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9 Inflation, Tax Rules, and the Long-term Interest Rate

with Lawrence Summers

Although the return to capital is a focus of research in both macroeconomics and public finance, each specialty has approached this subject with an almost total disregard for the other's contribution. Macroeconomic studies of the effect of inflation on the rate of interest have implicitly ignored the existence of taxes and the problems of tax depreciation.[1] Similarly, empirical studies of the incidence of corporate tax changes have not recognized that the effect of the tax depends on the rate of inflation and have ignored the information on the rate of return that investors receive in financial markets.[2] Our primary purpose in this paper is to begin to build a bridge between these two approaches to a common empirical problem.

The explicit recognition of corporate taxation substantially changes the relation between the rates of inflation and of interest that is implied by equilibrium theory. The Fisherian conclusion that the nominal rate of interest rises by the expected rate of inflation, leaving the real rate of interest unchanged, is no longer valid when borrowers treat interest payments as a deductible expense and pay tax on profits net of accounting depreciation.[3] A more general theory is discussed in the first section and is used there to analyze the expected impact of changes in inflation with the tax and depreciation rules in effect during the past twenty-five years. The

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1. For a review of recent empirical studies, see Sargent (1976). This criticism applies also to Feldstein and Eckstein (1970), and Feldstein and Chamberlain (1973).
2. The prominent econometric studies include Krzyzaniak and Musgrave (1963), Gordon (1967), and Oakland (1972). Other major empirical studies include Harberger (1962) and Shoven and Whalley (1972). None of this research refers to either inflation or financial-market return.
3. One statement of Fisher's theory can be found in Fisher (1930).

analysis shows that changes in the rate of inflation are likely to be significantly nonneutral even in the very long run.

Since the long-term interest rate measures the yield available to individual investors, analysis of it provides an operational way of studying the incidence of changes in corporate tax rules. Oddly enough, this natural way of measuring tax incidence has not been exploited before. The first section shows how to translate the postwar changes in tax rates and depreciation rules into the changes in the interest rate that would prevail if no shifting occurred; it thus lays the foundation for econometric estimates of the actual degree of shifting set out in later sections. This approach requires separating the effects of inflation from the effects of tax changes. Since most of the postwar changes in corporate taxation have been in depreciation rules and investment credits, the effect of these changes on the long-term interest rate is of obvious importance in determining their potential stimulus to investment.

In a previous theoretical paper, Feldstein analyzed how an increase in the rate of inflation would alter the interest rate in an economy in steady-state growth. Although that model brought out the important nonneutrality of inflation and the need to revise Fisher's theories to reflect taxation, its relevance is severely limited by the assumptions that all investment is financed by debt and that capital goods do not depreciate. Both of these restrictive assumptions were relaxed in a subsequent paper in which firms were assumed to finance investment by a mixture of debt and equity and in which capital depreciates.[4] Introducing depreciation permits an analysis of the effect of allowing only historic cost depreciation for tax purposes. This more general model shows that the way inflation affects the real interest rate depends on two countervailing forces. The tax deductibility of interest payments tends to raise the real interest rate while historic cost depreciation lowers it. The net effect can be determined only by a more explicit specification of depreciation and tax rules than was appropriate in that theoretical study. Such an explicit analysis is presented in the first section below. Equally important, the empirical analysis of the subsequent sections does not assume that saving is inelastic or that all forms of investment are subject to the same tax rules.

The three main sections of our paper might also be regarded as three separate studies tied together by the common theme of inflation, taxes, and the interest rate. In the first section, we extend previous theoretical studies of the interaction of taxes and inflation by making explicit calculations based on the actual tax rules of the past two decades. These calculations show how changes in tax rules and in inflation rates have altered the maximum nominal interest rate that firms could pay on a

4. See Feldstein (1976; chap. 3 above) and Feldstein, Green, and Sheshinski (1978; chap. 4 above).

standard investment. An important implication of this analysis is that Fisher's famous conclusion is not valid in an economy with taxes on capital income.

The second section is an econometric analysis of the observed relation between inflation and the long-term interest rate. A novel feature of this analysis is the use of an explicit predicted inflation variable which is derived from an optimal forecasting equation based on an ARIMA (autoregressive integrated moving average) process, as described there.

The third section studies the effects of changes in tax rules and in pretax profitability. This section is the most ambitious in its attempt to link the econometric estimates to the analytic method developed in the first section. We regard its results as preliminary because all of our estimates are conditional on specific assumptions about the mix of debt and equity used to finance marginal investments and about the relative yields on debt and equity that the market imposes. We believe that it is important to explore a wider range of assumptions and that our method provides the correct framework for such an extended analysis.

A brief concluding section summarizes the major findings.

9.1 The Analytic Framework

The central analytic feature of this paper is the operational method of converting any change in tax rules and in expected inflation into the implied change in the long-term interest rate that is consistent with a fixed marginal product of capital. This method is presented in the current section and is then used (1) to analyze the effects of specific changes in tax rules, (2) to derive the relevant generalization of the Fisherian relation between inflation and the interest rate, and (3) to calculate the implied equilibrium interest rate for each year form 1954 through 1976. These estimates underpin the empirical analysis in the rest of the paper.

9.1.1 A Simple Illustrative Model

It is useful to begin by analyzing a simple illustrative case in which all marginal investment is financed by debt.[5] Moreover, the aggregate supply of loanable funds is taken as fixed.[6] We assume also that all investment is subject to the same tax and depreciation rules.[7] While these assumptions do not even approximate reality, they do permit a simple exposition of our method. Working through this simple case makes it easier to examine

5. That the *marginal* investments of all firms are financed by debt does not preclude their using retained earnings to finance investment; this view is developed by Stiglitz (1973, and 1976). For a contrary argument, see Feldstein, Green, and Sheshinski (1979).

6. This implies that the volume of saving is fixed and that the demand for money is interest inelastic.

7. This assumption ignores, for example, the difference between the tax treatment of investment in plant and equipment and of investment in residential real estate.

the more general framework with mixed debt-equity finance, an elastic supply of loanable funds, and differential tax rules.

We start by examining an economy with no inflation and see how tax changes alter the rate of interest. We then see how the interest rate responds to inflation under alternative tax and depreciation rules.

The diagram below illustrates the traditional determination of equilibrium interest rate (i_0), which equates the inelastic supply of loanable funds (S) to the downward-sloping investment-demand schedule (I). In the absence of taxes, each point on the investment schedule indicates the internal rate of return on the marginal project at the corresponding aggregate level of investment.[8]

The introduction of a corporate income tax with proper economic depreciation and the deductibility of interest payments does not shift this investment schedule; any investment that could pay a maximum interest rate of i before the introduction of the tax can pay exactly the same rate subsequently.[9] In contrast, an investment tax credit or acceleration of depreciation would raise the maximum potential interest rate on every project and would therefore shift the investment-demand schedule to the right to line I'. Given a completely inelastic supply of investable funds such a tax change simply raises the interest rate without any increase in investment.

Tax Changes. Analyzing quantitatively the effect of tax changes (and later of inflation) calls for an operational method of translating tax changes into changes in the interest rate—that is, a method of calculating i_1 in the diagram; the method must be compatible with a fixed marginal product of capital. To do this, we select a hypothetical "standard investment" and calculate the internal rate of return under different tax regimes. Consider a standard investment in equipment in which the real net output declines exponentially at δ percent a year[10] until the project is scrapped at the end of T years; the initial value of net output (a_0) is chosen so that, in the absence of any tax, the project has an internal rate of return of 12 percent.[11] Such a project has net output $a_0(1+\delta)^{-t}$ in the tth year of its life, where a_0 is selected to satisfy

8. This is essentially Keynes's formulation of the schedule for the marginal efficiency of investment. We implicitly assume that mutually exclusive options are described by Irving Fisher's incremental method and that multiple internal rates of return can be ignored. For a cautionary note about this procedure, see Feldstein and Flemming (1964).

9. The pretax situation may be described by $f'(I) - i = 0$, where $f'(I)$ is the marginal product of investment; a tax at rate τ with the deductibility of interest does not change the implied value of i in $(1-\tau)f'(I) - (1-\tau)i = 0$.

10. Note that this is "output decay" and not "depreciation"; see Feldstein and Rothschild (1974) for an analysis of these concepts.

11. This is based on our earlier estimates of the pretax return on private investment in nonfinancial corporations; see Feldstein and Summers (1977). We raised the average return of 10.6 percent for 1948–76 reported there to 12 percent because we regard that sample period as overrepresenting cyclically low years, but the choice of any constant pretax rate of return does not alter our analysis.

