NBER WORKING PAPER SERIES

BUDGET DEFICITS, TAX RULES, AND REAL INTEREST RATES

Martin Feldstein

Working Paper No. 1970

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 1986

The research reported here is part of the NBER's research programs in Financial Markets and Monetary Economics, Economic Fluctuations and Taxation. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

Budget Deficits, Tax Rules, and Real Interest Rates

ABSTRACT

This paper examines three sources of the fluctuations in real interest rates during the past three decades: changes in budget deficits, changes in tax rules, and changes in monetary policy. The evidence indicates that budget deficits and monetary policy have had a strong influence on the level of long-term interest rates but fails to identify any effect of changes in corporate tax rates and investment incentives.

The analysis shows that it is projected future budget deficits rather than the current level of the actual or structural deficit that influence long-term interest rates. Each percentage point increase in the five-year projected ratio of budget deficits to GNP raises the long-term government bond rate by approximately 1.2 percentage points while the ratio of the current deficit to GNP (either actual or structural) has no significant effect. The specific parameter estimates imply that the increase in projected budget deficits was responsible for about two-thirds of the rise in the interest rates between 1977-78 and 1983-84.

Martin Feldstein
NBER
1050 Massachusetts Avenue
Cambridge, MA 02138

May 28, 1986

BUDGET DEFICITS, TAX RULES, AND REAL INTEREST RATES

Martin Feldstein*

The rise in the real long-term interest rate has been one of the most significant and contentious economic events of the 1980s. The interest rate on 10 year Treasury bonds rose from 8.2 percent in the second half of the 1970s to 12.4 percent in 1984 even though inflation fell from an average of 8.2 percent in the years 1975-79 to 4.0 percent in 1984. By any reasonable measure, the real long-term interest rate has been much higher in the first half of the 1980s than in any previous five-year period in this century. The high level of real interest rates affected not only domestic interest-sensitive industries but also, by raising the international value of the dollar, caused an unprecedented rise in the U.S. merchandise trade deficit.[1]

Understanding the cause of the high real interest rates is central to an analysis of the appropriate policy response. One leading view has been that the high real interest rates reflect the large current and projected government deficits and that those deficits should be reduced substantially or eliminated.[2] An alternative view emphasizes the increased demand for investment funds that resulted from the investment incentives in the 1981 tax legislation and concludes that deficit reduction would have little effect on real long-term interests rates.[3] Although I had previously noted (Feldstein, 1980b) and still believe that a pro-investment tax reform would raise real interest rates as well as investment, my judgment before doing the present research was that the increase in the government's demand for funds has been far more important as a cause of the high real interest rates in recent years.

The primary purpose of the present paper is to assess the relative importance of budget deficits and tax changes as causes of the rise in real interest rates.

It is, of course, impossible to discuss the movement of interest rates during the past decade without considering the changes in inflation and expected inflation that have also occurred during this same period. The effect of inflation on nominal and real interest rates depends on the structure of both the individual income tax and corporate income tax rates (see Feldstein, 1976 and 1983). An important secondary purpose of the present paper is to show how to incorporate both the personal and corporate tax rules in an econometric specification and to assess the implied effect of inflation on nominal and real interest rates. Although there have been a number of empirical studies of the interaction of tax rules and inflation, each study has looked only at either the personal tax rate or the corporate tax but never at the interaction between the two.[4] As the analysis developed below (and in Feldstein, 1976 and Feldstein, Green and Sheshinski, 1978) makes clear, a failure to include the effects of both tax systems has caused previous researchers to conclude incorrectly that the interest rate is not as responsive to inflation as the theory suggests.

The empirical analysis in the present paper also considers the effects on interest rates of changes in monetary policy and in business cycle conditions.

Although there have now been a number of studies of the effects of deficits on interest rates, the present study is novel in three important ways. First, the empirical analysis emphasizes the importance of expected future deficits rather than concurrent deficits. Second, the analysis assesses the change in investment incentives since 1981 as an alternative explanation of the subsequent rise in real interest rates. Third, the effect of inflation is incorporated in a way that includes both the personal and corporate tax systems.

The paper begins with a brief discussion and empirical analysis of the conditions that could in theory eliminate any relation between the budget deficit and the level of real interest rates. The next two sections discuss the theory and empirical implementation of the key determinants of interest rates. Section 2 also considers the reasons for believing that expected budget deficits rather than, or in addition to, the stock of national debt should influence the level of real interest rates. The third section discusses the effect on the level of interest rates of changes in tax rules and of the interaction of corporate tax rules and expected inflation. The analysis shows how personal and corporate taxes combine in interest rate determination. Section 4 presents a general specfication of the estimation equations, while Section 5 discusses the data definitions and sources. The empirical estimates of the basic equation and of several variants are presented and discussed in Section 6. There is a brief concluding section.

1. The Theoretical Case that There Is No Relation Between Deficits and Interest Rates

Much of the confusion in the popular debate about the relation between deficits and interest rates reflects a failure to distinguish between nominal and real interest rates and between cyclical and structural budget deficits.

But even when we focus properly on the relation between structural deficits and real interest rates, there are logically correct theoretical reasons why a higher deficit might not raise interest rates.

Within the traditional IS-LM framework, an increase in the budget deficit will not raise interest rates in three extreme cases: an infinitely elastic demand for money with respect to the interest rate; a zero elasticity of demand for money with respect to the level of nominal income; and an infinite elasticity of real demand with respect to the interest rate. In addition, a rise in the budget deficit caused by a tax cut would have no effect on interest rates if the marginal propensity to consume out of disposable income were zero. There is, of course, overwhelming evidence that none of these four conditions is even remotely true. Thus, within the conventional IS-LM framework, there is no empirically relevant case for the proposition that an increased structural budget deficit should not affect interest rates.[5]

1.1 The Ricardian Equivalency Hypothesis

Barro (1974) suggested a further reason why budget deficits, or, more accurately, budget deficits arising from temporary tax cuts, might have no effect on the level of interest rates. In Barro's analysis, individuals regard a tax cut as equivalent to a postponed tax liability that does not alter the budget constraint of the individual and his descendants taken together. Since they start with what they regard to be an optimal intergenerational allocation, they will not alter their consumption and will therefore save the entire tax cut. With no reduction in national saving, the interest rate should remain unchanged. This is the essence of what has come to be called the Ricardian equivalence proposition although it is an idea that Ricardo (1951) rejected as empirically false (O'Driscoll, 1977).

The effect of a budget deficit caused by a temporary rise in government spending is more ambiguous. If the government spending provides a service that the individual would otherwise have bought privately, the government spending is essentially equivalent to a tax cut. The individual reduces personal consumption by the amount of the current rise in government spending and the previous conclusion remains. If, however, the individual gets little or no benefit from the increased government spending but recognizes that the budget deficit implies a future tax liability, the individual will feel poorer and will reduce his personal consumption. But the concurrent reduction in personal consumption will be less than the increased deficit unless the increased annual deficit is permanent.

Barro's equivalence proposition requires a number of questionable assumptions. It assumes in particular that all individuals choose to make positive bequests and that the level of the bequest is selected by maximizing a function in which their children's utility is an argument. Bequests must not be made because the individual gets pleasure in giving or seeks to retain the affection of his children or dies prematurely. Abel (1985) has shown that the equivalence result also precludes various types of uncertainty and imperfections in annuity markets. Bernheim (1985) has recently shown that, since grandchildren and other future descendants are the result of marriages that link each family to currently unidentified other families, Barro type altruism has the implausible implication that each individual should be indifferent about lump sum taxes that transfer wealth from himself to any other individual. Empirical tests of the implications of Barro's theory based on aggregate time series data have not been decisive; Barro (1978) and Kormendi (1983) conclude that the theory is consistent with postwar U.S. experience while Feldstein (1982) and Kotlikoff and Boskin (1985) conclude that it is inconsistent.

The recent experience provides no support for the Barro view that an increased budget deficit does not raise interest rates because the increased deficit as such induces an equal rise in private saving. Table 1 shows that the budget deficit, which varied between -0.1 percent of GNP and 2.4 percent of GNP in the five year periods 1950 to 1979 jumped to 3.9 percent for the years 1980 to 1984. Although part of this rise in the deficit reflects the sharp recession, the cyclically adjusted deficits[6] (shown in column 2 of Table 1) also indicate an unusually large rise, from an average of 1.2 percent of GNP in the years 1950 to 1979 to 2.4 percent of GNP from 1980 to 1984 and 4.0 percent of GNP in 1984.

Almost all of the increase in the deficit between the 1970's and the first half of the 1980s was due to the rise in transfer payments and to increased interest on the national debt. Column 3 of Table 1 shows that federal spending on goods and services averaged 8.0 percent of GNP in the 1970s and remained at that level in the first half of the 1980s. Although there were year to year fluctuations, the 1984 level was 8.1 percent of GNP. Federal tax receipts as a percent of GNP actually rose slightly between the 1970s (19.5 percent of GNP) and the first half of the 1980s (20.1 percent of GNP), falling only to 19.2 percent of GNP in 1984. Thus, of the 3.0 percent of GNP rise in the deficit between the 1970s and 1984, only 0.1 percent was due

Table 1

Government Deficits and Private Saving
as Percentage of GNP

Years	Budget Deficit (1)	Structural Budget Deficit (2)	Government Spending on Goods and Services (3)	Tax Receipts (4)	Transfer Payments (5)	Personal Saving (6)	Net Private Saving (7)	Net Non-federal Saving (8)	Net National Saving (9)
1950-54	-0.1	1.1	12.4	18.5	2.9	6.8	7.0	6.9	7.0
1955-59	-0.1	0.3	11.3	18.2	3.7	6.8	7.3	7.0	7.1
1960-64	0.3	0.2	10.8	18.7	4.5	6.0	7.2	7.2	6.9
1965-69	0.3	2.0	10.6	19.3	4.9	7.1	8.4	8.5	8.1
1970-74	1.2	1.8	8.5	19.3	6.9	7.9	7.4	8.0	6.8
1975-79	2.4	1.8	7.4	19.6	8.9	6.7	7.0	8.1	5.7
1980-84	3.9	2.4	8.0	20.1	9.8	6.0	6.0	7.3	3.4
1980	2.3	1.8	7.5	20.6	9.4	6.0	5.4	6.6	4.2
1981	2.2	1.3	7.7	21.1	9.5	6.7	6.1	7.3	5.2
1982	4.8	2.2	8.4	20.1	10.3	6.2	5.4	6.5	1.6
1983	5.4	2.9	8.2	19.4	10.2	5.0	5.9	7.2	1.8
1984	4.8	4.0	8.1	19.2	9.4	6.1	7.4	8.9	4.1

to the rise in government spending on goods and services and 0.3 percent was due to the fall in tax receipts. Of the remaining 2.6 percent of GNP deficit increase, 1.5 percent of GNP was the rise in transfer payments (from 7.9 percent in the 1970s to 9.4 percent in 1984, shown in column 5) and 1.1 percent was the increase in net interest paid by the federal government.

Since the rise in spending on goods and services was such a small part of the increased deficit, the equivalence theorem implies that nearly all of the rise in the deficit should have been matched by an increase in private saving. The data in columns 6 through 8 of Table 1 show that no such increase in private saving occurred. On the contrary, net saving by any measure was lower during the first half of the 1980s than it had been in the previous three decades. Personal saving (column 6) averaged 6.0 percent of disposable personal income during the period 1980-84, lower than in any of the successive five year periods since 1950. The broader measure of net private saving as a percentage of GNP (column 7) also averaged 6.0 percent, an even bigger decline relative to past years. The even broader measure that combines private saving and the surpluses of state and local governments (column 8) shows a decline from the past.

The data in Table 1 lend no support to the equivalence hypothesis or to the proposition that the increased deficit did not raise interests rates because it induced an equal rise in private saving. Of course, since other influences on saving were also changing during this period, the evidence cannot definitively reject the equivalence hypothesis. For example, the sharp rise in the stock market might have been expected to reduce saving while the higher real rate of interest, lower personal tax rates, more rapid depreciation, and the universal availability of individual retirement accounts might have expected to raise the saving rate.[7] But despite the possible ambiguity about the correctness of the equivalence hypothesis, there is no doubt that during the years 1980 to 1984 the sharp rise in the budget deficit was not offset by a corresponding rise in private saving and, as a result, the net national saving rate (column 9) fell substantially.

