	Q4	13.61	11.44
1981	Q1	14.39	12.82
1981	Q2	14.91	12.75
1981	Q3	15.05	12.44
1981	Q4	11.75	12.44
1982	Q1	12.81	8.35
1982	Q2	12.42	7.33
1983	Q3	9.32	6.32
1982	Q4	7.91	5.22

1/ Predicted values based on equation (2.1), Table 2.

A number of conclusions emerge from Table 2. First, the coefficient on expected inflation is in all cases below unity. All of the subsample estimates of that coefficient lie within one standard error of the full-period result. Second, the money surprise variable produces the hypothesized negative impact on interest rates. 1/ The GAP variable produces the hypothesized positive impact on interest rates in a manner consistent with results reported by Tanzi (1980a). 2/

The impact on interest rates of an exogenous shock to aggregate demand as measured by an unanticipated increase in the fiscal deficit is of particular interest. The model presented in Section IV suggests a positive relationship that would represent the potential "crowding out" of private investment widely discussed in connection with large projected U.S. deficits after passage of the Economic Recovery Tax Act of 1981. Of course, here we are suggesting that only deficits differing from those projected subsequently to passage of that legislation will produce an impact on interest rates beyond that embodied in projections made at the time of its passage.

Results reported in Table 2 for all sample periods suggest that a surprise increase in the deficit at an annual rate of $10 billion during a quarter (an actual $2.5 billion surprise during the quarter) would

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1/ Money surprises are measured as residuals from an ARMA (0,8) model of money (M1) growth. For a full discussion of this procedure and of alternatives, see Makin (1983).

2/ The "time" variable in equation (10) is captured by the "noise model" of residuals estimated simultaneously with the coefficients on explanatory variables in the interest rate equation using the transfer function methodology.

raise the interest rate on three-month Treasury bills by four basis-points. 1/ This effect may seem small, but it should be remembered that this is the impact on the short-term bill rate only. Deficit "surprises" of $20 billion to 40 billion a quarter have not been uncommon since 1981, and surprises of this magnitude imply annual rates of $80 billion to $160 billion which in turn would move the short-term rate by 32 to 64 basis-points. The impact on longer-term rates could be larger.

Recall that discussion of the expected coefficient on expected inflation suggested that tax effects tend to push it above unity, and the Mundell-Tobin and Feldstein-Summers effects tend to push it below unity. The reported below-unity results are consistent with our hypothetical predicted value of 0.75 based on "reasonable" parameter values.

The significant negative impact on interest rates of the money surprise term is consistent with reported findings in a number of related studies. Levi and Makin (1979) report that output growth depresses interest rates, and Makin (1982a) reports that surprise money growth elevates output growth. Therefore, we would expect that both variables

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1/ Estimation employing the actual deficit in place of the surprise deficit gives

$$i_t = \underset{(15.57)}{2.187} + \underset{(7.25)}{1.067}\ \pi_t - \underset{(3.61)}{0.024}\ (m_t - {}_{t-1}m_t^e) - \underset{(1.60)}{0.251}\ \sigma_t^2 + \underset{(1.1)}{0.001}\ def._t$$

As noted earlier, the countercyclical deficit combined with the procyclical interest rates tends to bias downward the estimated coefficient on the deficit. The result also suggests the enhanced negative impact of inflation uncertainty, σ_t^2, on the interest rate when GAP is excluded from the estimated equation (see below).

would be negatively correlated with interest rates. Findings are also consistent with the hypothesis that surprise money growth produces liquidity effects discussed in Makin (1982b) and Khan (1980).

Uncertainty about inflation was not significant in the presence of all of the other variables. This is, of course, theoretically possible, since uncertainty about inflation depresses both saving and investment schedules. Indeed, results reported here suggest that it is not possible to reject the hypothesis that the net impact on the equilibrium after-tax real rate of these shifts is zero.

This result differs from findings reported in Levi and Makin (1979) and Makin (1983) where a significant negative coefficient on uncertainty about inflation was discovered. The reason for the different finding reported here may be linked to the presence of the GAP variable, which was not included in these other studies. A rise in GAP produces a significant positive impact on the interest rate. At the same time, it is negatively correlated with the measure of uncertainty about inflation, σ^2 ($\rho = -0.32$). The GAP variable is likely proxying for σ^2 with a rise in GAP associated with lower inflation uncertainty. No simple economic explanation for this association comes readily to mind, but it does reconcile results reported here with the finding reported elsewhere of a significant negative relationship between interest rates and inflation uncertainty. A rise in GAP may, in addition to its shift impact on investment, proxy for a drop in σ^2 which in turn is associated with higher interest rates.

Compared with the simple Fisher equation, results discussed at the beginning of this section and reported in Table 2, suggest that the impact of expected inflation on interest has been remarkably stable over a number of subperiods. It appears that the variability of that impact discovered in a number of investigations of the simple Fisher equation is due to time-varying bias on estimates drawn from equations that have omitted significant explanatory variables.