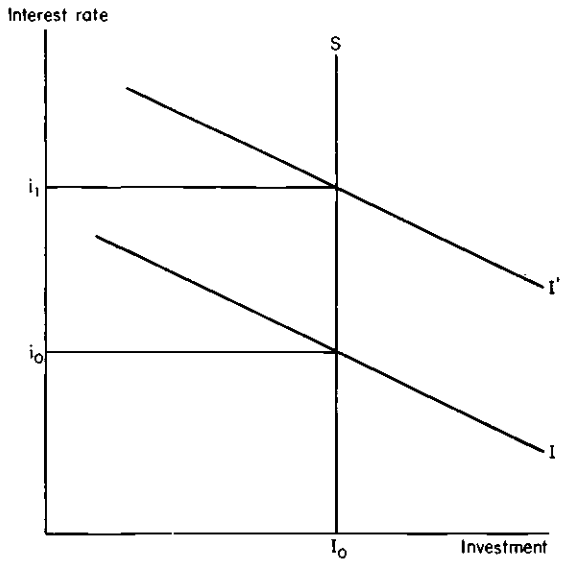

Figure 9.1

$$a_0 \sum_{t=1}^{T} \frac{(1+\delta)^{-t}}{(1.12)^t} = 1 \qquad (1)$$

In practice, it is important to distinguish between investments in equipment and in structures because the depreciation rules and tax credits affect the two very differently; for example, the investment tax credit does not apply to structures. Our "standard investment" is therefore specified to be a mix of equipment and structures in the ratio of 1.95 to 1.[12] The specification of equation (1) is used to describe an investment in equipment with a ten-year life and an exponential decay rate of 13 percent. The net output of the investment in structures is assumed to decay at 3 percent a year and the structure is scrapped after thirty years; the output of a dollar's investment in new structures is also chosen to make the pretax rate of return equal to 12 percent. The standard investment is a thirty-year "sandwich" project, of which 66.2 percent of the investment in the first year is in a standard structure and the remainder is in equipment; the equipment is then replaced at the end of ten and twenty years.

The maximum potential interest rate corresponding to any given tax regime (that is, the value of i_1, in the diagram) is defined as the interest rate that can be paid on the outstanding balance of the loan used to

12. This figure, when used in conjunction with the procedure described below, yields an investment mix corresponding to the average composition over the past twenty years.

finance the project, where the balance is reduced to zero at the end of the life of the project. If L_t, is the loan balance at time t and x_t, is the net cash flow of the project during t (except for interest expenses), the internal rate of return is the interest rate i that satisfies

$$(2) \qquad L_t - L_{t-1} = iL_{t-1} - x_t,\ t = 1, \ldots, T$$

where $L_0 = 1$ and $L_T = 0$. In the special case of the pure equipment project and no tax, equation (2) reduces to

$$(3) \qquad L_t - L_{t-1} = iL_{t-1} - a_0(1 + \delta)^{-t}$$

The solution of this equation with $L_0 = 1$ and $L_T = 0$ is exactly equivalent to the familiar definition of the internal rate of return given by equation (1).

When a tax rate τ is levied on the net output minus the sum of the interest payment and the allowable depreciation (d_t), the loan balance changes according to

$$(4) \qquad L_t - L_{t-1} = iL_{t-1} - x_t + \tau(x_t - d_t - iL_{t-1})$$

The value of i corresponding to any tax regime is therefore available by solving for the value of i that is consistent with equation (4) for our x_t "sandwich" with $L_T = 0$ and L_0 equal to one minus the investment tax credit.

Inflation. The preceding method of analysis can also be used to analyze the effect of inflation on the investment-demand schedule and therefore on the equilibrium rate of interest if the supply of loanable funds is inelastic. More generally, the method can be extended to decompose the increase in the interest rate induced by a rise in inflation into one part due to the shift in the demand for funds and one due to a shift in the supply; we return to this decomposition below.

It is again easiest to begin by examining the case in which marginal projects are financed by debt only. Consider first the situation in the absence of taxes. In terms of equation (2) the effect of introducing a constant expected inflation at rate π is to raise the future net profit in each year by a factor $(1 + \pi)^t$ and thus to convert the fundamental equation to

$$(5) \qquad L_t - L_{t-1} = iL_{t-1} - (1 + \pi)^t x_t,\ t = 1, \ldots, T$$

For any sequence of real net profits, the internal rate of return i that satisfies the initial and terminal equations ($L_0 = 1$, $L_T = 0$) is increased by exactly the rate of inflation.[13] With a fixed supply of loanable funds, this increase in the maximum potential interest rate on all projects would raise the equilibrium interest rate by the rate of inflation.

13. There is actually a second-order term; the internal rate of return rises from i without inflation to $(1 + i)(1 + \pi) - 1 = i + \pi + i\pi$ with inflation.

This Fisherian conclusion is no longer valid when taxes are considered.[14] Equation (4) now becomes

$$(6) \qquad L_t - L_{t-1} = iL_{t-1} - (1+\pi)^t x_t + \tau[(1+\pi)^t x_t - d(\pi)_t - iL_{t-1}]$$

where $d(\pi)_t$ is the depreciation allowed for tax purposes when there is inflation at rate π. Depending on the depreciation rule, the nominal maximum potential interest rate may rise by more or less than the rate of inflation. To see this, it is useful to consider the special case in which there is no depreciation. Equation (6) can then be written[15]

$$(7) \qquad L_t - L_{t-1} = (1-\tau)iL_{t-1} - (1-\tau)(1+\pi)^t x_t$$

This is exactly the same as (5) with the real project output replaced by an after-tax value, $(1-\tau)x_t$, and the interest rate by its after-tax value, $(1-\tau)i$. The effect of inflation is therefore to raise the *after-tax* potential rate of interest by exactly the rate of inflation: $d[(1-\tau)i]/d\pi = 1$, or $di/d\pi = 1/(1-\tau)$. With the U.S. marginal corporate tax rate of $\tau = 0.48$, this implies that the maximum potential interest rate rises by almost 2 percentage points for each 1 percent of inflation. If the supply of loanable funds were perfectly inelastic, the equilibrium interest rate would also rise by nearly 2 points.

The same relationship prevails if the asset depreciates and if the historic cost basis of the depreciation is increased in proportion to the price level.[16] Although this degree of sensitivity of the interest rate may seem surprising at first, it is easily understood: each percentage point of inflation permits an increase of 2 points in the interest rate because the after-tax cost of this increase is only 1 point.[17] Moreover, this "excess adjustment" of the pretax interest rate is just sufficient to keep unchanged the after-tax return to a lender with the same marginal tax rate.[18]

The practice of allowing only historic cost depreciation reduces the real value of depreciation allowances whenever the inflation rate increases. It is equivalent to levying a tax on the accruing increases in the nominal value of the asset. This extra tax implies that the real net-of-tax yield to lenders must be reduced by inflation and therefore that an increase in

14. These remarks are developed extensively in Feldstein (1976; chap. 3 above) and Feldstein, Green, and Sheshinski (1978; chap. 4 above).

15. Note that the asset appreciates in nominal value but there is no tax due on this appreciation as such.

16. See Feldstein, Green, and Sheshinski (1978).

17. Note that with price-indexed depreciation there is no capital gains tax on the accruing increase in the nominal value of the assets or, equivalently, on the decreasing real value of the liabilities.

18. If borrowers were taxed on the *real* capital gains that resulted from the decreasing real value of their liabilities, the interest rate would rise only by the rate of inflation. To leave lenders with the same after-tax real return, the real capital losses that result from the decreasing real value of their liabilities would have to be a deductible expense.

inflation raises the nominal pretax yield by less than $1/(1 - \tau)$. Explicit calculations of this effect will now be presented.[19]

Internal Rates of Return with Pure Debt Finance. Table 9.1 presents the calculated maximum potential interest rate with pure debt finance for our standard investment under seven tax regimes. The rates are calculated first on the assumption of no inflation and then on the assumption of a constant 6 percent rate of inflation.

Consider first the results corresponding to no inflation—column 1 of table 9.1. By construction, the maximum potential interest rate (MPIR) in the absence of both taxes and inflation is 12 percent for our standard investment. Imposing the tax regime that existed until 1954 (a 52 percent corporate tax rate and straight-line depreciation) leaves the MPIR essentially unchanged at 12.4 percent.[20] Successive tax regimes liberalized depreciation and raised the MPIR. The accelerated-depreciation options introduced in 1954 were adopted only gradually, but by 1960, the mix of depreciation patterns implied an MPIR of 13.3 percent. The introduction of the investment tax credit raised it further, to 14 percent in 1963. Currently, because of a 10 percent investment tax credit and the asset-depreciation-range (ADR) method of depreciation, the MPIR has reached 14.9 percent.[21] The tax changes since 1954 have thus raised the MPIR by one-fifth of its original value.[22]

Comparing the two columns of table 9.1 reveals the ways in which taxation changes the way inflation affects the rate of interest. With no tax, a 6 percent rate of inflation raises the MPIR by 6 percentage points—from 12.0 to 18.0. In contrast, with a 52 percent tax and straight-line depreciation (regime B), the 6 percent inflation raises the MPIR by 9.2 points (from 12.4 percent to 21.6 percent). Thus $di/d\pi = 1.53$ in this regime. Note that a lender (bondholder) thus experiences an increase in the real rate of return from 12.4 to 15.6 percent. However, since the personal tax is levied on the full nominal return, the lender will receive a reduced real return after tax unless his marginal tax rate is less than 35 percent. At a personal tax rate of 50 percent, for example, the real after-tax yield on bonds falls from 6.2 percent with no inflation to 4.8 percent with 6 percent inflation.

The same pattern can be followed with all of the other tax regimes of the postwar period. The figures in column 2 show that under every

19. The theory of this relation is discussed in Feldstein, Green, and Sheshinski (1978, chap. 4); see in particular the appendix to that paper by Alan Auerbach, pp. 59–60 above.

20. The MPIR is increased in the shift from regime *A* (no tax) to regime *B* because straight-line depreciation is slightly more generous than true economic depreciation.