1.2 The Inflow of Foreign Capital

A decline in the U.S. national saving rate would not increase the U.S. real rate of interest if there is perfect capital mobility in the world and the U.S. savings shortfall is small relative to world saving and to the stock of capital that is mobile in the short-term. Under these conditions, capital would flow into the United States to maintain the same rate of interest here and abroad. However, if U.S. assets are not a perfect substitute for foreign assets, an actual rise in the U.S. real interest rate relative to the interest rate abroad (or a fall in the relative risk of investing in the United States) will be necessary to induce a capital inflow.[8]

The U.S. experience since 1980, shown in Table 2 with budgetary data for the entire floating rate period that began in 1974, indicates that there is substantial short-term capital mobility but that U.S. and foreign assets are not perfect substitutes. Although foreign capital has come to the United States, the net capital inflow (column 2) has not been enough to offset the fall in the net national saving rate (column 1). The net national saving rate declined from 5.8 percent of GNP in 1974-79 to 3.4 percent of GNP in 1980-84, while the net capital inflow rose from essentially zero in 1974-79 to

Table 2

National Saving, International Capital Flows
and Interest Rates

Year	Net National Saving (1)	Net Capital Inflow (2)	Net Investment (3)	Real Interest Rate on 10-Year Government Bonds (4)	Real Interest Rate on Long-Term German Bonds (5)
	Percentage of GNP				
1974	6.5	-0.2	6.5	0.1	4.9
1975	3.8	-1.2	3.0	-1.7	2.4
1976	4.8	-0.3	4.8	1.8	1.7
1977	5.9	0.7	6.7	1.4	0.6
1978	7.0	0.7	7.6	2.0	0.4
1979	6.8	0.1	6.9	2.4	2.5
1980	4.2	-0.2	4.1	3.9	3.7
1981	5.2	-0.2	5.2	5.9	5.9
1982	1.6	0.2	1.8	6.0	4.9
1983	1.8	1.0	2.9	5.5	3.8
1984	4.1	2.6	6.6	6.9	3.9

0.7 percent of GNP in 1980-84; the increased capital inflow offset one third of the saving decline. As a result, net investment as a share of GNP (column 3) has declined, despite the tax changes in the 1981 tax legislation and the fall of inflation, both of which significantly raised the after-tax return on investment.

The capital inflow was achieved only with the help of a substantial rise in the real long-term rate of interest in the United States (column 4),[9] both relative to its own past values and relative to the real rate of interest abroad. Column 5 presents the real interest rate on German bonds as representative of the real yield available on foreign assets.[10] By the method used here, the real long-term interest rate in the United States rose from 1.0 percent in the 1974-79 period to 5.6 in the years 1980-84, an increase of 4.6 percentage points. During the same period, the real rate in Germany rose only 1.7 percentage points, from 2.7 percent to 4.4 percent. The flow of capital to the United thus reflects not only a rise in the U.S. real return but also an increased return relative to the yield on foreign securities.

The flow of capital to the United States was also encouraged during this period by a number of other influences. The disinflationary shift in monetary policy and the subsequent success in bringing inflation down reduced the perceived exchange rate risk of investing in dollar bonds. The problems in Latin America caused substantial capital flight to the United States, as well as a reluctance by American banks to continue net lending in Latin America after 1982. The slowdown of economic activity and domestic investment in Japan increased the flow of Japanese capital to the United States. And the decline of the real price of oil brought an end to the OPEC nation's surplus and its investment abroad. Although it is difficult to assess the relative importance of each of these, my belief is that on balance these additional factors increased the net flow of capital to the United States.

What is clear, however, is that the flow of foreign capital to the U.S. was not sufficient to maintain the previous net investment share of GNP even though real and relative U.S. interest rates rose during the period. More generally, the analysis of the present section indicates that neither the international mobility of capital, nor the response of personal saving to budget deficits, nor the properties of the LM and IS schedules suggest that the budget deficit could rise without an increase in the rate of interest. The remainder of this paper will attempt to assess how much of the observed rise in the real interest rate since 1980 has been due to the current and projected budget deficits and how much of that rise has been due to tax changes and other factors.

2. The Basic Interest Rate Equation

At least since the work of Patinkin (1965) and Tobin (1969), economists have recognized that the full set of interest rates and equity yields are determined simultaneously with the quantities of all private financial assets. In a simple static framework, the demand for each type of financial asset and the supply of each type of private financial asset is a function of all interest rates and equity yields, as well as of the level of income (as a measure of the level of economic activity and a proxy for private wealth).[11] This model can then be solved for the reduced form set of equations in which each interest rate and the quantity of each type of private security is a function of the two exogenously determined asset levels (money and government bonds), the level of real income, and the price level.

In particular, the simplest static equation for the interest rate on government bonds (i) is:

$$(2.1) \qquad i = F[\frac{M}{p}, \frac{B}{p}, \frac{Y}{p}]$$

where M is the stock of money or the monetary base, B is the stock of government debt, Y is the level of nominal income, and p measures the price level. Conventional analysis shows that i is a decreasing function of M/p and an increasing function of B/p and Y/p. Since we are now looking at a static equilibrium, there is no inflation and therefore no distinction between real and nominal interest rates. Although the price level is endogenous in the longer term, since asset yields adjust more rapidly than the prices of goods, we can treat the price level as predetermined in this short-run equilibrium, thereby allowing the government to alter M/p and B/p temporarily by changing M and B.[12]

This static analysis is inadequate because financial markets are forward looking. Anything that is currently expected to affect the future supply and demand for financial assets, and therefore future interest rates, will affect current interest rates as well. The equilibrium condition in financial markets is that, except for the effects of risk aversion, the expected total yield (including both the current yield and the anticipated real appreciation in value) must be the same for all assets. The current interest rate on long-term bonds must therefore change to maintain this equilibrium whenever future changes in asset supply and demand are expected to change future interest rates. Similarly, an increase in the expected rate of inflation induces a rise in the long-term interest rate because the inflation raises the nominal return on physical capital.

The reduced form equation that reflects these forward looking considerations includes not only the current values of M, B, Y, and p but also the expected future values:

$$(2.2) \qquad i_t = F\left[\frac{M_t}{p_t}, \left[\frac{M}{p}\right]^e_t, \frac{B_t}{p_t}, \left[\frac{B}{p}\right]^e_t, \frac{Y_t}{p_t}, \left[\frac{Y}{p}\right]^e_t, \pi^e_t \right]$$

where the variable x^e_t refers to the future values of x anticipated at time t and π^e is the expected rate of inflation.

In principle, these expectations relate not to a single future date but to all future values. In practice, of course, financial investors do not have such disaggregated expectations of future values but use at most a few summary measures of future conditions. The current section discusses the role of current and expected government debt and the way that the concept of expected future debt is made operational. The operation equivalents of expected inflation and the expected monetary growth are discussed in Section 5.

2.1 Anticipated Future Deficits

Anticipated future budget deficits are the link between the current government debt and its future value. If D_t is the deficit during year t and B_t is the stock of debt at the end of period t, it follows by definition that

$B_t = B_{t-1} + D_t$. An increase in the expected future deficits implies a larger future debt. This higher future value for the government debt implies a higher value of the future interest rate. A higher expected future interest rate raises the current value of the long-term rate because failure to do so would leave current bondholders with an anticipated capital loss and a lower total expected return than they could get by temporarily holding money or short-term securities.

More concretely, an anticipated future budget deficit means a smaller amount of funds at that future date to finance investment in plant and equipment. Restricting that investment will require a higher real rate of interest. Similarly, the anticipated budget deficit means that individuals will have to be offered a higher yield in the future to induce them to hold the larger amount of government debt in their portfolios. Both of these effects raise the expected future interest rate and therefore, in order to satisfy the intertemporal arbitrage condition, they raise the current long-term rate as well.

The longer that the rise in the budget deficit is expected to last, the greater will be the resulting rise in the interest rate. A transitory budget deficit of D_t for one period can be balanced by postponing current investment until the deficit shrinks and then substituting a fraction of the postponed investment over a period of years for a small portion of the investment that would otherwise have occurred in that year. In this way, a one year deficit is equivalent in its impact on private investment to a much smaller multi-year deficit. The interest rate increase required to postpone a single year's private investment in this way and to reduce the original investment of subsequent years to permit most of the postponed investment to occur will be much smaller than the interest rate increase that would be required to induce firms to abandon permanently a flow of investment equal to D_t per year for several years.

It is clear from this discussion that it is wrong to relate the rate of interest to the concurrent budget deficit without taking into account the anticipated future deficits. It is significant that almost none of the past empirical analyses of the effect of deficits on interest rates makes any attempt to include a measure of expected future deficits.[13] Similarly, it is inappropriate to relate the interest rate to the value of the government debt without taking into account the anticipated future budget deficits.[14]

2.2 Budget Deficits Versus the Stock of Debt

Budget deficits are, however, more than a link between current debt and future debt. Indeed, there are three reasons for expecting interest rates to be more sensitive to annual budget deficits than the link between deficits and debt would imply. The first of these reasons, stressed by Blanchard (1985), is that budget deficits raise aggregate demand and, through the resulting increase in the demand for money, raise interest rates. Anticipated future budget deficits therefore imply future increases in aggregate demand and interest rates which in turn raise the current long-term real rate of interest.

The second link between budget deficits and interest rates is through anticipated inflation and inflation uncertainty. Financial investors may fear that a sustained increase in the budget deficit would, by raising real interest rates, cause pressures on the Federal Reserve to ease money with the aim of reducing interest rates. If the Federal Reserve succumbed to those pressures, the result would be a rise in inflation and in nominal interest rates. Financial investors may reduce their demand for long-term bonds in the face of an enlarged budget deficit because they actually anticipate a higher rate of inflation or because the increased probability of such an inflationary policy makes long-term fixed interest securities a riskier asset. In contrast, the level of the national debt does not create such concerns about a shift in monetary policy because the Federal Reserve has already demonstrated a willingness to accept the resulting level of interest rates. It is the uncertainty about the future consequences of sustained future high budget deficits that causes the deficit to have an effect that goes beyond the effect of the enlarged debt per se.

The final distinction between the effect of a higher level of national debt and a higher level of the annual deficit reflects the adjustment costs that influence the optimal rate of investment. Although the size of the capital stock is optimal when the marginal product of capital is equal to the real rate of interest, the optimal rate of interest at any time reflects also the cost of adjusting the capital stock (Hayashi, 1982; Abel, 1980; Summers, 1981). For any given size of the capital stock and therefore the associated marginal product of capital (f'), the rate of investment will depend on the real interest rate (r) and on the cost of increasing the rate of investment, c(I) where c(I) is the cost of installing investment at rate I per period and c'(I) is therefore the cost of installing one extra unit of capital in the period. In the short run, a rise in the rate of investment increases the cost of investing: $c''(I) > 0$. If the cost of purchasing one unit of the capital good is 1, the cost of increasing the capital stock by one unit is $1 + c'(I)$. The optimal rate of investment at time t therefore satisfies

$$(2.3) \qquad f'(K_t) = r\,[1 + c'(I_t^*)].$$

In words, the marginal product of capital must be equal not to the interest rate but to the product of the interest rate and the cost of increasing the capital stock by one unit.

Consider now the effect of a temporary budget deficit that reduces the investable funds at time t. How does r have to vary to maintain the equilibrium condition of 2.3 when I_t is reduced? Totally differentiating 2.3 yields[15]

$$(2.4) \qquad f''dK_t = (1+c')dr + rc''dI_t.$$

Since the reduced investment in period t causes an equal reduction in the capital stock, $dK_t = dI_t$. Solving 2.4 and using $1+c' = f'/r$ (from (2.3) yields

$$(2.5) \qquad \frac{1}{r}\frac{dr}{dI_t} = \frac{f''}{f'} - c'' < 0.$$

The first term on the right hand side reflects the fact that the increased deficit reduces the capital stock and therefore raises the marginal product of capital. The second term reflects the fact that a lower rate of investment reduces the cost of investing. Since the lower cost of investing would raise the desired rate of investment above the level that can be financed, the lower cost of investment must be balanced by a higher rate of interest.