VI. Remaining Puzzles Concerning Interest Rates

Still, there remains a good deal about interest rate behavior that is not well understood, particularly in recent years. Although the levels of inflation and inflationary expectations fell sharply during 1982, both short- and long-term rates remained high, particularly during the first half of the year. The inconsistency of this experience with what our model would have predicted is clear from Table 3. Employing parameter values of the model estimated using 1980-81 data along with actual values of exogenous variables for 1982 badly underpredicts interest rate levels for the entire year.

One possible explanation for this result may have been the very unusual behavior of velocity during 1982. M-1 velocity grew at an average annual rate of 3.2 per cent from 1950 to 1982, although the rates of growth usually did fall somewhat during contractions. But the drop in actual velocity during 1982 was a remarkable 4.8 per cent. Based on a quarterly time series of M-1 velocity behavior from 1960-81, predicted growth of velocity during 1982 would have been about 2.95 per cent. The unanticipated drop in annual velocity growth over the year was 7.75 per cent, distributed over the quarters as shown in Table 3.

Table 3. 1982 Actual Versus Predicted Treasury Bill Rate and Velocity Growth Surprises, 1982

	Actual	Predicted	Actual-Predicted	Surprise Velocity Growth
I	12.81	8.35	4.46	-3.32
II	12.42	7.33	5.09	-0.12
III	9.32	6.32	3.00	-0.86
IV	7.91	5.22	2.69	-3.31

If, as some, including the Federal Reserve Board, have suggested (see testimony of Board Chairman Paul A. Volcker before the U.S. Senate Committee on Banking, Housing, and Urban Affairs, February 16, 1983), the collapse in velocity growth during 1982 represented a large, unpredictable increase in money demand, then excess money demand may have been responsible for the very high interest rates during much of 1982. The drop in interest rates during the last half of the year may have reflected some relief from that excess demand condition resulting from the rapid acceleration of money growth during that period. The annual growth rate of money (M-1) was 1.5 per cent during the first half of 1982 and 15.1 per cent during the second half.

It is tempting to attribute the persistence of high short-term interest rates during much of 1982, even in the face of lower expected inflation, to the unexpectedly sharp drop in velocity that occurred at the same time. However, coincidence does not necessarily imply causality and it is reasonable to ask if there has existed a stable relationship between unanticipated movements in velocity and interest rates over a longer time period and in the presence of the other explanatory variables in equation (10). As a matter of fact, unexpected velocity growth has, contrary to expectations, a weak positive impact on interest rates when included as an explanatory variable in equations like those reported in Table 2, either for the 1960-81 or the 1960-82 sample period. 1/ When

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1/ Unexpected velocity growth was employed in place of surprise growth of the money supply since velocity growth is defined as GNP growth less money supply growth and therefore is likely to be highly correlated with money growth.

interest rates are regressed on anticipated inflation together with velocity shocks alone, the velocity shocks again have a significant positive impact on nominal interest rates and the level of explanatory power is comparable to that of equations reported in Table 2.

The inconsistency between the negative association between velocity shocks and interest rates during 1982 and the positive association typical of the 1960-81 sample period can be explained as a manifestation of the identification problem first encountered by Henry Schultz in 1938. As Schultz discovered, where demand is highly volatile relative to supply, price, and quantitative measures map out a positive relationship. During 1982, a positive shock to money demand dominated money-supply shifts and the sharp drop in velocity reflected an excess money demand shift which caused interest rates, controlled for the level of expected inflation, to rise. Alternatively, during most of the postwar period including 1960-81, shocks to money supply have dominated shocks to money demand. As a result a sharp drop in velocity usually reflects a positive shock to money supply which in turn produces a simultaneous negative impact on interest rates while liquidity effects are dominating expectation effects. The result, consistent with findings reported in Table 2 on the effects of unexpected money growth, is a dominant positive association between velocity shocks and interest rates during much of the postwar period.

In short, most of the shocks to monetary equilibrium which have caused short-term rates to move beyond or below levels implied by changes in expected inflation, at least during the 1960-81 sample period, have been supply shocks. In contrast, 1982 was characterized by dominance of a (positive) demand shock which prevented short-term interest rates from falling in line with expected inflation. Once the situation was alleviated short-term rates fell roughly in line with the drop in expected inflation. The expected real rate on three-month Treasury bills fell from 7.09 per cent during the second quarter of 1982 to 3.25 per cent during the fourth quarter of 1982.

VII. Concluding Remarks

This paper has attempted to demonstrate a need to expand the simple Fisherian view whereby changes in interest rates are explained largely by changes in expected inflation. The need for this expansion became particularly evident during the early 1980s. Our measure of expected inflation dropped from 10.5 per cent per annum during the fourth quarter of 1980 to 7.6 per cent per annum during the third quarter of 1981. Over the same period, average yields on three-month Treasury bills *rose* from 13.6 per cent to 15.1 per cent. Some explanation for this apparent discrepancy in terms of results reported here may be useful.

The failure of interest rates to display a sustained drop during 1981 as the expected rate of inflation fell steadily resulted from a combination of forces. During the first quarter of 1981, some downward pressure on interest rates did materialize, but a sustained fall was prevented by a rise in economic activity. Our measure of excess capacity (minus GAP) fell from 5.5 per cent during the fourth quarter of 1980 to 4.3 per cent during the first quarter of 1981. Our estimates suggest that this change alone would add about 25 basis-points to short-term rates.