21. The effective rate of tax credit of 9 percent shown in the table differs from the statutory rate of 10 percent because of limitations on loss offset and carryover. Also, certain firms and types of investment are not eligible for the credit. In all our work, we use the effective rate.

22. Note that because interest is deductible, a lower tax rate actually lowers the MPIR, as illustrated by the tax cut in 1964 (switching from regime E to F).

Table 9.1 Maximum Potential Interest Rate with 100 Percent Marginal Debt Finance, Alternative Tax Regimes, and Inflation Rates

Percent

Tax Regime (corporate tax rate, depreciation method, and other provisions)	Inflation Rate 0	Inflation Rate 6 percent
(A) No tax	12.0	18.0
(B) 52 percent; straight-line depreciation	12.4	21.6
(C) 52 percent; accelerated depreciation as of 1960	13.3	22.6
(D) 52 percent; investment tax credit of 5.6 percent; depreciation as of 1963:4 with Long amendment	14.0	23.7
(E) Same as D, except Long amendment repealed	14.2	23.8
(F) Same as E, except 48 percent	14.0	23.0
(G) Current law: 48 percent; investment tax credit of 9 percent;[a] asset depreciation range	14.9	24.3

SOURCE: Derived by method described in text.

a. See text note 21.

regime, a 6 percent inflation rate would raise the nominal rate of return by between 9.0 and 9.7 percentage points.

Although the assumption that marginal investments are financed completely by debt is a useful analytic simplification, the implied interest rates shown in columns 1 and 2 are clearly inconsistent with market experience. The real long-term interest rates are not (and never have been during the postwar period) even remotely close to the high values presented in table 9.1. We turn therefore to the more relevant case of investments financed by a mix of debt and equity.

9.1.2 The Interest Rate with Mixed Debt-Equity Finance

Our view of the role of debt and equity finance starts with the observation that issuing more debt increases the riskiness of both the bonds and the stocks of the firms.[23] Issuing additional debt thus raises the interest rate that the firm must pay and lowers the price of its shares. The firm therefore does not finance all incremental investment by debt but selects a debt-equity ratio that, given tax rules and investor preferences, minimizes the cost of its capital. If the firm is in equilibrium, the mix of debt and equity used to finance an incremental investment is the same as its average debt-equity investment.[24] The interest rate than a firm can pay on

23. This view is developed explicitly in Feldstein, Green, and Sheshinski (1979). The traditional Modigliani-Miller conclusion that the cost of capital is independent of the debt-equity ratio holds generally only in a world without taxation and bankruptcy.

24. If the firm issues no new equity, it establishes its desired debt-equity ratio by its dividend policy and its debt-issue policy.

a "standard investment" depends on this debt-equity ratio and on the relation between the equity yield and the debt yield that is consistent with the preferences of portfolio investors.

In our analysis, we assume that the ratio of debt to total capital is one to three, roughly the average ratio of nonfinancial corporate debt to the replacement value of that sector's capital during the past decade. Although it would clearly be desirable to extend our analysis to make the debt-equity ratio endogenous, this generalization must be postponed until later research.

Our basic assumption about the preference of portfolio investors is that, because equity investments are riskier than debt investments, portfolio equilibrium requires a higher yield on equity than on debt. We consider two variants of the yield differential. First, we assume that the real equity yield (denoted by e) must exceed the real interest rate $(i - \pi)$ by a constant risk premium, D.[25]

$$e = i - \pi + D \tag{8}$$

We shall examine several different values of D. Our alternative specification relates the risk premium to the differences in real *after-tax* rates of return to an investor. Computational results analogous to table 9.1 are presented for both specifications and both are examined in the econometric analysis below.

If the portfolio investor has a marginal personal tax rate θ, the real after-tax return on a bond may be written $i_n = (1 - \theta)i - \pi$. Specifying the real after-tax yield on equity (e_n) is more complex. Let p be the fraction of the real equity yield that is paid out and $(1 - p)$ the fraction that is retained. The part that is paid out is taxed at rate θ while the retained earnings are subject only to an eventual tax at the capital gains rate. We use θ_g to denote the "equivalent concurrent capital gains tax rate"—that is, the present value of the future tax equivalent to taxing the retained earnings immediately at rate θ_g. In addition to these taxes on real equity earnings, the stock investor must also pay a tax on the *nominal* capital gains that occur solely because of inflation. With inflation at rate π, the resulting nominal capital gain at rate π is subject to capital gains tax at effective rate θ_g. The real net return may therefore be written:

$$e_n = [p(1 - \theta) + (1 - p)(1 - \theta_g)]e - \theta_g \pi$$

Our after-tax alternative to equation (8) is therefore

$$e_n = i_n + D \tag{9}$$

or

25. Since we assume a constant debt-equity ratio, changes in the risk premium are not induced by changes in that ratio. Note also that e includes the real gains that accrue to equity investors at the expense of bondholders.

(10) $$[p(1-\theta)+(1-p)(1-\theta_g)]e-\theta_g\pi = (1-\theta)i-\pi+D$$

For our numerical calculations, we assume the reasonable values $p = 0.5$, $\theta = 0.4$, and $\theta_g = 0.10$.

The method of calculating the maximum potential interest rate used in the pure-debt model (discussed above) can be applied to find the values of i and e that satisfy either (8) and (9) for our "standard investment." Note that a firm's net cost of funds (N) is a weighted average of the net-of-tax interest that it pays and the yield on its equity. In nominal terms,

(11) $$N = b(1-\tau)i + (1-b)(e+\pi)$$

In the special case of pure-debt finance, $N = (1-\tau)i$; the solution of the difference equation (6) provides a value for i and, since τ is known, for N as well. More generally, regardless of the mix of debt and equity finance, the solution of equation (6) can be interpreted as equal to $N/(1-\tau)$; that is, it is equal to the cost of funds to the firm stated as if all these costs were deductible from the corporate income tax.

To calculate the value of i corresponding to any tax regime we therefore proceed in three steps. First, we solve equation (6) to obtain a value of $N/(1-\tau)$. Second, we multiply this by $(1-\tau)$ to obtain N. Finally with this known value of N we can solve the two equations simultaneously (11 and 8 or 10) for i and e.

Table 9.2 presents the interest rates corresponding to the pretax portfolio-balance rule of equation (8). Separate results with and without inflation are presented for three risk premiums ($D = 0.06$, 0.08, and 0.04). Note first that the implied interest rates, especially those corresponding to $D = 0.06$, are much closer to observed experience than the results based on complete debt finance in table 9.1.[26]

The numbers in column 1 (zero inflation rate) deserve comment for two reasons. First, unlike the results in the pure-debt model of table 9.1, the introduction of the corporate income tax significantly lowers the implied bond yield. This reflects the payment of a significant tax, which must reduce both the equity and debt yields. Similarly, in contrast to table 9.1, the reduced corporate tax rate in 1964 now causes an increase in the MPIR. Second, the various liberalizations of depreciation and the introduction of the investment tax credit raise the MPIR. The absolute increase is smaller than in the pure-debt case of table 9.1, but the proportional rise is substantially larger.

26. Note that in regimes B through G the values for $D = 0.08$ and $D = 0.04$ differ from the corresponding values for $D = 0.06$ by 0.016. This constant difference holds to the three-decimal-place accuracy of our table but is not an exact relation when the corporate tax rate τ changes.

Table 9.2 **Maximum Potential Interest Rate with One-Third Debt Finance and Selected Pretax Risk Differentials for Alternative Tax Regimes and Inflation Rates**

Percent

Tax Regime (corporate tax rate, depreciation method, and other provisions)	Pretax Risk Differential (D): 6 percent, Inflation rate 0 (1)	6 percent, Inflation rate 6 (2)	8 percent, Inflation rate 0 (3)	8 percent, Inflation rate 6 (4)	4 percent, Inflation rate 0 (5)	4 percent, Inflation rate 6 (6)
(A) No tax	8.0	14.0	6.7	12.7	9.3	15.3
(B) 52 percent; straight-line depreciation	2.4	7.7	0.8	6.1	4.0	9.3
(C) 52 percent; accelerated depreciation as of 1960	2.9	8.3	1.3	6.7	4.5	9.9
(D) 52 percent; investment tax credit of 5.6 percent; depreciation as of 1963:4 with Long amendment	3.3	8.9	1.7	7.3	4.9	10.5
(E) Same as D, except Long amendment repealed	3.4	9.0	1.8	7.4	5.0	10.6
(F) Same as E, except 48 percent	3.8	9.4	2.2	7.8	5.4	11.0
(G) Current law: 48 percent; investment tax credit of 9 percent;[a] asset depreciation range	4.4	10.2	2.8	8.6	6.0	11.8

SOURCE: Derived by method described in text.

a. See text note 21.

The effect of a 6 percent inflation rate is seen by comparing columns 1 and 2. With no tax, the MPIR rises by the full amount of the inflation; a 6 percent inflation raises it from 8.0 percent to 14.0 percent. The presence of taxes again changes this relation but the effect is very different with mixed debt-equity finance than in the pure-debt case. In each of the tax regimes, a 6 percent inflation rate raises the nominal interest rate by only about 5.5 percent: $di/d\pi = 0.92$. This implies that the real rate of return on debt falls even for the lender (bondholder) who is not subject to any personal tax. For a lender who pays a significant marginal tax rate, the equilibrium real net internal rate of return can easily be negative. Under regime C, the real net yield to a 50 percent taxpayer falls from 1.45 percent to -1.85 percent. With the most recent regime (G), the 6 percent inflation rate reduces the real net yield from 2.2 percent to −0.90 percent.