Note that only the first of these two effects, the change in the marginal product of capital, is associated with a change in the size of the national debt caused by a <u>past</u> budget deficit. This effect is likely to be relatively small. For example, with a Cobb-Douglas technology, equation 2.5 implies that $dr/r = -(1-\alpha)(dk/k)$ where α is the capital share coefficient and dk/k is the proportional reduction in the capital stock caused by the change in the national debt. Even a relatively large change in the capital has only a modest effect on the equilibrium rate of interest. For example, with $dk/k = -0.1$ and $\alpha = 0.3$, the change in the equilibrium interest rate is $dr = 0.07r$ or about 0.75 percentage points.

In contrast, a change in the rate of investment also changes the concurrent interest rate through the second channel by changing the cost of installing capital. This effect may be powerful since the very limited evidence on the costs of adjustment suggest that they are quite significant.[16] Of course, any change in the long-term interest rate must be consistent with financial investors' expectations about future interest rates. A very transitory increase in the budget deficit would therefore raise only the short-term interest rate significantly, thereby inducing business investors to postpone investment. But a rise in the budget deficit that is expected to be sustained for a number of years could substantially raise interest rates on bonds with that duration. A substantial increase in medium-term interest rates would, of course, also raise the interest rate on longer-term securities.

The evidence that is presented is Section 6 of this paper supports the view that the level of interest rates is more sensitive to the budget deficit than to the stock of national debt. No attempt is made in the current analysis to assess the relative importance of the aggregate demand, inflation uncertainty, and adjustment cost reasons for that difference. The empirical analysis also confirms that interest rates are more sensitive to deficits that are expected to be sustained for a number of years than to very short-term fluctuations in the budget deficit.

Estimating the model described in this section requires time series data on the expected future values of budget deficits, of inflation and of the other variables identified in equation 2.2. Before discussing the implementation of these expectations, I turn in the next section to the role of taxes in determining the rate of interest.

3. Tax Rules and Inflation

Taxes affect interest rates in two principal ways. The corporate tax rate and the tax depreciation rules influence the demand for funds by altering the interest rate that firms can afford to pay for funds to finance any given investment. The personal tax rate influences the supply of funds by putting a wedge between the gross interest rate that firms pay and the net return that households receive.

Moreover, because tax rules are written in terms of nominal interest rates and depreciation instead of real interest rates and depreciation, changes in the rate of inflation can have very significant effects on the equilibrium real interest rate. The most obvious effect is that borrowers deduct their nominal interest costs. If this were the only effect of inflation, any change in the expected rate of inflation would cause nearly twice as big a change in the nominal interest rate. For example, if in the absence of inflation firms paid a 5 percent rate of interest and had a 46 percent corporate income tax, the real net cost of those funds would be 2.7 percent. If inflation rose to 5 percent, the pretax rate of interest would have to rise from 5 percent to 14.3 percent to continue to leave firms with a real after-tax cost of funds of 2.7 percent.

One reason that such sensitivity of interest rates to inflation is not seen in practice is that inflation also reduces the real value of depreciation allowances, thereby making projects less profitable and reducing the real rate of interest that firms can afford to pay to finance those projects. Feldstein and Summers (1978) showed that under the tax rules prevailing in the late 1970s these two effects were of approximately equal magnitude for projects that were financed completely by debt, causing the interest rate to rise by the increase in the rate of inflation. With partial debt finance, the analysis is more complex and implies that an increase in inflation causes a greater than equal rise in the nominal interest rate (see Feldstein, Green and Sheshinski, 1978).

Since individual purchasers of corporate bonds must pay tax on their nominal interest income, a constant real pre-tax interest rate means a lower after-tax real rate of interest as inflation rises. For example, an individual with a 30 percent marginal tax rate has a real after-tax interest rate of 3.5 percent when there is no inflation and a 5 percent rate of interest. If inflation rises to 5 percent and the interest rate to 10 percent, that individual's real pre-tax rate of return remains constant but the after-tax rate falls to 2.0 percent.

Since 1981, depreciation rules have become more generous, and both inflation and personal tax rates have declined. The more generous depreciation rules would in themselves tend to raise the real interest rate that corporations can pay, a point that I developed in Feldstein (1980). The fall in the rate of inflation also increased the value of depreciation allowances and therefore the real return that firms can afford to pay. Both of these changes would therefore have led to higher interest rates in recent years. At the same time, however, the fall in personal tax rates and the decline in inflation increased the real after-tax return that capital providers received at any given pre-tax real cost of funds to the borrowers. This increased the supply of debt capital and this in itself would have led to lower real interest rates since 1981. The net effect of these two countervailing pressures depends on the relative magnitude of the two effects and on the relative elasticities of saving and investment. This section discusses how these effects can be measured and the econometric evidence section shows the size of the net impact on actual market interest rates.

3.1 The Maximum Potential Interest Rate

The effect of tax rules and inflation on the corporate demand for funds can be summarized by the maximum potential interest rate (MPIR), a concept that is a natural generalization of the familiar internal rate of return (IRR). In an economy without taxes, the IRR measures the rate of interest that a firm could pay to finance a particular investment that is financed solely by debt. When a corporate income tax system is introduced, the MPIR100 measures the rate of interest that the firm can pay to finance a particular investment if the investment is 100 percent debt financed.

More explicitly, consider a project that: (1) has pre-tax real net output of x_t per dollar of plant and equipment initially invested and nominal pre-tax net receipts of $p_t x_t$; (2) is permitted depreciation allowances for tax purposes of a_t; (3) and pays tax on nominal output less interest expenses and depreciation allowances at rate τ. The price level of the firm's net output is assumed to move in proportion to the general price level of the economy. The firm investing in this project needs initial cash per dollar of the project equal to one dollar minus the investment tax credit. Thereafter, the loan balance (L_t) is reduced by the project's after-tax income but grows by an annual amount equal to the product of the net-of-tax rate of interest and the previous year's loan liability.

Thus, the MPIR100 = i* satisfies the equation:

$$(3.1) \qquad L_t = (1+i^*)L_{t-1} - p_t x_t + \tau(p_t x_t - a_t - i^* L_{t-1})$$

$$= [1 + (1-\tau)i^*]L_{t-1} - (1-\tau)p_t x_t - \tau a_t$$

subject to the condition that L_0 = 1 minus the investment tax credit per dollar of investment and that the loan is repaid when the project is scrapped ($L_T = 0$). In the absence of taxation ($\tau = 0$), the solution of this difference equation for i* is equivalent to the traditional IRR formula.

More generally, the project will not be financed exclusively by debt but debt will be a proportion b of the total finance and equity the remaining fraction, 1 - b. In this case, the firm's net nominal cost of funds will be

$$(3.2) \qquad n = b(1-\tau)i + (1-b)(e+\pi)$$

where e is the real cost of equity capital (i.e., the earnings price ratio) and π is the expected rate of inflation. When there is partial debt finance, equation (3.1) defines the maximum potential net return (MPNR); that is, letting n^* denote the MPNR and substituting n^* for $(1-\tau)i^*$ in equation (3.1) yields the maximum nominal cost of funds (with interest net of the corporate tax) that the firm can afford to pay.

For any given MPNR, the maximum potential interest rate depends on the relation between the rate of interest and the return on equity. The behavior of portfolio investors maintains a rough relation between the expected real net-of-tax rate of interest and the corresponding expected real net return on equity. The real net rate of interest is

$$(3.3) \qquad i_n = (1-\theta)i - \pi$$

where θ is a weighted average of the marginal tax rates paid by individuals and institutional holders of corporate securities. The corresponding real net return on equity is

$$(3.4) \qquad e_n = (1-\theta)d \cdot e + (1-\theta_g)(1-d)e - \theta_g \pi$$

where d is the fraction of real earnings paid as dividends and θ_g is the effective tax rate on capital gains. The form of equation (3.4) assumes that retained earnings cause a corresponding amount of real accrued capital gain. In addition, shareholders pay capital gains tax on the nominal appreciation caused by inflation.

If the net yield on equity is equal to the net yield on debt plus a risk premium (δ),

$$(3.5) \qquad e_n = i_n + \delta,$$

the definitions of i_n and e_n in (3.3) and (3.4) provide a relation between the pre-tax equity and debt returns, e and i:

$$(3.6) \qquad [(1-\theta)d + (1-\theta_g)]e = (1-\theta)i - (1-\theta_g)\pi + \delta$$

Combining this equation with the definition of the firm's net cost of funds in equation (3.2) provides two equations that together determine the maximum potential interest rate (MPIR) and the corresponding maximum potential equity return as a function of the MPNR (i.e., the value of n* that is the solution of equation (3.1)) and of the tax rates, expected inflation and corporate finance parameters (b and d).

The MPIR values have been derived on the assumption that the basic investment project is a "sandwich" of equipment and structures that lasts for 34 years and replicates the average mixture of equipment and structures in the capital stock of the non-financial corporate sector. More specifically, the sandwich consists of an initial investment of 33 dollars of structures and 33 dollars of equipment. The output associated with the structures is assumed to decay at a rate of 3 percent a year; at the end of 34 years, the remaining structure is scrapped without value. The output associated with the equipment decays more rapidly, at 13 percent per year, and the equipment is scrapped without value at the end of 17 years. At year 17, a new equipment investment is made with real value (in the prices of year 1) of 33 dollars; this then decays in the same way as the initial equipment investment and is scrapped at the same time as the structure.

The first-year net output values of the structure and of the equipment are set to satisfy two conditions. First, the overall pretax rate of return on the investment sandwich is 10.3 percent.[17] Second, the after-tax rates of return on the two types of investments are equal under the tax rules prevailing in a base period (chosen to be 1960). These conditions and the decay schedules described in the previous paragraph uniquely determine the x_t values of equation (3.1).

The expected inflation rates for equations (3.2) through (3.6) and the expected price levels for equation (3.1) are obtained from Box-Jenkins' forecasts of consumer price index inflation using an AR1 specification. For each date, the forecast uses only data available at that time. The resulting "rolling" AR1 forecasts of inflation are then summarized by a single measure of expected inflation by calculating a present value of future inflation rates. A summary of these expected inflation rates is presented in column 2 of Table 3; individual annual values are presented in Appendix Table A-1. For comparison, the average values of the 5-year inflation rates expected by financial market participants are shown in column 3.[18] The rolling AR1 inflation forecasts are quite close to the financial market participants' expectations during the recent years for which comparisons are possible.

The appropriate value of the debt share of investment (the parameter b in the above equations) is ambiguous. Although it could be argued that any marginal investment might be financed solely by debt, the observation that firms have maintained a relative constant ratio of debt to capital suggests

Table 3

Inflation Rates and Tax Rules

Years	Interest Rate on 5-Year Government Bonds (1)	ARIMA Inflation Forecast (2)	Inflation Forecast Survey (3)	Maximum Potential Interest Rates MPIR33 (4)	MPIR100 (5)	Interest Rate for Constant After-tax Real Return (6)
1960-64	3.9	2.0	n.a.	3.5	15.1	3.5
1965-69	5.4	2.3	n.a.	4.5	15.9	3.9
1970-74	6.8	4.8	n.a.	7.4	19.0	7.4
1975-79	8.0	7.0	n.a.	11.8	24.4	10.5
1980-84	12.3	6.7	7.4	13.5	25.6	10.9
1980	11.5	7.6	9.4	13.6	25.1	11.4
1981	14.2	8.0	8.2	16.3	28.2	14.0
1982	13.0	7.0	6.8	14.7	26.8	12.3
1983	10.8	5.6	6.4	12.7	24.3	8.6
1984	12.2	5.5	6.2	10.4	23.8	8.4

that firms' borrowing levels are determined by their equity base in a way that makes the true effective marginal debt-capital ratio similar to the average ratio. The analysis that follows experiments with two different MPIR values corresponding to two possible marginal debt shares: MPIR100 corresponds to pure debt finance, $b = 1$; MPIR33 corresponds to $b = .33$.