Rates remained high during the second quarter of 1981 owing, among other things, to a shift to unexpectedly tight money. (See Makin (1982b) for a fuller discussion.) This shift by itself raised short-term rates by about 24 basis-points according to our estimates. Unexpectedly tight money persisted into the third quarter of 1981, during which passage of the Economic Recovery Tax Act of 1981 also added to higher rates. Short-term rates were 2.61 percentage points above the level predicted by our interest rate equation during the third quarter of 1981, suggesting that some exogenous shock pushed up rates. This was the largest positive residual during the 20 years covered by our sample and seems likely to be attributable to fundamental changes in the outlook for the cyclical pattern of deficits attributable to passage of the Economic Recovery Tax Act of 1981. [This factor is discussed further below.]

In the fourth quarter of 1981, there was a sharp fall in short-term rates. This drop was attributable to, among other things (a) a large increase in excess capacity (29 basis-points); (b) a large positive surprise in money growth (36 basis-points); (c) a surprise surplus during that quarter (16 basis-points); and (d) a drop in inflationary expectations (48 basis-points). The actual drop of 330 basis-points was greater than the 129 basis-points indicated here, but the discrepancy is considerably reduced by accounting for the effects of variables other than expected inflation. In practice, our "noise model," or the past history of the three-month Treasury bill rate itself accounts for all but 69 basis-points of the remainder actual drop in rates.

During December 1981 and January 1982 there was a sharp acceleration of money growth accompanied by a rise in interest rates. This would be contrary to our prediction if part of the sharp increase came as a surprise. It must be remembered, however, that the sharp increase coincided with the first appearance of reports of sharply higher projections of U.S. fiscal deficits totaling $338.7 billion over fiscal years 1982 through 1984. These projections, which were revised upward even further during 1982, suggest another reason for persistently high interest rates during the first half of 1982. If these figures materialize, they may well break the traditional countercyclical pattern historically followed by U.S. fiscal deficits. If the U.S. economy expands during 1982-84 a rise in fiscal deficits will coincide with attempts by the private sector to increase borrowing. Traditionally, in the expansionary phase of the cycle there has been a drop in fiscal deficits. The perception of a change in the cyclical pattern of deficits has kept interest rates high since the end of 1981, whereas normally the dramatic drop in inflation and expectations about future inflation would have lowered rates. Viewed in this way, it may be that the "surprise" increase in money growth during December 1981 and January 1982 in fact cushioned the upward pressure on rates caused by the likelihood of procyclical U.S. fiscal deficits coupled with the then held expectation that the U.S. economy would recover during the second quarter of 1982. 1/

1/ A sharp drop in interest rates did materialize by August 1982, when it became clear that recovery of the U.S. economy was to be delayed. and when monetary policy began to become more accommodative.

Finally, there does exist the possibility that an atrophy of "fiscal illusion" resulting in a rise in perceived tax rates employed to calculate real after-tax returns has tended to elevate observed pretax market rates. Such a rise in perceived tax rates would magnify the impact on observed pretax interest rates of rises in expected after-tax real rates.

The high volatility of interest rates since 1979 is explained fairly straightforwardly by the sharp rise in the volatility of expected inflation (the variance of π rose from 0.44 during the June 1976-December 1978 period to 2.13 during the June 1979-December 1981 period) and by the likely increase in volatility of expected after-tax real rates resulting from increased uncertainty about the cyclical pattern of U.S. fiscal deficits and from pressures created by adherence to monetary targets. The elevated level of variance of expected inflation likely reflects in part the increased volatility of money growth since 1979. This is disquieting in view of the stated goal of reducing volatility of money growth under new Federal Reserve System operating procedures but not mysterious in its predictable impact on uncertainty about the outlook for inflation. Persistent success in targeting aggregates ought to reduce sharply the volatility of expected inflation. The net result will be more stable nominal rates even given some higher level of real rate volatility.

Overall interest rates have remained high since 1980, although progress in lowering expected inflation would normally have brought reductions, because a number of forces have acted to raise after-tax real rates since that time. Interest rates have been highly volatile in response to the elevated uncertainty about the outlook for inflation and for expected real rates.

These findings suggest a need for further investigation in a number of areas. Can effects of tax policy on interest rates be considered separately from effects of other variables? Analysis by Peek (1981) suggests that this may be possible. How significant is the perceived structural change in the cyclical behavior of U.S. fiscal deficits in pushing up real rates? Is there evidence that fiscal illusion has moderated and, if so, by how much? Might it be expected to reappear given a sharp reduction in the level of expected inflation? If higher real rates persist owing to "crowding out" associated with persistently enlarged fiscal deficits, what will be the effects on private saving, on international capital flows, and on private investment? What are the implications of elevated uncertainty about expected inflation? And finally and perhaps most important, what are the implications for the world economy of the unusual behavior exhibited by U.S. interest rates since 1979? More specific questions include possible effects on observed and real exchange rates, effects on worldwide economic growth and capital formation, and implications for the form of the international monetary system.

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