Table 9.3 presents the corresponding maximum potential interest rates for the net-of-tax portfolio-balance rule of equation (10). Again, the corporate income tax causes a substantial reduction in the real interest rate. The liberalized depreciation rules raise this interest rate substantially but, even in the absence of inflation, it remains significantly below the value without taxes. The most important difference between the results of tables 9.2 and 9.3 is the greater sensitivity of MPIR to inflation with the net-of-tax portfolio-balance rule of table 9.3. Comparing columns 1 and 2 shows that a 6 percent inflation rate would raise the nominal

Table 9.3 **Maximum Potential Interest Rate with One-Third Debt Finance and Selected Net-of-Tax Risk Differentials for Alternative Tax Regimes and Inflation Rates**

Percent

	Net-of-Tax Risk Differential (D)					
	6 percent		4 percent		5 percent	
	Inflation rate		Inflation rate		Inflation rate	
Tax Regime (corporate tax rate, depreciation method, and other provisions)	0 (1)	6 (2)	0 (3)	6 (4)	0 (5)	6 (6)
(A) No tax	8.0	14.0	9.3	15.3	8.6	14.3
(B) 52 percent; straight-line depreciation	0.9	8.4	3.4	10.9	2.2	9.6
(C) 52 percent; accelerated depreciation as of 1960	1.5	9.1	4.0	11.6	2.8	10.4
(D) 52 percent; investment tax credit of 5.6 percent; depreciation as of 1963:4 with Long amendment	2.0	9.9	4.5	12.4	3.2	11.2
(E) Same as D, except Long amendment repealed	2.1	9.9	4.6	12.4	3.4	11.2
(F) Same as E, except 48 percent	2.6	10.3	5.1	12.8	3.9	11.6
(G) Current law: 48 percent; investment tax credit of 9 percent;[a] asset depreciation range	3.3	11.3	5.8	13.8	4.6	12.6

SOURCE: Derived by method described in text.

a. See text note 21.

MPIR by 7.5 percent under regime B, implying $di/d\pi = 1.25$; this result is essentially independent of the differential (D) that is assumed. The faster writeoffs that are incorporated in the succeeding tax regimes reduce the extent to which inflation lowers the value of the tax depreciation. The smaller adverse effect on the value of depreciation raises $di/d\pi$; the value of 1.25 under regime B comes 1.32 with regime D and 1.33 with the current regime (G).

The maximum potential interest rates shown in tables 9.2 and 9.3 have two very important implications. First, inflation severely depresses the real net rate of return (i_n) that can be paid to a bondholder on the basis of our standard investment project. Consider an investor whose marginal tax rate is 40 percent. Table 9.2 implies that with current law and a risk differential of $D = 0.06$, a 6 percent inflation raises the nominal before-tax return from 4.4 to 10.2 percent, but reduces the real net return from 2.6 percent to 0.1 percent. With the more favorable assumptions of table 9.3, a 6 percent inflation reduces the real return from 2.0 percent to 0.8 percent. This has obvious effects on the incentive to save and to make risky portfolio investments.

The second implication relates to the firm's incentive to invest. It is frequently argued that, because their real net borrowing rate has fallen, firms now have a greater incentive to invest than they did a few years ago. The calculations of tables 9.2 and 9.3 show that the inference is wrong because inflation also reduces the maximum real net borrowing rate that firms can afford to pay on any investment. Table 9.2 with $D = 0.06$ implies that in the absence of inflation a firm could afford to pay an after-tax interest cost of 2.3 percent on the standard investment project.[27] Inflation at 6 percent reduces the maximum real after-tax interest rate for this project below zero to −0.7 percent![28] The real net cost of debt finance must thus fall by 3.0 percentage points to avoid reducing the incentive to invest. Similarly, with table 9.3, the firm could afford a net interest cost of 1.7 percent in the absence of inflation but only a negative cost, −0.1 percent, with 6 percent inflation. It is clear that the usual way of evaluating investment incentives in terms of the real net cost of finance is very misleading with the U.S. tax system when inflation is significant.[29]

9.1.3 The Effect of a Variable Supply of Investable Funds

Until now, all of our calculations have referred to the same standard investment project and therefore implicitly to a fixed supply of investable funds. Moreover, we have assumed that inflation has no effect on the

27. $(1 - \tau)i = 0.52\ (0.044) = 0.0229$.
28. $(1 - \tau)i - \pi = 0.52\ (0\ 102) - 0.06 = -0.0070$.
29. The empirical results of the next two sections suggest that the actual real net interest rate falls by about enough to keep incentives to invest unchanged despite the low maximum potential interest rate.

supply of loanable funds to the nonfinancial corporate sector. The econometric estimation of the actual effect of changes in the corporation tax requires attention to both of these issues.

Once again we begin by considering an economy in which there is no inflation and all marginal investment is financed by debt. The notion of a fixed supply of loanable funds (the vertical *S* of line figure 9.1) rested on the assumption that our analysis relates to the entire economy and that the supply of saving is interest inelastic. It is important for subsequent empirical analysis to drop these two assumptions. Our econometric analysis will deal with the long-term corporate bond rate; but the demand for long-term credit comes not only from business firms, but also from investors in residential real estate, from state, local, and federal governments, and from abroad. These investment demands are not directly affected by the investment tax credit, accelerated depreciation, or changes in the corporate tax rate. This implies that the supply of loanable funds to the nonfinancial corporate sector is an increasing function of the long-term bond yield and that this supply function is not shifted by the changes in corporate tax rules. This supply elasticity would be increased by a positive response of domestic saving and international capital flows to the net interest rate.

Figure 9.2 is therefore a more appropriate representation than figure 9.1. A more liberal depreciation policy (a shift from *I* to *I'*) has a more limited effect on the long-term interest rate. The magnitude depends on

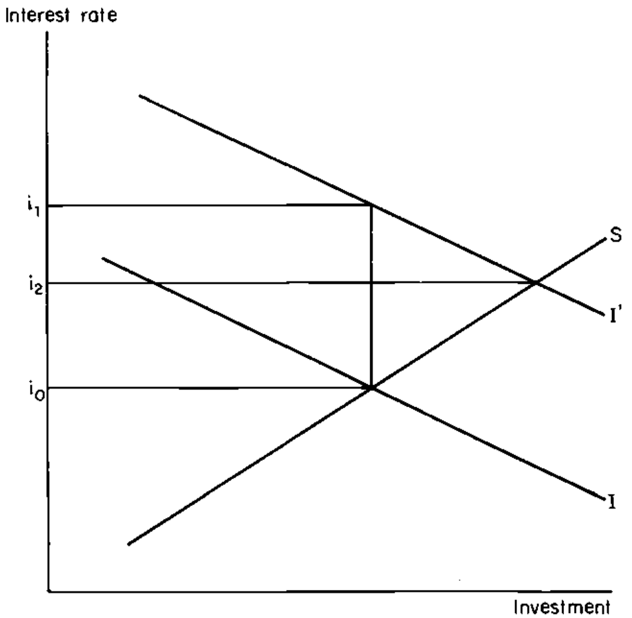

Figure 9.2

the elasticity of the supply of loanable funds to the nonfinancial business sector and therefore on both the relative size of the rest of the debt market and the degree of substitutability in investors' portfolios.

The ratio of the actual change in the long-term interest rate $(i_2 - i_0)$ to the change that would have occurred $(i_1 - i_0)$ if investment and therefore the marginal product of capital had remained the same thus measures the extent to which the tax change is shifted from corporate capital to capital elsewhere and to labor.

Our empirical analysis below focuses on the extent of tax shifting in this general sense. We look at the tax changes as summarized by the change in the corporate maximum potential interest rate and ask what impact this potential change actually had on the yields available to portfolio investors with uncommitted funds. The ratio of $(i_2 - i_0)$ to $(i_1 - i_0)$ is analogous to the definition of the incidence of corporate tax changes used in previous empirical studies.[30] This measure of incidence should be distinguished from the more general concept of the fracion of the tax change borne by capital in *all* sectors. A change in the corporate tax might be borne solely by capital even though the corporate sector bore only a modest fraction.[31] Our estimate of the ratio of $(i_2 - i_0)$ to $(i_1 - i_0)$ therefore does not measure the shift of the tax change from capital to labor. We return later to consider how well our empirical analysis of the tax-included change in the long-term bond rate measures the impact of the tax on the yield to capital in general and not just on the capital invested in the corporate sector.

To implement this approach, we could calculate the maximum potential interest rate for our hypothetical "standard investment" under the tax regime of each quarter during the sample period. This would yield the i_1 values of figure 9.2 corresponding to different tax rules. We could then estimate an equation relating the actual interest rate (i_2) to these values. In practice, however, it is necessary to allow also for changes in inflation that shift the supply of available funds.

The response of supply to changes in the rate of inflation depends on three basic factors: (1) the effect of nominal interest rates on the demand for money; (2) the effect of the real net interest rate on saving; and (3) the effect of inflation on the real yields available in other forms of investment open to portfolio investors. Our empirical analysis does not attempt to disentangle these aspects or to model explicitly the effect of inflation on yields of alternative assets.[32] Instead, we distinguish only between the changes in the rate of interest caused (1) by the inflation-induced rise in the nominal rate of return and (2) by all other effects of inflation.