Finally, the MPIR values assume that dividends are 44 percent of real equity earnings and that the equity risk premium (δ) is 6 percentage points. During the period 1960 to 1984, the dividend payout ratio averaged 0.xx. Although the ratio varied cyclically during this period, successive five year averages show no trend. Alternative calculations were done with $\delta = 0.04$ and $\delta = 0.08$; the results are not sensitive to the choice of risk premium.

Columns 4 and 5 of Table 3 present the MPIR values corresponding to the two different assumptions about the marginal debt to capital ratio. Since the equity yield is required to be higher than the yield on debt, a higher debt share corresponds to a higher and more volatile MPIR value.

3.2 The Net Return to Portfolio Investors

The changing values of the MPIR that firms can afford to pay represent shifts in the demand for funds and therefore only half of the story of the effect of inflation and tax rules on the rate of interest. The other half of the story is the shifts in the supply of funds that result from changes in the difference between the pre-tax interest rate that firms pay and the net-of-tax interest rate that savers receive.[19]

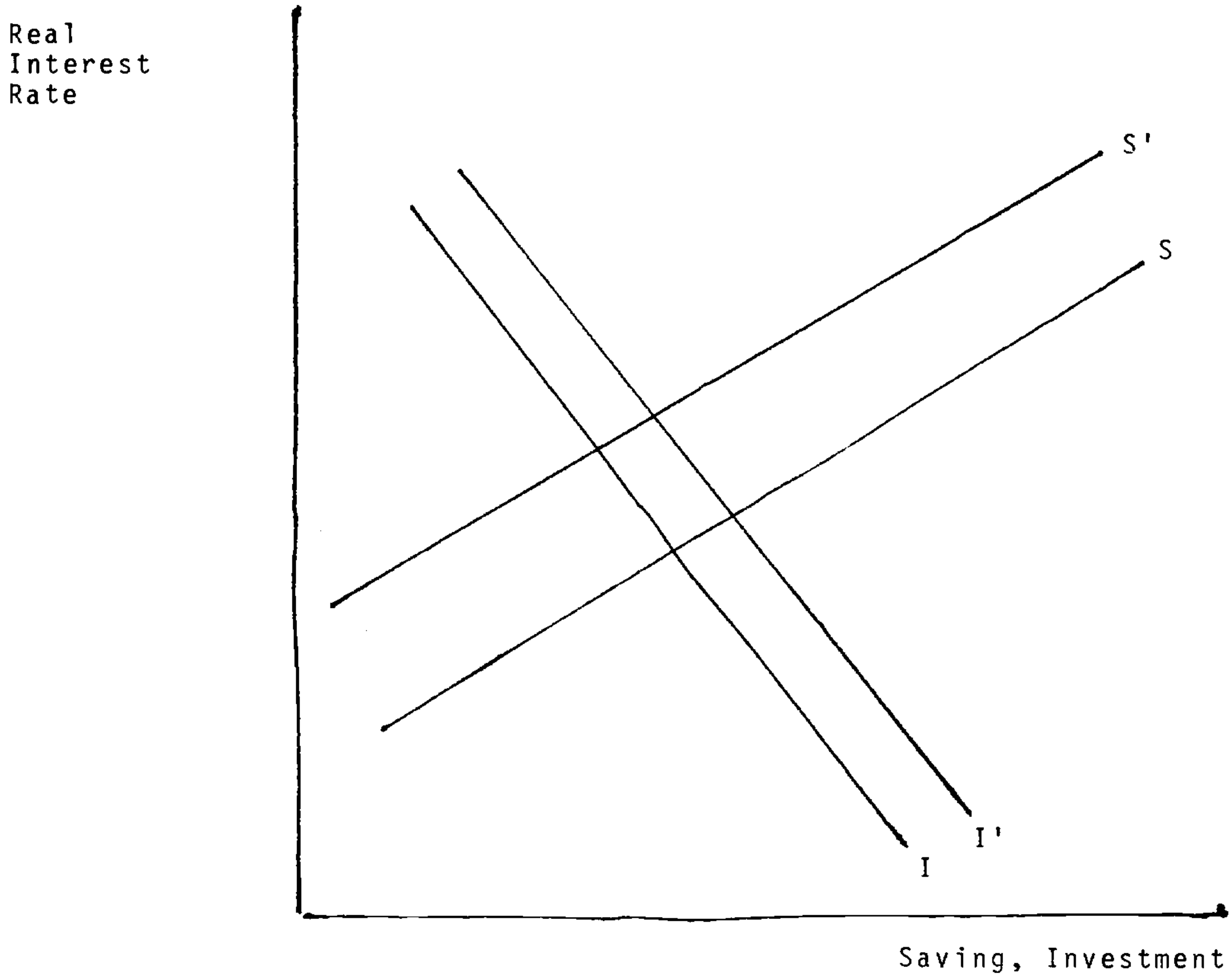
To measure the shifts in supply, it is useful to calculate the changes in the pre-tax rate of interest that would be required to maintain a constant real net-of-tax return to the holders of corporate debt. This "fixed net return" method is analogous to the fixed pre-tax return used to calibrate the MPIR calculations. Column 6 of Table 3 shows the pre-tax interest rate that corresponds to an after-tax real rate of 0.4 percent, the average rate during the period 1960-84.

Note that during the second half of the 1970s, when inflation was high and the maximum personal tax rate was 70 percent, a pre-tax interest rate of 10.5 percent was required to yield the average 0.4 percent after-tax real return. By comparison, the combination of reduced inflation and lower tax rates meant that the same net real return could be achieved in 1984 with a pre-tax interest rate of only 8.4 percent. A comparison with the expected inflation rates of column 2 shows that this represents a fall in the required real pre-tax interest rate as well as in the nominal pre-tax interest rate; the implied real pre-tax required rate of interest fell from 3.5 percent in 1975-79 to 2.9 percent in 1984.

3.3 Changes in the Equilibrium Interest Rate

Figure 1 illustrates the shift in the demand and supply of funds between the 1970s and the first half of the 1980s. The interest rate on the vertical axis is the gross pre-tax interest rate paid by corporate borrowers minus the expected rate of return. The increase in the MPIR implies that the demand schedule for debt capital shifted up. A real MPIR33 (i.e., the MPIR33 of column 4 minus the expected rate of inflation of column 2) schedule drawn with an arbitrary slope is shifted up by the observed 3.1 percentage point rise. The rise in the real interest rate required to maintain a fixed 0.4 percent

Figure 1



net real return is shown as an upward shift by 1.1 percentage points in an SS supply curve. The relative importance of the shifting supply and demand curves obviously depends on the slopes of the two curves. Although they are drawn here in a way that attributes most of the rise to the shift of the investment demand schedule, that is simply a result of the slopes that have been assumed.

To assess the actual effect of the shifts in the demand and supply of funds requires an explicit model in which the MPIR is a function of the volume of investment and the supply of funds is a function of the real net rate of interest. Such a model is developed in the remainder of this section. The next section extends this analysis to include the effects of government debt and deficits and other factors that affect the rate of interest.

The MPIR derived in section 3.1 shows how changes in tax rules and inflation alter the interest rate that firms can pay to finance a hypothetical project with a fixed real rate of return. An increase in the overall volume of investment reduces the pretax return on the marginal project. If we approximate this relation between the actual MPIR at time t(i^*_t)and the MPIR at the initial pretax rate of return (i^*_{0t}) as a linear function of the difference between the actual rate of investment (I_t) and the initial rate of investment at which the fixed rate of return is calculated (I_0) we have:[20]

$$(3.7) \qquad i^*_t = i^*_{0t} - \alpha_1(I_t - I_0)$$

By inverting this relationship, the level of investment can be written as a function of the associated MPIR:

$$(3.8) \qquad I_t = I_0 - \frac{1}{\alpha_1}(i_t^* - i_{0t}^*)$$

The supply of funds schedule can be similarly approximated as a linear relation between the actual supply of funds (S_t), the initial supply of funds (S_0), and the difference between the actual real net return ($(1-\theta)i - \pi^e$) and the initial real net return (R_0):

$$(3.9) \qquad S_t = S_0 + \alpha_2[(1-\theta_t)i_t - \pi_t^e - R_0]$$

By setting $I_t = S_t$ and equating the maximum potential interest rate that firms pay to the pre-tax market return that savers receive (i.e., setting i_t^* in (3.8) equal to i_t in equation (3.9)), we obtain an equation for the market interest rate:

$$(3.10) \qquad i_t = \frac{I_0 - S_0 + \alpha_2 R_0}{\alpha_2(1-\theta_t)+\alpha_3} + \frac{\alpha_2}{\alpha_2(1-\theta_t)+\alpha_3}\pi_t^e + \frac{\alpha_3}{\alpha_2(1-\theta_t)+\alpha_3} i_{0t}^*$$

where, for notational convenience, I substitute α_3 for $1/\alpha_1$.

This expression shows how corporate tax rules, inflation and the personal tax rate all influence the equilibrium market rate of interest. Consider first the effect of a change in depreciation provisions or other corporate tax rules. In the extreme case in which the supply of funds is fixed ($\alpha_2 = 0$), a change in tax rules alters the market interest rate by the same amount as it changes the MPIR on the standard project ($di/di_0^* = 1$). More generally, with the supply of funds an increasing function of the net return ($\alpha_2 > 0$), the market interest rate rises by less than the increase in the MPIR on the standard project.[21]

An increase in the rate of expected inflation affects the market interest rate in two ways. There is the effect that works through the supply of funds, represented by the second term in (3.10). In addition, a rise in inflation changes the MPIR in a way that reflects both the erosion of the real value of depreciation and the deductibility of nominal interest payments in the calculation of tax liabilities. As already noted, the tax rules of the late 1970s made these two effects approximately equal for 100 percent debt-financed projects (implying as an approximation that $di_0^*/d\pi = 1$) while with partial debt finance $di_0^*/d\pi^e > 1$. Combining these two terms implies that

$$(3.11) \qquad \frac{di_t}{d\pi^e} = \frac{\alpha_2 + \alpha_3 (di_0^*/d\pi^e)}{\alpha_2(1-\theta_t) + \alpha_3} > 1$$

A rise in the expected inflation rate thus raises the nominal interest rate by more than one percentage point for each percentage point rise in expected inflation in order to offset in part the fact that the suppliers of funds must pay tax on the increased inflation premium in the interest rate. The precise magnitude of the nominal interest rate rise depends on the debt-equity mix, the elasticities of supply and demand for funds, and the effective tax rates paid by the suppliers of funds. An increase in the demand elasticity relative to the supply elasticity (i.e., a greater value of α_3/α_2) is likely to reduce the sensitivity of the interest rate relative to the expected rate of inflation.

Equation (3.10) could be estimated directly if the only factors affecting the interest rate were inflation and tax rules. To incorporate the effect of budget deficits and monetary policy as well requires a richer specification. The next section develops that specification.

4. A General Specification

A complete specification of the behavior of the interest rate must combine the portfolio and budget deficit effects discussed in Section 2 with the tax and inflation effects of Section 3. The reduced form specification developed in this section uses the MPIR variable to capture the effects of the corporate tax rules (including depreciation rules and corporate tax rates) and the interaction of corporate tax rules and inflation. The non-linear econometric equation, which extends the specification of equation (3.10), also takes into account the role played by the personal tax rate on portfolio income.

Any reduced form specification that incorporates all of these effects must inevitably simplify reality. Nevertheless, the equation presented below does capture the four main determinants of the interest rate (government debt and anticipated deficits; monetary policy; tax rules; and expected inflation). It also uses the theory developed in Section 3 to impose a structure that incorporates the complex tax rules and the tax-inflation interaction in an appropriate way.[22]

The analysis of Sections 2 and 3 imply that the supply of funds to the bond market can be written as a function of the real net-of-tax interest rate, the real stock of government debt (B/p), the expected future real budget deficits $(D/p)^e$, the real monetary base (M/p), the rate of change of the monetary base, and the expected rate of inflation. Each of the asset variables will be expressed as a ratio to real GNP (as a measure of wealth and of the scale of real transactions):

$$(4.1) \qquad S_t = S_0 + \beta_1[(1-\theta_t)i_t - \pi_t^e - R_0] + \beta_2(B_t/p_tY_t) + \beta_3(D/pY)_t^e + \beta_4(M_t/p_tY_t) + \beta_5(\dot{M}/M)_t + \beta_6\pi_t^e$$

Note that $(D/pY)_t^e$ refers to future deficits expected at time t. The separate inflation variable enters because of the effect of expected inflation on the demand for money balances. Additional variables will be considered in the empirical analysis of the next section.