30. See, for example, Krzyzaniak and Musgrave (1963) and Oakland (1972). However, these authors analyzed the effect, not on uncommitted funds, but on the return of existing investments.

31. See, for example, Harberger (1962) for an explicit analysis of the incidence of a change in the corporate tax in an economy with more than one sector.

32. Benjamin Friedman's explicit modeling of the supply of and demand for corporate debt might usefully be extended in this direction. See, for example, Friedman (1977).

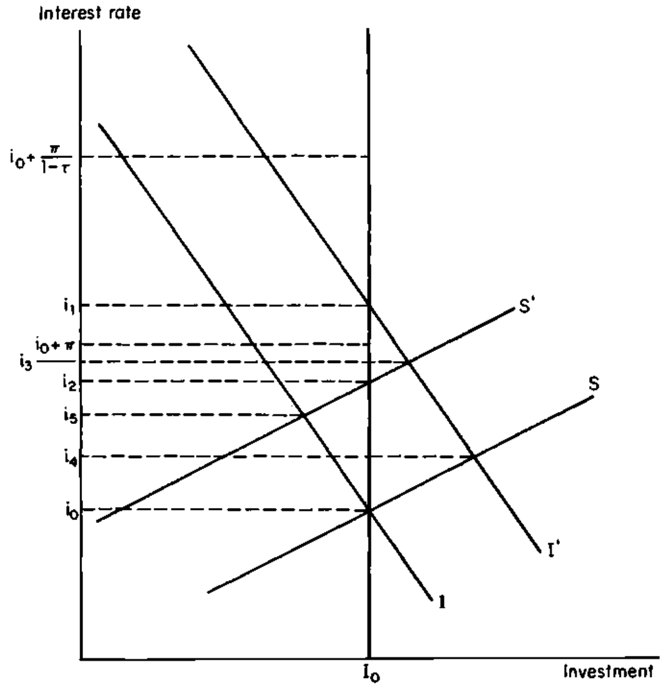

Figure 9.3

This distinction is illustrated in figure 9.3. In the absence of inflation, the equilibrium interest rate is i_0 and investment is I_0. The effect of inflation at rate π is to raise the investment-demand schedule to I'. In a pure Fisherian economy, the vertical displacement of this schedule would equal the rate of inflation: $i_1 - i_0 = \pi$. But with taxes and historic cost depreciation, this vertical shift is likely to be somewhere between π and $\pi / (1 - \tau)$, as it is in figure 9.3. Inflation will also shift the supply schedule of loanable funds from S to S'. In the pure Fisherian world, this vertical displacement would also equal the rate of inflation: $i_2 - i_0 = \pi$, implying $i_2 = i_1$.[33] More realistically, the supply shift will depend on the three factors identified in the previous paragraph. The change in the equilibrium interest rate will depend on the shifts and the slopes of both the demand and supply schedules.

As this analysis indicates, an empirical study of the relation between inflation and the interest rate should *not* be construed as a test of Irving Fisher's theory. Wih a complex structure of taxes, Fisher's conclusion would not be expected to hold. The purpose of an empirical study should instead be to assess the response of nominal long-term interest rates to inflation and therefore the effect on real after-tax yields. The statistical

33. Note that if the supply is perfectly inelastic (that is, if the schedule is vertical), the Fisherian result can occur with no shift in supply.

analysis presented below therefore begins by trying to measure this response of the interest rate to expected inflation;[34] in terms of figure 9.3, this coefficient equals $(i_3 - i_0)/\pi$. Our analysis can also go further and estimate how much of the increase in the interest rate would be due to a shift in the demand for funds with the supply schedule fixed $(i_4 - i_0)$ and how much to the shift in supply with a fixed demand schedule $(i_5 - i_0)$. With linear demand and supply schedules, this procedure provides an exact decomposition of the observed changes: $i_3 - i_0 = (i_4 - i_0) + (i_5 - i_0)$.

The current discussion of the effect of inflation when all marginal investments are financed by debt is extended and applied below to investments in which debt finance provides one-third of marginal capital and equity finance, two-thirds. Our analysis assumes that the debt-equity ratio is unaffected by the rate of inflation and that the *real* rates of return to debt and equity have a constant net or gross differential.

9.2 Estimating the Effect of Inflation

In this section we begin the empirical investigation of the impact of expected inflation on the long-term rate of interest. As we emphasized above, we do not regard this as a test of Fisher's conclusion since there is no reason to expect such a one-for-one impact of inflation on the interest rate in an economy in which taxes play such an important role. Instead, our aim is to estimate the net impact of expected inflation on the nominal rate of interest in order to assess the effect of inflation on the real cost of capital and the real return to investors. If the supply of loanable funds for the purchase of bonds were fixed, we would expect the equilibrium interest rate to rise in the same way as the maximum potential interest rate. In fact, however, the supply schedule is likely to be neither completely inelastic nor independent of the inflation rate. Without a much more detailed analysis, we must regard a wide range of inflation impacts as plausible a priori.

At this stage we focus on the relation between the interest rate and expected inflation. The next section introduces the effects of changes in tax and depreciation rules. Since adding the tax variable does not alter the conclusion about the effect of inflation, we prefer to start with the simple specification in which we can concentrate on making expected inflation an operational concept.

In all of our analyses, we measure the long-term interest rate by an average of yields on new issues of high-grade corporate bonds, adjusted to be comparable to the Aaa rate.[35] The use of new-issue yields is important because seasoned issues with lower coupon rates will also have

34. The operational specification of expected inflation is discussed below.
35. Data Resources, Inc., made this series available to us.

lower market yields owing to the more favorable tax treatment of capital gains. The new-issue yield, however, is influenced by the call-protection feature, which may make it respond more to inflation rates than it would otherwise.

The expected rate of inflation is defined in terms of the price of consumer goods and services as measured by the deflator of personal consumption expenditures in GNP. In principle, our analysis should recognize that wage rates and the prices of consumption goods, of investment goods, and of the output of nonfinancial corporations do not move proportionately and would be expected to have different effects on the supply and demand for investment funds. In practice, it is not possible to include more than one inflation variable and the choice does not alter the results in an essential way. We use expectations of the consumption price for three reasons: (1) This is the price that should affect household decisions. (2) Although firms produce investment and intermediary goods, they also purchase these goods; the consumption price may therefore be a good approximation of the price of sales by the nonfinancial corporate sector to the rest of the economy. (3) The future movement of nominal wage rates may be approximated best by the expected movement in consumer prices.

This section develops two approaches to specifying the expected future rate of inflation. The first uses the familiar distributed lag on past inflation rates, with the identifying restriction that the weights on past inflation must sum to one. Recognizing that this restriction may be invalid, we explore an alternative approach based on a series of separate optimal forecasts of inflation. In practice, the two approaches lead to very similar results.

Consider first the distributed-lag approach that has been used ever since Irving Fisher's own pioneering work on this subject. We posit that the interest rate (i) in related to expected inflation (π^*) according to

$$i_t = \beta_0 + \beta_1 \pi_t^* \tag{12}$$

where

$$\pi_t^* = \sum_{j=0}^{T} w_j \pi_{t-j} \tag{13}$$

with

$$\sum_{j=0}^{T} w_j = 1 \tag{14}$$

Substituting equation (13) into equation (12) yields the estimable equation

$$i_t = \beta_0 + \beta_1 \sum_{j=0}^{T} w_j \pi_{t-j} \tag{15}$$

The key coefficient β_1 is estimable only because of the identifying restriction of equation (14).

Equation (15) was estimated by assuming that the weights on lagged inflation (that is, $j > 0$) satisfy a second-order polynomial and that $T = 16$ quarters; the coefficient of the concurrent inflation rate ($j = 0$) was unconstrained. The basic parameter estimates are presented in equation (16). (The numbers in parentheses here and in the equations that follow are standard errors.)

$$(16) \qquad \underset{(0.17)}{i_t = 3.05} + \underset{(0.05)}{0.19\ \pi_t} + \beta_1 \sum_{j=1}^{16} w_j \pi_{t-j}$$

$$\beta_1 \sum_{j=1}^{16} w_j = \underset{(0.06)}{0.64}$$

Sample period: 1954:1–1976:4; $\bar{R}^2 = 0.82$; Durbin-Watson = 0.21.

The identifying restriction that $\sum_{j=0}^{16} w_j = 1$ implies that $\beta_1 = 0.83$.[36] With no inflation, the interest rate would be 3.05 percent; with a sustained (and hence expected) inflation rate of 6 percent, the nominal interest rate would rise to 8.03 percent.

Sargent has rightly emphasized that the identifying restriction of equation (14) may be unwarranted.[37] The optimal weights (the w_j) depend on the nature of the process that is being forecast. If the π_t remain constant for a long time, it is clearly appropriate that the weights sum to unity and therefore predict that the same π_t will continue. But where the historic pattern of the π_t is more varied, a different set of weights will be optimal. Dropping the restriction of equation 14 leaves β_1 in (15) underidentified. This apparently led Sargent to abandon the estimation of β_1 and to attempt to test Fisher's conclusion indirectly by examining a rational expectations model of unemployment.[38] We do not think that so circuitous a route is necessary and propose instead to develop an explicit optimal forecast measure of expected inflation for use as a regressor to estimate equation (12) directly.

To derive forecasts of inflation rates, we use the optimal ARIMA forecasting procedure of Box and Jenkins.[39] We assume that the forecasts made at any time are to be based only on the information available at that time. This requires reestimating a separate Box-Jenkins equation for each quarter based on the observations available as of that quarter. To

36. That is, 0.64 + 0.19, the latter being the coefficient of π_t.

37. See Sargent (1973).

38. Sargent concludes that his indirect evidence was ambiguous. When taxes are recognized, even the theoretical link between Sargent's equation and the inflation-interest relation is unclear.

39. In principal, of course, the Box-Jenkins procedure is too restrictive and one should derive forecasts from a completely specified econometric model. Unfortunately, doing so requires projecting all of the exogenous variables. The more general procedure that requires estimates of monetary and fiscal policy for many years ahead would not necessarily yield better forecasts than the simpler Box-Jenkins procedure. See Box and Jenkins (1970).

relax the assumption that inflation rates are generated by the same stochastic process over the entire postwar period, we specify that the ARIMA process estimated at each date is based only on the most recent ten years of data.[40] After some preliminary analysis of the data, we selected a first-order autoregressive and first-order moving-average process. With the inflation rates measured as deviations from the ten-year sample means, denoted by π, this ARIMA process can be written as

$$\pi_t = \phi\pi_{t-1} + \epsilon_t - \theta\epsilon_{t-1} \tag{17}$$

where ϵ_t is a purely random disturbance. Equation (17) was estimated by the Box-Jenkins procedure for changing samples ending in each quarter from 1954:1 through 1976:4. The minimum mean-square-error forecast of the inflation rate in quarter $t + 1$ as of quarter t is

$$\hat{\pi}_{t+1} = \frac{\phi - \theta}{1 - \theta L}\pi_t \tag{18}$$

where L is the lag operator.

A striking result of these estimates of the predicted inflation rate, shown in table 9.4, is the implied change in the sum of the optimal forecast weights on past inflation rates.[41] Because we assume that inflation rates follow a stationary process, our specification implies that the optimal weights always sum to less than one.[42] Until 1970, the implied sum of the weights was always between 0.30 and 0.40. During the 1970s, the sum of the weights has risen markedly, from 0.45 in 1970 to 0.55 in 1973 to 0.71 in 1976. Since the mean lag has remained almost constant, the rapidly rising weights imply an increased sensitivity of the optimal inflation forecast to recent experience.[43] This has potentially important implications for the changing evidence on the "accelerationist hypothesis" and other issues that we shall not explore in this paper.[44]

The expected inflation rate that affects the long-term interest rate involves a long horizon and not merely the next quarter. We can use

40. Since our sample begins in the first quarter of 1954, it is not appropriate to use a ten-year history of inflation that stretches back into World War II. The earliest inflation observation used is the first quarter of 1947; the sample is extended until a full ten years is available.

41. It follows from equation (18) that, when the process is represented as an autoregressive process, the sum of the weights is $(\phi - \theta)(1 - \theta)$.

42. Recall that our estimates are based on deviations from the sample mean so that a constant inflation rate would eventually be predicted accurately.

43. The mean lag, $1/(1 - \theta)$, was approximately 1.4 quarters until 1970 and has since been between 1.5 and 1.6 quarters.

44. The coefficients of the distributed lag on past inflation have been regarded as a test of the accelerationist hypothesis that the long-run Phillips curve is vertical. This implicitly accepts an identifying restriction like our equation (14). The evidence of an increasing coefficient on lagged inflation might be better interpreted as a changing relation between past inflation and expected inflation. For evidence of the increasing coefficients on past inflation in this context, see Gordon (1971) and Eckstein and Brinner (1972).

Table 9.4 **The Long-term Interest Rate and the Predicted Inflation Rate, 1954–76**

Percent

Year	Long-term Interest Rate (i_t)	Predicted Inflation Rate (π_t^e)	Year	Long-term Interest Rate (i_t)	Predicted Inflation Rate (π_t^e)
1954	2.9	2.9	1966	5.4	2.0
1955	3.2	2.7	1967	5.8	1.9
1956	3.7	2.6	1968	6.5	2.3
1957	4.4	2.6	1969	7.7	3.1
1958	4.0	2.2	1970	8.5	3.3
1959	4.8	2.3	1971	7.4	3.6
1960	4.7	2.4	1972	7.2	3.2
1961	4.4	1.9	1973	7.7	4.3
1962	4.2	1.7	1974	9.0	8.0
1963	4.2	1.7	1975	9.0	5.2
1964	4.4	1.7	1976	8.3	5.2
1965	4.5	1.8			

SOURCES: The long-term interest rate is an average of yields on new issues of high-grade corporate bonds adjusted to the comparable Aaa rate. The series was provided by Data Resources, Inc. The predicted inflation rate is the weighted (discounted) average of ten years of quarterly Box-Jenkins forecasts (see text).

equation (18) to calculate iteratively a sequence of inflation rates in future quarters. We define the expected inflation rate π_t^e as the weighted average of the quarterly predicted inflation rates during the subsequent ten years, where the weights reflect discounting of future inflation by the interest rate. Moderate changes in the average period would have no appreciable effect on our analysis.[45]

Equation (19) presents the estimated interest rate equation based on the optimal inflation forecast:

$$(19) \qquad i_t = 2.9 + \underset{(0.09)}{0.94}\, \pi_t^e$$

Sample period: 1954:1–1976:4; $\bar{R}^2 = 0.53$; Durbin-Watson = 0.13.

The estimate 0.94 is very close to one and certainly not significantly different. Thus, this estimate, based on an optimal Box-Jenkins forecast of future inflation, is very similar to the traditional distributed-lag estimate of equation (16).

Forecasting inflation on the basis of past inflation is clearly more appropriate at some times than at others. If the reduction in inflation rates after the Korean War was properly anticipated, the estimates of expected inflation based on past inflation rates would be too high for the

45. When we return to explicit analysis of the internal rate of return in the next section, the inflation forecasts can be incorporated directly into its calculation.

early years in table 9.4. We have therefore reestimated equations (16) and (19) for the period beginning in 1960. The results are quite similar to the estimates for the entire sample: the weights sum to 0.75 with the polynomial distributed lag, and the coefficient is 0.88 when the predicted inflation variable (π_t^e) is used.

The very low Durbin-Watson statistics of our estimated equations indicate an extremely high first-order autocorrelation of the stochastic errors. This is just what we would expect in an efficient market for long-term bonds. The *change* in the long-term interest rate from quarter to quarter (and therefore the change in the price of the asset) would be expected to depend on *changes* in such fundamental determinants as the expected inflation rate with a stochastic disturbance that is serially uncorrelated and that therefore cannot be predicted. This serial independence in first differences corresponds to the observed high autocorrelation when the *level* of the interest rate is the dependent variable. The high autocorrelation of the residuals implies that our method of estimation is inefficient and that the standard errors are underestimated. We have not, however, followed the common statistical procedure of estimating the equation in first-difference form (or, more generally, after an autoregressive transformation) because we believe that doing so would introduce a substantial errors-in-variables bias. Specifically, we recognize that a variable like π_t^e is only an imperfect measure of expected inflation. Because inflation (and presumably expected inflation) has changed substantially during our sample period, most of the variance in the π_t^e series will reflect the variance of the true (but unobserved) expected inflation. A relatively small amount of "noise" will cause a correspondingly small downward bias in the coefficient of the π_t^e variable. In contrast, taking the first differences of the π_t^e series would eliminate most of the systematic component of its variance while leaving the measurement error. The result would be a very substantial bias in the coefficient. In terms of the mean-square error of the estimated coefficient, it is better to accept the inefficiency of ordinary least-squares estimation of the untransformed equation than to subject the estimates to a much more serious bias.[46]

To explore this view, we did estimate equation (19) with a first-order autoregressive transformation. The maximum-likelihood procedure implied a serial correlation of 0.99 and parameter estimates as follows:

$$\text{(20)} \qquad \underset{(1.8)}{i_t = 5.0} + \underset{(0.08)}{0.14}\ \pi_t^e + 0.99u_{t-1}$$

Sample period: 1954:1–1976:4; $\bar{R}^2 = 0.97$; Durbin-Watson = 1.8.

We regard the very low parameter estimate of 0.14 as an indication of the relative error variance in the quarterly changes in π_t^e rather than as

46. As noted in the text, the substantial autocorrelation does, however, imply that our standard errors are underestimated.

evidence that the true coefficient of π_t^e is so low. This conclusion is supported by using an instrumental-variable procedure to estimate equation (19) in first-difference form:[47]

$$(21) \qquad i_t - i_{t-1} = \underset{(0.04)}{0.04} + \underset{(0.22)}{0.66} \, (\pi_t^e - \pi_{t-1}^e)$$

Sample period: 1954:1–1976:4; Durbin-Watson = 1.86.

The estimated inflation coefficient of 0.66 (with a standard error of 0.22) is much closer to the basic parameter values of equations (16) and (19).