The nominal interest rate that borrowers are willing to pay depends on the tax rules, financing conventions, and inflation expectations as represented by the MPIR(i_t^*), on the volume of investment (through its effect on the marginal product of capital), and on the existing debt and expected future budget deficits:

$$(4.2) \qquad i_t = i_{0t}^* - \gamma_1(I_t - I_0) + \gamma_2(B_t/p_tY_t) + \gamma_3(D/pY)_t^e$$

Solving (4.2) for I_t and equating I_t to S_t of (4.1) yields the reduced form equation for the interest rate:

$$(4.3)\qquad i_t = \frac{I_0+\beta_1 R_0-S_0}{\beta_1(1-\theta_t)+\gamma_1^{-1}} + \frac{\gamma_1^{-1}}{\beta_1(1-\theta_t)+\gamma_1^{-1}}\, i^*_{0t} + \frac{\gamma_2\gamma_1^{-1}-\beta_2}{\beta_1(1-\theta_t)+\gamma_1^{-1}} \cdot \left(\frac{B_t}{p_t Y_t}\right)$$

$$+ \frac{\gamma_3\gamma_1^{-1}-\beta_3}{\beta_1(1-\theta_t)+\gamma_1^{-1}}\left(\frac{D}{pY}\right)^e_t - \frac{\beta_4}{\beta_1(1-\theta_t)+\gamma_1^{-1}}\left(\frac{M_t}{p_t Y_t}\right)$$

$$- \frac{\beta_5}{\beta_1(1-\theta_t)+\gamma_1^{-1}}\left(\frac{\dot{M}}{M}\right)_t + \frac{\beta_1-\beta_6}{\beta_1(1-\theta_t)+\gamma_1^{-1}}\pi^e_t$$

With only 7 variables, it is clearly not possible to estimate all 8 parameters. In particular, β_1 and γ_1 cannot be estimated separately, only their ratio. Dividing the numerator and denominator of each term of (4.3) by β_1 yields the equation:

$$(4.4)\qquad i_t = \frac{c_0}{c_1+(1-\theta_t)} + \frac{c_1}{c_1+(1-\theta_t)}\, i^*_{0t} + \frac{c_2}{c_1+1-\theta_t}\left[\frac{B_t}{p_t Y_t}\right] + \frac{c_3}{C_1+1-\theta_t}\left(\frac{D}{pY}\right)^e_t$$

$$- \frac{c_4}{c_1+1-\theta_t}\left(\frac{M}{PY}\right)_t + \frac{c_5}{1-\theta_t+c_1}\left(\frac{\dot{M}}{M}\right)_t + \frac{c_6}{1-\theta_t+c_1}\pi^e_t$$

This is the basic specification that has been estimated with annual data for the 25 years from 1960 through 1984. Before turning in Section 6 to the estimates of this equation and of the several variants that have also been estimated, it is necessary to discuss the specific operational definitions of the variables used to represent the terms in equation 4.4.

5. Data Definitions and Sources

The interest rate that is analyzed in the current paper is the yield on Treasury bonds with five years to maturity. The five year maturity was selected because that is the maximum period for which the government and private forecasters prepare forecasts of future budget deficits. Many of the equations have also been reestimated with 10-year interest rates and very similar results obtained. A summary of this variable appears in column 1 of Table 3; annual values are presented in Appendix Table A-1.

The construction of the MPIR variable (i^*_{0t}) has been described in Section 2. The basic regression has been estimated with three different assumptions about the marginal debt capital ratio (one-third; two-thirds; and 100 percent) and three different assumptions about the debt-equity risk differential (4 percent; 6 percent; and 8 percent). In addition, the assumption that the pretax profitability of investment of the standard project remains constant at 10.3 percent has been replaced with the assumption that the projected profitability varies annually with the observed profitability of capital. The MPIRVP (for MPIR with varying profitability) is based on annual profitability calculated as the ratio of the total pretax capital income to the replacement value of the capital stock.[23]

Government debt is the stock of publicly held government debt during the calendar year, an average of the beginning and end of year values. This series, which is derived from Office of Management and Budget (1985) is presented in Appendix Table A-1. In the regression equations the nominal debt is divided by full-employment nominal GNP.

The anticipated future budget deficits variable is an average of the projected deficit-to-GNP ratio for the five subsequent years including the concurrent year. Although five-year deficit and GNP forecasts have been made in recent years, comparable forecasts are not available for the earlier years of the sample. The analysis here therefore assumes that, for the years for which it is available, the actual deficit is the best estimate of the deficit that individuals had previously anticipated. For the years 1985 and beyond, the projected deficit is measured by the July 1985 forecasts published by Data Resources, Inc.[24] For recent years, the five years projected deficits are a combination of actual experience and DRI forecasts; e.g., the five years forecast for 1982 combines the actual deficits for 1983 and 1984 with the DRI forecasts for 1985, 1986 and 1987. The historic deficit data on a calendar year basis is obtained from Office of Management and Budget (1985).

Since the 5-year deficit forecast is only a proxy for long-term deficit expectations, it is appropriate to eliminate the cyclical component of the deficit and to focus on the structural component. The structural deficit is calculated here as the deficit that would prevail if the economy were at the inflation-threshhold level of unemployment. I take this "natural rate" level to have increased linearly from 5.5 percent in 1960 to 6.5 percent in 1980 and to have remained at 6.5 percent since that date. The cyclical deficit is calculated from the difference between the actual unemployment rate and the inflation threshold unemployment rate by using the rule of thumb that each percentage point of cyclical unemployment reduces GNP by 2.2 percent and that the cyclical deficit increases by 37 percent of the difference between actual and cyclically-adjusted "full employment" GNP.[25] The calculation combines the observed unemployment rates through 1984 with the DRI forecasts of unemployment through 1989.

For each year in the five year projection period, the structural deficit is divided by the projected measure of full-employment nominal GNP, i.e., the nominal GNP at the inflation threshold level of unemployment. Anticipated GNP is assumed to be the actual GNP through 1984 and the DRI forecasts are used for the years after that. The correction to a full-employment basis is made with the procedure described in the preceding paragraph. Column 4 of Table 4 summarizes the projected structural-deficit-to-GNP ratios; individual annual values are presented in Appendix Table A-1.

Separate estimates have also been made using the actual deficit rather than the structural deficit. The results are quite similar although the explanatory power of the structural deficits is greater. The five-year projected values of the actual-deficit-to-GNP ratio are summarized in column 3 of Table 4.

Finally, for comparison the regressions substitute the current year actual and structural deficit-GNP ratios for the 5-year projected future deficit-GNP ratios. As expected, these series have a much smaller impact on interest rates and much weaker explanatory power than the five year projected deficits. The basic data are presented in columns 1 and 2 of Table 4.

The basic monetary variable is the monetary base divided by nominal GNP. In addition to this ratio, the empirical analysis also includes the rate of change of the monetary base.

The expected inflation variable is the same "rolling" AR1 forecast of the GNP deflator used in constructing the MPIR variable and presented in Table

Table 4

Actual and Projected Budget Deficits
as Percentage of GNP

Years	Actual Deficit (1)	Structural Deficit (2)	Five Year Projection Actual (3)	Five Year Projection Structural (4)
1960-64	0.3	0.2	0.4	1.0
1965-69	0.3	2.0	0.7	2.1
1970-74	1.2	1.8	1.9	1.8
1975-79	2.4	1.8	2.3	1.7
1980-84	3.9	2.4	4.4	3.0
1980	2.3	1.8	3.9	2.3
1981	2.2	1.3	4.4	2.8
1982	4.8	2.2	4.9	3.2
1983	5.4	2.9	4.6	3.4
1984	4.8	4.0	4.2	3.3

Structural deficits are expressed as percentages of full-employment GNP.

Table 3. As a less-restrictive alternative, the linear regressions presented in the next section also use a variety of polynomial distributed lag specifications.

6. The Empirical Estimates

The parameter estimates presented in this section provide strong evidence that expected future budget deficits have a large and statistically significant effect on the interest rate on government bonds. The evidence also confirms a substantial negative effect of liquidity (the level of the monetary base relative to nominal GNP and the rate of change of the monetary base) and a positive effect of the expected rate of inflation. In contrast, changes in the demand for funds that result from shifts in corporate tax rules or from the interaction of the tax system and inflation do not appear to have a significant effect on interest rates.

These basic findings are quite robust to the specification of the interest rate equation, to the measurement of expected inflation, and to the inclusion of a dummy variable designed to absorb any special factors that raised the level of interest rates in the first half of the 1980s.

The analysis also shows the importance of focusing on the expected deficits over several future years rather than a single year's deficit. When the basic variable that measures the average deficit over the next five years is replaced with the ratio of the current deficit to GNP or the current structural deficit to GNP, the coefficient becomes small and insignificant.

Equation (6.1) is a typical example of the parameter estimates obtained with the nonlinear specification of the type derived as equation (4.4) in Section 4. For simplicity, the algebraic

$$(6.1) \qquad i_t = \frac{17.7}{1-\theta_t - \underset{(0.06)}{0.07}} - \frac{\underset{(0.06)}{0.07}}{1-\theta_t - \underset{(0.06)}{0.07}} \text{MPIR336}_t + \frac{\underset{(0.15)}{0.54}}{1-\theta_t - \underset{(0.06)}{0.07}} \text{DEFEX}_t$$

$$+ \frac{\underset{(0.014)}{0.029}}{1-\theta_t - \underset{(0.06)}{0.07}} \text{BONDS}_t - \frac{\underset{(0.26)}{1.87}}{1-\theta_t - \underset{(0.06)}{0.07}} \text{MBASE}_t - \frac{\underset{(0.08)}{0.38}}{1-\theta_t - 0.07} \text{MBGRO}_t$$

$$+ \frac{\underset{(0.09)}{0.24}}{1-\theta_t - \underset{(0.06)}{0.07}} \text{INFEX}_t \qquad 1960\text{-}84 \quad \bar{R}^2 = 0.972, \; \text{DWS} = 1.52$$

variables of equation (4.4) are replaced with the following mnemonics: DEFEX is the average of the five year projected ratio of structural budget deficits to GNP; BONDS is the ratio of the publicly held government debt to nominal GNP; MBASE is the ratio of the monetary base to nominal GNP; MBGRO is the rate of growth of the monetary base; INFEX is the expected inflation variable obtained from the rolling ARIMA procedure; and MPIR336 is the maximum potential interest rate defined in Section 2 and calculated for equation 6.1 on the assumption that debt represents 33 percent of additional funds and that the real yield difference between debt and equity is 6 percent.

The effect of changes in corporate tax rules and in the interaction between inflation and the corporate tax system is reflected in the MPIR variable. The contraint implied by the derivation of equation (4.4) makes the numerator of the coefficient of the MPIR variable the same as the parameter in the denominator of each of the coefficients; this parameter was denoted c_1. The estimated value of c_1 in this specification is -0.07 with a standard error of 0.06; the parameter is therefore not significantly different from zero and has the wrong sign. Evaluating the coefficient of MPIR336 at the mean value of the relevant personal tax rate ($\theta = 0.3$) implies a value of -0.11 with an approximate standard error of 0.11. Thus the overall coefficient is also small (implying that a full percentage point shift in the demand for funds only moves the interest rate by 11 basis points), insignificant and of the wrong sign.

The small size and the incorrect sign of the MPIR variable is a common finding of a variety of alternatives to the specification of equation (6.1). It suggests that the underlying data do not indicate any effect on interest rates of changes in effective corporate tax rates. Although a tax effect may well be present, it is apparently too small or too erratic to be measured by this model. Even the tax changes enacted in 1981-82 only implied a rise in the investment-GNP ratio of less than one percentage point (Feldstein and Jun, 1986), substantially less than the concurrent shift in the national saving rate implied by the rise of the budget deficit or even by the apparently autonomous shift of personal saving. The tax effect might also be too complex for corporations and financial markets to recognize immediately and may therefore only have its impact on interest rates after a lag that is too long to be measured by this model of concurrent annual observations. The market's ability to perceive the effects of tax changes may also vary with the nature of the change. These possibilities deserve further analysis but for now it must be concluded that there is no evidence that the rapid rise in real interest rates in the 1980s was caused by the changes in corporate tax rules and in the interaction of inflation and the corporate tax structure.[26]

The coefficient of the expected deficit variable has a numerator of 0.54

(with a standard error of 0.15) and a denominator with a mean value of 0.63. This coefficient implies that an increase of one percentage point in the ratio of the expected deficit to GNP raises the five-year bond rate by 0.86 percentage points. Between 1977-78 and 1983-84, the expected deficit-GNP ratio rose from 1.6 percent to 3.4 percent, implying a 1.5 percent rise in the interest rate. Since the interest rate on five year bonds rose from 7.6 percent to 11.5 percent during this same interval, equation (6.1) implies that the rise in the projected deficit accounts for about 45 percent of the observed interest rate increase. During the same interval, the implied real interest rate (the difference between the five year bond rate and INFEX) rose 4.5 percentage points, implying that the rise in the projected deficit accounts for 40 percent of the rise in the real interest rate. The alternative specifications presented below generally imply a somewhat larger effect, indicating that the rise in the deficit was responsible for about half of the increase of interest rates in the 1980s.

Before looking at those alternative specifications, I will comment briefly on each of the other coefficients in equation (6.1). The coefficient of BONDS implies that a rise in the ratio of publicly held government debt to GNP has an additional positive effect on the level of interest rates. Each percentage point increase in the ratio of debt to GNP raises the interest rate by an estimated 4.6 basis points. Since the debt-GNP ratio rose from 25.6 percent in 1977-78 to 40.6 percent in 1983-84, this coefficient implies a 6.9 basis point rise in the interest rate. The combined effect of the rise in projected deficits and the rise in the government debt implies an interest rate increase of 2.2 percentage points or about 55 percent of the observed interest rate increase.

The coefficient of the MBASE variable indicates that a higher ratio of the monetary base to nominal GNP reduces the rate of interest, with each percentage point rise in the monetary base-GNP ratio reducing the interest rate by nearly three percentage points. However, the actual changes in MBASE during the 1980s have been rather small. MBASE was 5.8 percent in 1984, 6.0 percent in 1980 and 6.3 percent in 1977-78. Equation (6.1) therefore implies that the reduction in MBASE raised the interest rate by 60 basis points between 1980 and 1983-84 and by a full percentage point between 1977-78 and 1983-84.

The rate of increase of the monetary base (MBGRO) also has a negative coefficient with a value that implies that each one percentage point increase in the rate of growth of the monetary base reduces the concurrent interest rate by 60 basis points. Although the rate of growth of the monetary base declined temporarily in 1981 and 1982, it was essentially the same at the end of the period as it had been in the late 1970s. The fluctuations in the rate of growth of the monetary base can therefore account for some of the sharp rise in interest rates in the early 1980s but not for the higher level of rates in 1983-84 than in 1977-78.

Finally, the ARIMA forecast of expected inflation has a positive coefficient with a mean value of 0.38. This value is too low if it is interpreted as a measure of the effect on the rate of interest of a permanent rise in past inflation. But given the data from which the estimate is obtained it can only be interpreted in a more limited way as the partial effect on expected inflation of the past history of observed inflation rates. Financial

Table 5

Alternative Specifications of Nonlinear Interest Equations

	(1)	MPIR (2)	DEFEX (3)	BONDS (4)	MBASE (5)	MBGRO (6)	INFEX (7)	RU (8)	Const. (9)	$\bar{R}^2$ DWS
T5.1	MPIR336	-0.07	0.54	0.029	-1.87	-0.38	0.24		17.7	0.972
		(0.06)	(0.15)	(0.014)	(0.26)	(0.08)	(0.09)		(2.7)	1.522
		-0.11	0.86	0.046	-2.97	-0.60	0.38		28.1	
T5.2	MPIR336VP	-0.14	0.66	0.034	-1.49	-0.30	0.28		13.9	0.983
		(0.03)	(0.11)	(0.010)	(0.19)	(0.05)	(0.05)		(2.0)	2.054
		-0.25	1.18	0.060	-2.66	-0.54	0.50		24.8	
T5.3	MPIR100	-0.09	0.52	0.033	-1.80	-0.35	0.19		17.9	0.974
		(0.05)	(0.14)	(0.014)	(0.24)	(0.07)	(0.06)		(2.3)	1.624
		-0.15	0.85	0.054	-2.95	-0.57	0.31		29.3	
T5.4	MPIR100VP	-0.10	0.64	0.033	-1.54	-0.31	0.26		15.7	0.982
		(0.02)	(0.12)	(0.011)	(0.21)	(0.06)	(0.05)		(2.0)	2.153
		-0.17	1.07	0.055	-2.57	-0.52	0.43		26.2	
T5.5	MPNRVP	-0.17	0.59	0.031	-1.35	-0.26	0.24		13.6	0.984
		(0.03)	(0.10)	(0.009)	(0.19)	(0.03)	(0.04)		(1.8)	2.012
		-0.32	1.11	0.058	-2.55	-0.49	0.45		25.5	
T5.6	MPNRVP	-0.17	0.59	0.042	-1.34	-0.26	0.26	-0.06	13.3	0.984
		(0.03)	(0.10)	(0.015)	(0.19)	(0.05)	(0.05)	(0.06)	1.8	1.907
		-0.32	1.11	0.079	-2.13	-0.49	0.49	-0.11	25.1	
T5.7	MPIR100VP	-0.14	0.59	0.066	-0.90	--	0.33		8.5	0.951
		(0.03)	(0.18)	(0.014)	(0.24)		(0.07)		(2.1)	1.841
		-0.25	1.05	0.118	-1.61		0.59		15.2	
T5.8	MPIR100VP	-0.13	0.85	--	-0.69	--	0.31		8.5	
		(0.05)	(0.26)		(0.34)		(0.11)		(3.1)	0.823
		-0.23	1.44		-1.21		0.54		14.8	

investors and corporate borrowers also base their inflation forecasts on their observations of monetary and fiscal policies and their expectations of future monetary and fiscal policies. The INFEX variable rose from 6.2 percent in 1977-78 to 8.0 percent in 1981 and fell to 5.5 percent by 1984.

Because of the nonlinear specification and the normalization that has been chosen, no coefficient is estimated for the personal tax rate variable. The specification implies that an increase in the value of the personal tax rate causes an increase in the interest rate. This reflects the fact that an increase in the personal tax rate reduces the net return for any given interest rate and therefore reduces the demand for bonds. More specifically, the form of the equation implies that $di/d\theta = i/(1-\theta+c_1)$. At $i = 0.1$, $\theta = 0.3$ and $c_1 = -0.07$, this implies that $di/d\theta = 0.16$. Thus a rise in θ from 0.3 to 0.4 would raise i from 0.10 to 0.116. With these parameter values, an increase in θ causes a small rise in the net-of-personal tax rate of interest; with c_1 equal to zero, the net rate of interest is unaffected by changes in the personal tax rate.

Table 5 shows the coefficient estimates for a variety of alternative specifications. The primary emphasis is on alternative definitions of the MPIR variable but some of the specifications show the effect of omitting particular variables. Column 1 indicates the definition of the MPIR variable. MPIR336 is the variable used in equation (6.1) and corresponds to 33 percent debt finance at the margin and a 6 percent difference in the real net yields required on debt and equity. MPIR336VP implies that the MPIR is based on a varying profitability rate (as described in Section 3) while the absence of the letters VP implies a fixed rate of return is assumed in calculating the maximum potential interest rate. MPIR100 indicates 100 percent debt finance at the margin; in this case, there is no need to specify the difference between the equity and debt yields. MPNR indicates the maximum potential net return return that the corporation can afford to pay and does not explicitly derive the decomposition of this into a debt and equity return.

Each entry in Table 5 contains three numbers: the coefficient in the numerator of the structural equation corresponding to that variable (e.g., -0.07 corresponds to c_1 and 0.029 corresponds to c_2); the standard error of that coefficient estimate shown in parentheses; and finally the composite coefficient value obtained by dividing the numerator by $c_1 + 1 - \bar{\theta}$ where $\bar{\theta}$ is the mean value of the personal tax average over the entire sample period. The coefficients of equation (T5.1) reproduce the figures already presented in equation (6.1). Equation (T5.2) differs because the maximum potential interest variable has been calculated on the assumption that the annual demand for funds (as represented by the MPIR) varies in response to changes in current pretax real profitability as well as to changes in tax rules and inflation. The explanatory power of the equation is somewhat better and the Durbin-Watson statistic indicates no remaining serial correlation of the residuals. The individual parameter estimates are very similar to those of equation (T5.1). The coefficient of the MPIR variable is again relatively small and of the wrong sign, although now substantially larger than its standard error. The expected deficit variable is again quite large; the composite coefficient of DEFEX is 1.18, implying that each percentage point increase in the expected ratio of deficit to GNP raises the long-term interest rate by 1.18 percentage points. From 1977-78 to 1983-84, the implied increase in the interest rate is 2.1 percentage points. In addition, the rise in the debt-GNP ratio over this period implies a further interest rate increase of a a further 0.7 percentage points. The other coefficients are similar enough to their values in equation (5.1) that no further comment is warranted.

Equations (5.3) and (5.4) use an MPIR variable derived on the assumption that the marginal project is financed solely by debt (MPIR100 with fixed pretax profitability and MPIR100VP when variations in pretax profitability are taken into account).

One of the difficulties of measuring the maximum potential interest rate is that the calculation must specify not only the share of debt finance on the marginal project but also the relation between the yields on debt and equity. Equations (T5.5) and (T5.6) avoid these problems by relating the market interest rate to the maximum potential net return to debt and equity combined that firms can afford to pay rather than the maximum potential interest rate. Equation (T5.6) also introduces the rate of unemployment as an indicator of cyclical changes in the demand for funds; its coefficient is insignificant; a similar result is obtained when the unemployment variable is introduced into other specifications. The estimated effects of the other variables are again quite similar to those in the earlier equations.

Finally, equations (T5.7) and (T5.8) show the effect of dropping the variables representing the growth of the monetary base and the ratio of government debt to GNP. Omitting the growth of the monetary base reduces the coefficient of ratio of the monetary base to GNP but leaves the other coefficients essentially unchanged. Dropping the ratio of debt to GNP variable further reduces the coefficient of the monetary base-GNP variable but raises the coefficient of the deficit variable.

In summary, the coefficients of Table 5 indicate a strong effect of budget deficits and monetary policy but cannot isolate a positive effect of changes in the demand for funds induced by changes in tax rules. The significant negative coefficients of the MPIR variable raises the possibility that all of the specifications of Table 5 have been incorrect. In particular, the nonlinear specification derived in section 4 forces the coefficient of the MPIR variable to be the same as the coefficient that appears in each of the denominators. An alternative linear specification has therefore been explored. The results with that specification, presented below, imply that the MPIR has a positive, small and statistically insignificant effect on the market interest rate. Those linear specifications confirm the conclusion that while a tax effect on interest rates may have occurred, the budget and monetary effects have been much more important.

Before turning to that linear specification, I present in Table 6 some additional variations on the basic nonlinear specification reflecting different definitions of the budget deficit variable. Equation (T6.1) replaces the five-year expected ratio of deficit to GNP by the current value of the deficit to GNP ratio (denoted DEF). The small and insignificant coefficient of the concurrent deficit shows the importance of correctly focusing on expected future deficits. Replacing the current deficit with the current structural deficit (DEFS in equation (T6.2)) does not alter this conclusion.