Although our evidence is thus roughly consistent with Irving Fisher's conclusion that the interest rate rises by the rate of inflation, both the mechanism and the implications are quite different. The rise in the nominal rate of interest reflects the impact of the tax and depreciation rules. Although the nominal interest rate rises by approximately the increase in expected inflation, the net result is far from neutral. For the individual lender, the rise in the nominal interest rate is sufficient to keep the real return *before tax* unchanged, but implies a sharp fall in the real return *after tax*. For example, a lender with a 50 percent marginal tax rate could find a real net yield of 3 percent in the absence of inflation reduced to zero by a 6 percent inflation.

Inflation is so not neutral from the firm's point of view. With an increase in the interest rate equal to the increase in inflation, the *real* net interest cost to the firm falls substantially. But, as tables 9.2 and 9.3 showed, the potential real net interest rate that the firm can pay also falls. There is neutrality with respect to the firm and therefore with respect to investment only if the actual rate falls by an equal amount. Equivalently, there is neutrality only if the actual and potential nominal interest rates rise by an equal amount. If the first rises by more than the second, the firm must adjust by reducing investment.

9.3 Changes in Tax Rules, Inflation, and Pretax Profitability

We return now to the method of analyzing the effects of changes in tax rules and inflation rates that was developed in the first section. We extend this method here to deal with forecasts of changing inflation rates and with fluctuations in the pretax rates of return.

Our analysis begins by deriving for each quarter between the first quarter of 1954 and the final quarter of 1976 the maximum potential interest rate that is compatible with our "standard investment" project. For this calculation we assume that debt finances one-third of the investment. One series of such internal rates of return is derived on the

47. The first-difference specification is essentially equivalent to the maximum-likelihood transformation of equation (20).

assumption of a constant 6 percent risk differential between the pretax yields on debt and equity. We refer to this variable as MPIR33G to denote a maximum potential interest rate based on 33 percent debt finance and a gross-of-tax risk differential. As table 9.2 showed, changing the risk differential from 6 percent to any other constant would change all of the internal rates of return only by a constant and would therefore not alter the regression results; in more formal language, the risk-differential parameter is not indentifiable on the basis of available experience. A second series is derived on the assumption of a constant 6 percent risk differential between the net-of-tax yields on debt and equity; we denote this MPIR33N. The risk-differential parameter is again not identifiable.

Three factors determine the changes in the MPIR variable from quarter to quarter: tax rules, inflation, and pretax profitability. For each quarter we use the tax rules that were appropriate for that quarter and assume that they would not be changed during the life of the project. We also use an optimal Box-Jenkins forecast equation to obtain quarterly forecasts of inflation rates on the basis of the information then available. The tax rules and inflation forecasts are combined using the method outlined in section 9.1 to obtain an estimated internal rate of return.

In performing that operation, it is also appropriate to relax the assumption that the "standard investment" project has the same pretax profitability in every period. In practice, the actual pretax rates of profit have experienced substantial gyrations during the twenty-five years.[48] A permanent rise or fall in the pretax profitability of investment would cause an equivalent shift in the demand for funds; even a temporary change could cause some shift. To allow for this possibility, we have also calculated an MPIR series based on the assumption that the pretax internal rate of return is not a constant 12 percent but varies from quarter to quarter.[49]

Our analysis of changing profitability is based on the series for the "net profit rate" developed in our previous paper (Feldstein and Summers, 1977). This rate is measured as the ratio of corporate profits before tax plus interest payments to the sum of fixed capital, inventories, and land. The data relate to nonfinancial corporations and are corrected for changes in the price level. Both profits and capital stock are net of the Commerce Department estimate of economic depreciation. We have interpolated the annual series to obtain quarterly figures.

It would be incorrect to assume that firms extrapolate short-run variations in profitability to the entire life of their investments. We posit instead that the demand for funds is based on a cyclically adjusted value of profitability. Specifically, we follow our earlier analysis of profitability and relate the profit rate to the concurrent rate of capacity utilization. We

48. See Feldstein and Summers (1977).

49. This is equivalent to changing the parameter a_0 of equation (1) each quarter to recalibrate the pretax rate of return.

then use this equation to estimate the profit rate that would be expected in each quarter if the capacity utilization were a standard 83.1 percent, the average for the sample period. This cyclically adjusted profit rate is then used to recalibrate the maximum potential interest rate for each quarter. We use the suffix AP to denote a variable expressing the internal rate of return that has been adjusted for variations in profitability; thus MPIR33NAP is the MPIR variable that is based on a risk differential net of tax and that has a varying profitability.

Table 9.5 shows the four MPIR variables corresponding to differentials gross of tax and net of tax and to fixed and varying profitability. Note that differences in the average level reflect the risk differential. Variations over time within each series are therefore more important than differences among the series.

Table 9.5 **Values of Maximum Potential Interest Rate for Standard Investment Project, 1954–76**[a]

Percent

	Constant Pretax Profitability		Varying Pretax Profitability	
Year	*MPIR33G*	*MPIR33N*	*MPIR33GAP*	*MPIR33NAP*
1954	5.7	5.4	4.6	4.1
1955	5.9	5.6	5.3	4.9
1956	6.0	5.7	4.1	3.5
1957	5.5	5.9	4.0	3.3
1958	6.0	5.7	4.2	3.5
1959	6.1	5.8	5.0	4.5
1960	6.1	5.8	4.6	4.0
1961	6.0	5.6	4.9	4.3
1962	6.4	6.0	5.8	5.3
1963	6.5	6.2	6.1	5.7
1964	7.1	6.8	7.0	6.7
1965	7.3	7.2	7.4	7.2
1966	7.3	7.1	6.8	6.6
1967	7.2	7.1	6.2	5.9
1968	6.9	6.7	5.7	5.3
1969	6.5	6.4	4.2	3.7
1970	6.8	6.9	3.9	3.4
1971	7.4	7.6	4.9	4.6
1972	7.7	7.9	5.0	4.6
1973	7.9	8.3	3.8	3.5
1974	8.4	9.6	2.7	2.8
1975	8.3	9.0	5.2	5.2
1976	8.2	8.8	4.8	4.8

SOURCE: Derived by method explained in the text.

a. All MPIR variables are based on debt financing for one-third of the investment and risk differentials of 6 percent. See text for definitions of the symbols.

These MPIR values can now be used to estimate how tax changes affect the actual long-term rate of interest. If the supply of funds to the nonfinancial corporate sector were completely inelastic, the actual interest rate would be expected to rise by the same amount as the MPIR. In the traditional language of public finance, the full effect of changes in the tax rules would then be borne by capital in the corporate sector. More generally, however, the supply of capital to the nonfinancial corporate sector is not fixed but is an increasing function of the nominal rate of interest. The elasticity of the supply of funds to nonfinancial corporate business and the elasticity of the demand for funds by those firms together determine how much a tax-induced shift in the demand for funds raises the return to capital. For a given demand elasticity, the effect on the equilibrium interest rate of a shift in demand versus inversely with the elasticity of supply. The greater the supply elasticity, the greater will be the increase in corporate investment relative to that in the rate of interest.

Although an estimate of the elasticity of supply of funds to the nonfinancial corporate sector is not available, the relative magnitude of the funds raised by this sector is informative. Between 1970 and 1975, the funds raised in credit markets by all nonfinancial sectors totaled $1,029 billion.[50] Of this, corporate bonds accounted for only $107 billion. The total funds raised by corporations, including bank borrowing and mortgages as well as bonds, totaled $334 billion, or only about one-third of total funds raised. The obligations of state and local governments alone accounted for $89 billion; net borrowing for residential mortgages was $253 billion. It is clear that fluctuations in the demand for borrowed funds by corporations due to changes in tax rules and productivity may be small relative to the total flow of funds in credit markets. The potential supply of long-term lending from abroad and the elasticity of financial saving with respect to the real rate of interest strengthen this conclusion. Although a more extensive analysis of this issue would be desirable, these crude figures do suggest that the elasticity of supply of funds to the corporate sector may be substantial. If so, the effect of changes in MPIR on the actual interest rate will be correspondingly small.

In using the MPIR variable to estimate the effect on the interest rate of the shifts in the demand for funds induced by tax changes, it is important to adjust for the concurrent shifts in supply caused by changes in expected inflation. To control for such changes in the interest rate, our regression equation relates the interest rate to the expected rate of inflation (π^*) as well as to the appropriate MPIR variable:[51]

50. The statistics in this paragraph are from the Flow of Funds Accounts of the Federal Reserve System.

51. Our analysis uses both the polynomial distributed-lag specification and the variable constructed from Box-Jenkins forecasts. Factors other than inflation also shift the supply of funds available to the nonfinancial corporate sector: (*a*) shifts in saving behavior; (*b*) shifts in liquidity preference; and (*c*) shifts in the demand for funds by governments, by the rest of the world, and by investors in residential real estate. Although none of these shifts is likely

$$(22) \qquad i_t = \alpha_0 + \alpha_1 \, MPIR + \alpha_2 \pi^*$$

The coefficient of the MPIR variable can therefore measure the net effect of tax changes; in terms of figure 9.3, this net effect is $(i_4 - i_0)/(i_1 - i_0)$, or the ratio of the change in the interest rate that would occur with a fixed supply curve of funds $(i_4 - i_0)$ to the change that would occur if that supply were perfectly inelastic $(i_1 - i_0)$.[52] The total impact of an increase of 1 percentage point in the expected rate of inflation can be calculated as the sum of (1) the coefficient of the expected inflation variable, α_2, and (2) the product of the coefficient of the MPIR variable and the value of $dMPIR/d\pi$ implied by calculations leading to table 9.2.