As I noted above, the five year expected deficit ratio (DEFEX) has been calculated on the assumption that, when the actual observed deficit ratios are

Table 6

Alternative Deficit Variables in Nonlinear Inherent Equations

	MPIR (1)	Deficit (2)	MPIR (3)	Deficit (4)	BONDS (5)	MBASE (6)	MBGRO (7)	INFEX (8)	Const. (9)	$\bar{R}^2$ DWS
T6.1	MPIR336VP	DEF	-0.03	-0.05	0.05	-2.39	-0.34	0.11	22.1	0.957
			(0.06)	(0.09)	(0.02)	(0.31)	(0.10)	(0.08)	(3.03)	0.977
			-0.04	-0.07	0.07	-3.57	-0.51	0.16	33.0	
T6.2	MPIR336VP	DEFS	-0.04	0.02	0.05	-2.33	-0.35	0.10	21.8	0.957
			(0.06)	(0.11)	(0.02)	(0.31)	(0.10)	(0.08)	(3.03)	1.037
			-0.06	0.03	0.08	-3.53	-0.53	0.15	33.0	
T6.3	MPIR336VP	DEFALT	-0.15	0.60	0.04	-1.51	-0.28	0.29	14.0	0.979
			(0.03)	(0.12)	(0.01)	(0.22)	(0.06)	(0.05)	(2.03)	1.758
			-0.27	1.09	0.07	-2.75	-0.51	0.53	25.5	
T6.4	MPIR100VP	DEFALT	-0.11	0.59	0.04	-1.55	-0.29	0.27	15.8	0.979
			(0.03)	(0.13)	(0.01)	(0.23)	(0.06)	(0.06)	(2.2)	1.917
			-0.19	1.00	0.07	-2.63	-0.49	0.46	26.8	

available, they are the best proxy for what people had previously thought. Although this approach appears to work relatively well for the sample as a whole, it is not very plausible as a description of expectations in the years just before the sharp deficit increase of the early 1980s. I have therefore reestimated the basic equations with a modified expected deficit variable (DEFALT) that is equal to DEFEX in every year except 1977 through 1980 when the forecast is assumed to project continuation of the 1980 structural deficit to GNP ratio for all years after 1980. For example, DEFALT for 1978 combines the actual structural deficit ratios for 1978, 1979, 1980 and then susbtitutes the 1980 ratio for 1981 and 1982 as well.

Substituting DEFALT for DEFEX in equations (T6.3) (with MPIR33VP) and (T6.4) (with MPIR100VP) shows that the substitution improves the overall goodness of fit, increases the estimated impact of expected deficits, and leaves the qualitative properties of the other coefficients generally unchanged. Although DEFALT seems a better variable a priori and works better in practice, I will not pursue this variable further here to avoid the appearance that a variable has been constructed to increase the estimated effect of the budget deficit.

I turn finally to Table 7 and the linear approximations of the basic specification of equation (4.4). Each of the variables now enters linearly, including the personal tax rate θ. The first three equations of Table 7 use the five-year projected ratio of structural deficits to GNP while the last two equations use the one year concurrent ratio of the structural deficit to GNP (equation (T7.4)) or the ratio of the actual deficit to GNP (equation (T7.5)). It is also possible in this linear format to replace the constrained

Table 7

Alternative Specifications of Linear Interest Equations

Eq.	Variable Definitions											
	MPIR	Deficit	MPIR	Deficit	BONDS	MBASE	MBGRO	INFPDL	THETA	DUM8084	Const	$\bar{R}^2$ DWS
T7.1	MPIR336VP	DEFEX	0.020 (0.065)	1.36 (0.28)		-1.62 (0.50)	-0.60 (0.08)	0.38 (0.26)	40.1 (9.3)		5.65	0.987 2.123
T7.2	MPIR336VP	DEFEX	0.023 (0.074)	1.37 (0.33)	-0.004 (0.042)	-1.60 (0.56)	-0.61 (0.11)	0.38 (0.27)	40.5 10.4		5.53	0.986 2.150
T7.3	MPIR336VP	DEFEX	-0.007 (0.056)	0.88 (0.29)		-1.80 (0.42)	-0.56 (0.08)	0.32 (0.22)	29.5 (8.7)	1.22 (0.44)	10.73	0.991 2.264
T7.4	MPIR336VP	DEFS	0.104 (0.109)	0.10 (0.17)	0.090 (0.057)	-3.64 (0.53)	-0.40 (0.16)	-0.47 (0.27	45.1 (15.1)		20.43	0.970 1.245
T7.5	MPIR336VP	DEF	0.016 (0.091)	0.03 (0.15)	0.125 (0.059)	-3.54 (0.52)	-0.38 (0.18)	-0.20 (0.20)	38.0 (15.6)		19.97	0.967 1.019

ARIMA inflation forecast variable with a more general polynomial distributed lag on past inflation rates. Since the distributed lag specification (a third order polynomial over a six year lag) typically has greater explanatory power, this is the specification presented; using the ARIMA forecast of inflation instead does not substantially alter the coefficients of the other variables.

The striking thing about these linear equations is that in every case the coefficient of the MPIR variable (defined here as MPIR33VP is much smaller than its standard error and in all but one case it is positive. This supports the conclusion that the estimated negative coefficients of the MPIR variable in the nonlinear equations of Tables 5 and 6 are the result of the nonlinear constraint that forced the estimated parameter in the numerator of the MPIR coefficient to be the same as the parameter in the denominator of all of the coefficients. It also implies even more convincingly than the nonlinear equations that the tax effect has been less important as a determinant of the interest rate than either the budget deficits or the changes in monetary policy and inflation.

In the linear specification, the ratio of national debt to GNP (i.e., the BONDS variable) is generally small and insignificant when the multiyear projected DEFEX variable is included. The coefficient of DEFEX is approximately 1.35 and is unaffected by whether or not the BONDS variable is in the equation. This coefficient is quite similar to the total coefficient of DEFEX in equation (T5.8) when the BONDS variable is excluded.

The coefficients of the monetary variables (MBASE and MBGRO) are quite similar to the values implied by the nonlinear specifications. The choice between the ARIMA inflation forecast and the polynomial distributed lag specification is also inconsequential.

The linear specification also permits an independent estimate of the effect of the personal tax rate. The estimate coefficient implies that an increase in the personal tax rate raises the rate of interest. The specific parameter estimate implies an effect approximately two and a half times as large as the effect implied by the nonlinear specification. However, the calculated variation in θ during the sample period was very small; the standard deviation of 2.3 percentage points implies a variation in the interest rate of 0.9 percentage points. Moreover, between 1975-79 and 1983-84, the value of θ only rose from 0.319 to 0.326, implying a 28 basis pont increase in the interest rate.

Equation (T7.3) provides a very strong test of whether the rise in the interest rate in the 1980s was due to changes in the structural economic variables (and particularly the rise in the expected deficit) or was caused by some unknown factor operating in these years. The equation introduces an additional variable equal to one in the years 1980 to 1984 and zero otherwise. This dummy variable is significant and indicates a 1.22 percentage point rise in the interest rate in these five years for reasons not already specified in the equation. Two things about this equation should be noted. First, the other coefficients, are modified only modestly by including this dummy variable. Even the budget deficit variable remains at 0.88 with a standard error of 0.29. Second, the coefficient of this dummy variable is not subject to the usual tests of statistical inference since the dummy variable was created because the interest rates are known to have been unusually high in these years. The effect of this variable is therefore to "overcorrect" for temporary random effects and causes the true coefficients of other variables that were important in the 1980s to be underestimated.

Equations (T7.4) and (T7.5) confirm that the concurrent deficit variable is inferior to the projected future deficit as a determinant of the level of interest rates. The overall explanatory power of equations (T7.4) and (T7.5) are lower than in the other equations and the Durbin-Watson statistic indicates substantial serial correlation of the residuals.

7. Conclusion

This paper has examined three sources of the fluctuations in real interest rates during the past three decades: changes in budget deficits, changes in tax rules and changes in monetary policy. The evidence indicates that budget deficits and monetary policy have had a strong influence on the level of long term interest rates but fails to identify any effect of changes in corporate tax rates and investment incentives.

The analysis shows that it is projected future budget deficits rather than the current level of the deficit that influences long-term interest rates. Each percentage point increase in the five-year projected ratio of budget deficits to GNP raises the long-term government bond rate by approximately 1.2 percentage points while the ratio of the current deficit to GNP (either actual or structural) has no significant effect. The specific parameter estimates imply that the increase in projected budget deficits in the early 1980s was responsible for about two-thirds of the rise in the interest rate between 1977-78 and 1983-84.

There are at least three interesting directions for future research along the lines developed in this paper. First, it would be useful to extend the present analysis by looking at the effects of fiscal policies on the level of interest rates and exchange rates regarded as jointly dependent variables.

Second, the impact of the federal deficit variable could be decomposed to see whether there are different effects of government spending on goods and services, transfer payments and tax receipts.

And, third, it would be useful to extend the sample to include the years after 1984 when the interest rates began to decline. I believe that interest rates fell in 1985 and 1986 because of a combination of declining inflation expectations, the anticipation of progress on budget deficits, and the easing of monetary policy. If this is correct, the experience of 1985 and 1986 supports the inferences of the present analysis. A brief word about this conjecture is therefore an appropriate conclusion to this paper.

Many financial market participants had expected an acceleration of inflation in early 1985 because of the rapid growth of the monetary aggregates a year earlier. When inflation remained low, inflation expectations were revised and interest rates fell. The expectation of lower inflation was strongly reinforced in early 1986 by the fall in the price of oil.

Although budget deficits of more than five percent of GNP were predicted for the remainder of the decade in February of 1985, by the summer of that year it was clear that the Congress would pass a budget resolution that cut projected deficits substantially. This occurred and the trend to lower deficits was reinforced by the subsequent passage of the Gramm-Rudman-Hollings ammendment. By February 1986, the Congressional Budget Office was predicting a current services deficit of about 3.5 percent of GNP for 1988 and smaller deficits for the end of the decade.

Finally, the Federal Reserve in 1986 reduced the discount rate twice and permitted the growth of M1 to substantially exceed the upper end of the target range.

It would be useful to try to separate these influences and to assess whether the sudden shift in the prospect for tax legislation in the spring of 1986 had any impact on interest rates.

Cambridge, Mass.
June 1986

Appendix

Table A-1

Annual Values of Individual Data Series

	Expected Inflation (INFEX)	Federal Debt, Privately Held ($ billion)	Structural Deficit ($ billion)	5-Year Projected Structural Deficit to GNP Ratio	5-Year Interest Rate	Maximum Potential Interest Rate (MPIR33)	Full Employment GNP ($ billion)
1960	2.2	203.7	-3.2	0.2	4.1	2.4	507.0
1961	2.1	209.4	-1.0	0.5	3.8	2.3	537.7
1962	2.1	214.2	4.4	0.9	3.7	4.1	564.6
1963	2.0	216.0	-0.2	1.5	3.8	4.1	596.6
1964	1.7	219.2	6.1	2.0	4.1	4.7	630.1
1965	1.6	219.3	6.5	2.1	4.2	4.9	672.1
1966	1.8	225.2	14.2	2.3	5.1	5.1	722.6
1967	2.1	231.5	26.2	2.3	5.1	3.6	764.2
1968	2.7	245.6	22.7	2.0	5.7	3.4	828.4
1969	3.3	251.4	10.5	1.8	6.9	5.5	892.9
1970	3.7	257.8	20.6	1.8	7.4	4.8	970.5
1971	4.0	254.3	22.9	1.9	6.0	5.3	1075.3
1972	4.1	270.2	21.6	1.8	6.0	7.5	1172.9
1973	4.5	289.0	19.5	1.8	6.9	8.0	1288.7
1974	7.5	311.6	18.0	1.8	7.8	11.6	1416.6
1975	9.7	388.5	41.2	1.8	7.8	15.0	1625.0
1976	5.8	449.2	33.5	1.7	7.2	10.2	1770.9
1977	6.0	494.2	34.9	1.5	7.0	10.4	1947.8
1978	6.4	548.6	35.3	1.6	8.3	11.0	2148.0
1979	7.0	639.6	27.9	1.8	9.5	12.5	2385.9
1980	7.6	746.8	46.8	2.3	11.5	13.6	2670.8
1981	8.0	862.7	37.4	2.8	14.2	16.3	3030.4
1982	7.0	1070.6	68.4	3.2	13.0	14.7	3284.7
1983	5.6	1297.4	95.7	3.4	10.8	12.7	3528.9
1984	5.5	1534.7	145.8	3.3	12.2	10.4	3744.1

Footnotes

* Professor of Economics, Harvard University and President, National Bureau of Economic Research. I am grateful to Donald T. Regan for persuading me of the importance of this subject and to Andrew Berg for help with all aspects of the calculations presented in this paper. This research is part of the NBER Study of the Government Budget and the Private Economy.

1. The link between high real interest rates and the dollar has also been a controversial subject. Although the theoretical rationale for the relation is clear (see, e.g., Dornbusch, 1976 and 1983), empirical research has been ambiguous. For supporting evidence see Frenkel (1979), Sachs (1985) and the 1983 Economic Report of the President. Evans (1985) and Meese and Rogoff (1985) find no statistical support for the dollar-interest rate relationship. See Feldstein (1986) for an empirical analysis of the issue that avoids the problems inherent in measuring the real interest rate on long-term bonds.

2. This is the position taken in the Economic Report of the President for 1983 and 1984. The link between budget deficits and interest rates is a standard result of Keynesian IS-LM analysis (see, e.g., Dorbusch and Fischer, 1984). Blanchard (1985) correctly stresses the importance of anticipated future deficits, an issue to which I return below. It is also an implication of the full-employment framework of conventional neoclassical growth theory (Diamond, 1965; Feldstein, 1980a). Empirical support of the link between deficits and interest rates is mixed, as the survey by Seater (1985) demonstrates. No relation or a very small effect is reported by Evans (1985), Plosser (1982) and by Tanzi (1985). The theoretical basis for this lack of

relation between interest rates and the deficit is either the induced increase in savings stressed by Barro (1974) or a perfectly elastic supply of capital from abroad; both of these arguments are considered in more detail in Section 1 below.

3. This position is presented in the U.S. Treasury (1983) and in the 1985 Economic Report of the President.

4. Among those who have estimated interest rate equations with a single tax are Tanzi (1980), and Feldstein and Summers (1978).

5. This point is worth stressing only because the 1983 Treasury study of budget deficits and interest rates emphasized that the traditional IS-LM theory does not point unambiguously to a theoretical relationship between interest rates and deficits (U.S. Treasury, 1983). While this is true at a formal theoretical level, it has no empirical relevance.

6. The cyclically adjusted budget deficit is calculated at an unemployment rate of 6.5 percent for the period since 1980 using the approximation that each percentage point of excess unemployment reduces GNP by 2.2 percent and that each dollar decline of GNP raises the actual deficit by 37 cents. The analysis assumes that the natural rate of unemployment rose gradually between 1960 and 1980 and therefore calculates the cyclically adjusted deficit at unemployment rates that rise from 5.5 in 1960 to 6.5 in 1980 at a rate of 0.05 percent per year.

7. Some of these effects are actually ambiguous. Feldstein and Feenberg (1983) noted that the short-run effect of providing universal IRA eligibility might be to depress savings since, for many individuals, that would raise disposable income and lifetime wealth without changing the marginal return on saving until existing liquid assets available for transfer to IRA accounts

were exhausted. Bernheim and Shoven (1985) showed that the rise in real interest rates permitted corporations to reduce their contributions to defined benefit plans, a component of personal saving.

8. In Feldstein (1983), I presented a model of international portfolio adjustment and evidence that international capital flows follow a stock adjustment process with limited long-run substitutability.

9. The real rate of interest is calculated here as the nominal interest yield on 10 years government bonds minus the average of inflation in the current and three past years. Although a more sophisticated measure of expected inflation is used in the econometric analysis in subsequent sections, the four year average is an easy basis for comparing U.S. and German real yields.

10. The real rate of interest on German bonds is the difference between the interest rate on German government bonds cited in the Morgan Guaranty Trust Company World Financial Markets and a 4 year average rate of inflation. More sophisticated analyses show a similar increase in U.S. rates relative to foreign rates; see the 1984 Economic Report of the President, Chapter 2.

11. The role of taxes is ignored in the present section and developed in Section 3.

12. This is the answer to Sargent's (1976) criticism that the Feldstein-Eckstein (1970) analysis treated M/p as exogenous.

13. An exception is Sinai and Rathjens (1983).

14. Feldstein and Eckstein (1970) made the mistake of using only the concurrent ratio of debt to GNP, a specification that makes it impossible to assess the effect of current and future budget deficits.

15. This is a simplification because it assumes that future values of r remain constant.

16. See Abel (1980) and Summers (1981) and the evidence that costs of adjustment cause firms to respond only very slowly to changes in the optimal capital stock.

17. This was the average pre-tax rate of return on capital in the non-financial sector, net of state and local property taxes. Those taxes are subtracted as a cost to the firm for present purposes even though they should not be subtracted in calculating the social return on private investment.

18. These expectations, collected by Richard Hoey and distributed by Drexel Burnham Lambert, are only available for the period since 1978. The annual values used in Table 3 are simple averages of the monthly values presented by Hoey.

19. Feldstein and Summers (1978) studied the effect on the interest rate of changes in the MPIR but did not allow for the effects of changes in inflation and tax rules on the supply of funds. The Feldstein-Summers study also did not deal with the effect of budget deficits.

20. This holds precisely only if the investment is 100 percent debt financed or the investor tax rates on dividends and capital gains are equal. When these conditions are not satisfied, α_1 is a function of the personal and corporate tax rates and the corporate financial behavior.

21. Note that if projects are financed in part by equity the MPIR depends also on the personal income and capital gains tax rates.

22. There is, of course, always the risk that imposing a particualr nonlinear structure causes spurious results. The next section therefore also

presents estimates of a linear equation in which the data are more free to "speak for themselves."

23. This series is based on calculations presented in Feldstein and Jun (1986); it represents profitability before federal tax but after state and local taxes.

24. At an earlier stage of this research, the projected deficits of the Congressional Budget Office were used but these are not available publicly on a calendar year basis. The results were very similar to those presented below.

25. For a more extensive discussion of these relationships, see Office of Management and Budget (1984).

26. In an earlier paper, Lawrence Summers and I (1978) estimated a very much simplified form of equation (6.1) that only included the MPIR and INFEX variables. In that specification we found a small but positive effect of MPIR on the rate of interest. We explained the small size of the effect by the fact that corporate borrowing represents only a small part of the total funds raised by all borrowers in the U.S. financial market.

Bibliography

Abel, Andrew, "Empirical Investment Equations: An Interpretive Framework," Journal of Monetary Economics, Carnegie-Rochester Series on Public Policy, 1980.

__________, "Precautionary Saving and Accidental Bequests," American Economic Review, September 1985, 75, 777-91.

Barro, Robert, "Are Government Bonds Net Wealth?" Journal of Political Economy, November 1974.

Bernheim, Douglas and Shoven, John, "Pension Funding and Saving," National Bureau of Economic Research Working Paper No. 1622, 1985.

__________, Shleifer, Andrei, and Summers, Lawrence, "Bequests as a Means of Payment," Journal of Political Economy, December 1985.

Blanchard, O., "Debts, Deficits and Finite Horizons," Journal of Political Economy, April 1985, 92, 223-47.

Boskin, Michael and Kotlikoff, Laurence, "Public Debt and U.S Saving: A New Test on the Neutrality Hypothesis," National Bureau of Economic Research Working Paper No. 1646, 1985.

Diamond, Peter, "National Debt and Neoclassical Economic Growth," American Economic Review, 1965, 55, 1125-50.

Dornbusch, Rudiger, and Fischer, Stanley, Macroeconomics, New York: McGraw-Hill, 1984.

Eckstein, O. and Feldstein, Martin, "The Fundamental Determinants of the Interest Rate," Review of Economics and Statistics, November 1970, 52, 4.

Evans, P., (1985a), "Do Large Deficits Produce High Interest Rates?" American Economic Review, March 1985.

__________, (1985b), "Is the Dollar High Because of Large Budget Deficits?" mimeo, September 1985.

Feldstein, Martin, "Inflation Income Taxes and the Rate of Interest: A Theoretical Analysis," American Economic Review, 1976.

__________, (1980a), "Fiscal Policies, Inflation and Capital Formation," American Economic Review, September 1980, 70, 636-50.

__________, (1980b), "Tax Rules and the Mismanagement of Monetary Policy," American Economic Review, May 1980, 70, 182-86.

__________, "Government Deficits and Aggregate Demand," Journal of Monetary Economics, January 1982, 9, 1-20.

__________, (1983a), "Domestic Saving and International Capital Movements in the Long Run and the Short Run," European Economic Review, 21, 129-51.

__________, (1983b), Inflation Tax Rules and Capital Formation, Chicago: University of Chicago Press.

__________, "The Budget Deficit and the Dollar," in NBER Macroeconoics Annual, 1986, September 1986.

__________, and Feenberg, Daniel, "Alternative Tax Rules and Personal Savings Incentives: Microeconomic Data and Behavioral Simulations," in M. Feldstein, ed., Behavioral Simulations Methods in Tax Policy Analysis, Chicago: University of Chicago Press, 1983.

__________, Green, Jerry, and Sheshinski, Eytan, "Inflation and Taxes in a Growing Economy with Debt and Equity Finance," Journal of Political Economy, 1978.

__________, and Jun, Joosung, "The Effects of Tax Rules on Nonresidential Fixes Investment: Some Preliminary Evidence from the 1980's," National Bureau of Economic Research Working Paper No. 1857, 1986, in M. Feldstein, ed., The Effects of Taxation on Capital Formation, forthcoming.

__________, and Summers, Lawrence, "Inflation, Tax Rules and the Long-Term Interest Rate," Brookings Papers on Economic Activity, 1978, 1, 61-109.

Frankel, Jeffrey, "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials," American Economic Review, September 1979.

Hayashi, F., "Tobin's Marginal q and Average q: A Neoclassical Interpretation," Econometrica, 1982.

Kormendi, Roger, "Government Debt, Government Spending and Private," 1983.

Meese, R. and Rogoff, K., "Was is Real? The Exchange Rate-Interest Differential Relation, 1973-1984," National Bureau of Economic Research Working Paper No. 1732, 1985.

O'Driscoll, Gerald, "The Ricardian Nonequioalence Theoreum," Journal of Political Economy, 1977, 85, 207-10.

Office of Management and Budget, Executive Office of the President, Historical Tables: Budget of the U.S. Government FY 1986, Washington, DC: U.S. Government Printing Offices, 1985.

Patinkin, Don, Money, Interest and Prices, 2nd ed., New York: Harper and Row, 1965.

Plosser, C., "Government Financing Decisions and Asset Returns," Journal of Monetary Economics, May 1982.

Ricardo, David, The Works and Correspondence of David Ricardo, P. Sraffa, ed., Cambridge: Cambridge University Press, 1951.

Sachs, Jeffrey, "The Dollar and the Policy Mix: 1985," National Bureau of Economic Research Working Paper No. 1636, 1985, in the Brookings Papers on Economic Activity, forthcoming.

Sargent, Thomas, "Interest Rates and Expected Inflation: A Selective Summary of Recent Research," Explorations in Economic Research, Cambridge, Mass.: National Bureau of Economic Research, Summer 1976, 3, 303-25.

Seater, J. J., "Does Government Debt Matter?" Journal of Monetary Economics, 1985, 16, 121-31.

Sinai, A. and Rathjens, P., "Deficits, Interest Rates, and the Economy," Data Resources U.S. Review, June 1983, 1.27-.41.

Summers, Lawrence, "Taxation and Corporate Investment: A q-Theory Approach," Brookings Papers on Economic Activity, 1981, 67-127.

Tanzi, Vito, "Fiscal Deficits and Interest Rates in the United States: An Empirical Analysis," IMF Staff Papers, December 1985, 32, 551-76.

The Economic Report of the President, for 1983 and 1984.

Tobin, James, "A General Equilibrium Approach to Monetary Theory," Journal of Money, Credit and Banking, 1969.

United States Treasury Department, The Effects of Deficits an Prices of Financial Assets: Theory and Evidence, Washington, DC: U.S Government Printing Offices, March 1984.