Although time is required to change investment and thereby to alter the equilibrium return on investment, the prices of bonds and stocks can adjust very quickly to reflect this eventual long-run equilibrium. A failure to adjust quickly would otherwise provide opportunities for profitable speculation. We therefore specify that the interest rate adjusts to changes in MPIR within the quarter.

The estimated coefficients of equation (22) for each of the concepts of MPIR are presented in table 9.6. Note first that the evidence favors the less restricted polynomial distributed-lag specification of shifting inflation expectations (equations 6-1 to 6-4) over the Box-Jenkins forecast (equations 6-5 to 6-8).[53] We will therefore concentrate our comments on the results based on the former specification and return to the remaining equations afterward. It is not possible to choose between the gross-risk differential concept of MPIR (equations 6-1 and 6-2) and the net-risk differential concept (6-3 and 6-4) on the basis of the goodness of fit of the equations.[54] Similarly, the evidence does not favor either the MPIR variable based on constant pretax profitability (6-1 and 6-3) or that based on changing profitability. Fortunately, the same basic conclusions are implied by all four specifications.

First, a shift in the demand for funds appears to raise the long-term interest rate by approximately one-fourth of the increase in the MPIR; a rise of 100 basis points in MPIR would thus raise the long-term interest rate by approximately 25 basis points.[55] This indicates that the supply of

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to be caused by the changes in the tax rates that shift the demand by nonfinancial corporate business, we cannot be certain that the shifts in supply that are not caused by inflation are uncorrelated with our explanatory variables.

52. This method assumes that the response of the interest rate to a change in the demand function is the same regardless of the cause of the shift—tax rules, inflation, and pretax profitability.

53. This may reflect the fact that the MPIR variable already contains the Box-Jenkins inflation forecast.

54. The $\bar{R}^2$ values are extremely close; although this is not itself an accurate guide in the presence of high serial correlation, the Durbin-Watson statistic and the $\bar{R}^2$ together imply that the evidence offers little basis for choice between the models.

55. The point estimates vary between 0.12 with MPIR33NAP and 0.43 with MPIR33G.

Table 9.6 **Effects of Changes in Taxation and Inflation on the Long-term Interest Rate**[a]

	Independent Variable					Summary Statistic		
Equation and Concept of *MPIR*[b]	Constant	*MPIR*	Inflation Rate π_t	$\sum_1^{16} \pi_{t-1}$	Predicted Inflation Rate π^e	$\bar{R}^2$	Durbin-Watson	Implied Inflation Effect[c]
6-1 *MPIR33G*	0.53 (0.84)	0.43 (0.14)	0.15 (0.05)	0.54 (0.07)	...	0.83	0.24	1.11
6-2 *MPIR33GAP*	1.99 (0.56)	0.18 (0.09)	0.23 (0.05)	0.65 (0.06)	...	0.82	0.25	1.05
6-3 *MPIR33N*	1.38 (0.79)	0.32 (0.14)	0.14 (0.06)	0.53 (0.08)	...	0.82	0.19	1.10
6-4 *MPIR33NAP*	2.39 (0.45)	0.12 (0.07)	0.21 (0.05)	0.64 (0.06)	...	0.82	0.24	1.01
6-5 *MPIR33G*	−3.53 (−0.96)	1.13 (0.16)	...	...	0.52 (0.10)	0.69	0.28	1.61
6-6 *MPIR33GAP*	0.97 (1.07)	0.30 (0.16)	...	...	1.09 (0.11)	0.54	0.15	1.38
6-7 *MPIR33N*	−2.54 (−0.76)	1.10 (0.14)	...	...	0.25 (0.12)	0.71	0.16	1.72
6-8 *MPIR33NAP*	1.44 (0.83)	0.25 (0.13)	...	...	1.04 (0.10)	0.54	0.14	1.37

SOURCE: Text equation (22).

a. The dependent variable in all equations is the long-term interest rate. All equations are estimated for 1954:1 to 1976:4. The numbers in parentheses are standard errors.

b. Defined in the text.

c. The implied inflation effect is the sum of (1) the inflation coefficients and (2) the product of *MPIR* coefficient and $dMPIR/d\pi$ for regime G in tables 9.2 and 9.3.

funds to the corporate sector is quite elastic. Apparently, investment incentives aimed at the corporate sector do raise investment rather than dissipating because of offsetting increases in the return to debt and equity capital. In terms of figure 9.3, the estimate implies that $i_4 - i_0$ is only about one-fourth of $i_1 - i_0$ because the expansion of corporate investment reduces the pretax rate of return on investment.[56]

The extent to which the increase in corporate investment represents an increase in total national investment depends on the offsetting effect of the higher interest rate. If the total supply of investable funds were fixed, traditional investment incentives would succeed only in transferring investment to corporate business from other sectors, such as homebuilding. But the supply of investable funds is not fixed. Total investment can increase because savings rise, the net international capital flow to the United States increases, or the government reduces its deficit. Indeed, a principal rationale for investment incentives has been to maintain aggregate demand with a smaller government deficit. The effect of tax-induced changes in MPIR on total national investment requires an analysis that goes beyond the current framework.

The present study can also provide only partial information about the incidence of changes in the corporate tax rules. The estimate that α_1 is approximately 0.25 suggests that only a small part of the increase in MPIR is shifted to the corporate bondholder. The more general question of the extent to which the incidence of the tax change is shifted from capital in general to labor cannot be answered accurately on the basis of current information. The answer depends on the change in the return to capital outside the corporate sector and on the share of the corporate sector in the total capital stock. Consider, for example, a change in the corporate tax that implies an increase of 100 basis points in MPIR and that causes a rise of 25 basis points in the long-term bond rate. If the return to all other forms of capital also increased by 25 basis points and if corporate capital accounted for one-third of the total privately owned capital stock, 75 percent of the benefit of the tax change would fall on capital and 25 percent on labor.[57] Since corporate bonds and other securities are not perfect substitutes, it would probably be more reasonable to assume that the average rise in the yield on capital is less than 25 basis points. This in turn would imply that capital as a whole bears less than 75 percent of the effect of stimulative changes in corporate tax rules. The remainder would be shifted to labor through the higher productivity and

56. Hall and Jorgenson (1967) are not far from the truth in their assumption that the interest rate remains constant when tax incentives vary; to the extent that their assumption is wrong, they overstate the tax-induced changes in the desired capital stock.

57. More generally, the share of a corporate tax change that is borne by capital in general equals the rise in the average return to capital (relative to the change in MPIR) divided by the corporate share of the capital stock.

wages that result from increased investment. This estimate must be regarded as preliminary and subject to substantial error.

The estimated effect of changes in expected inflation support the conclusion of the second section that the long-term bond rate rises by approximately the same amount as the increase in inflation. Although the corporate MPIR variable rises by about one-fifth more than the increase in inflation, the effect of inflation on the supply of funds to the corporate sector implies that the net change is smaller than this. In terms of the last diagram, if the investment-demand schedule is shifted by inflation alone, $i_1 - i_0$ would exceed π. But $i_1 - i_0$ is found to be approximately equal to π, which implies that inflation substantially reduces the real net return to lenders.

We turn finally to the estimates of equations (6-5 to 6-8), which use the Box-Jenkins variable to indicate shifts in the supply of funds. These equations provide a less satisfactory explanation of variations in the interest rate. The results are also quite sensitive to whether MPIR is adjusted for changes in profitability. With no such adjustment, the results are quite unsatisfactory.[58] In contrast with the cyclically adjusted MPIR variable (equations 6-6 and 6-8), the results are very similar to the estimates based on the distributed lag specification of inflation. Moreover, when these equations are estimated in first-difference form (using instrumental-variable estimation) the parameter values are quite stable. The coefficient of *MPIR33GAP* is 0.53 (with a standard error of 0.44) and the coefficient of π^e is 0.96 (0.57); with *MPIR33NAP*, the corresponding coefficients are 0.31 (0.27) and 0.91 (0.46).

To examine the possibility that the long-term interest rate responds to cyclical conditions directly, we reestimated the equations of table 9.6 with capacity utilization as an additional variable. In general, its coefficient was small and statistically insignificant. In one key specification, corresponding to equation (6-2), the capacity utilization variable was significantly positive (implying that an increase of 1 percentage point in capacity utilization has the direct effect of raising the long-term interest rate by 5 basis points) and the coefficient of the MPIR variable was reduced to 0.07 with a standard error of 0.10. This suggests a further reason for caution in interpreting the point estimates of the coefficient of the MPIR variable but supports the conclusion that the actual interest rate is changed very little by tax-induced shifts in the maximum potential rate of interest.

Obviously, the estimates presented in this section must be treated as preliminary and regarded with caution. However, they offer no grounds for rejecting the conclusion of section 9.2 that an increase in the rate of

58. The coefficients of the MPIR variables in equations (6-5 and 6-7) are both unreasonably high. When these equations are estimated in first-difference form (using instrumental-variable estimation) the MPIR coefficients become very small and statistically insignificant.

inflation causes an approximately equal increase in the nominal pretax interest rate. This conclusion supports the analytic results of the first section that the tax deductibility of interest payments just about offsets the historic cost method of depreciation. Finally, the results of this section suggest that the supply of funds to the nonfinancial corporate sector is elastic enough to make a tax-induced change in the maximum potential interest rate cause a substantially smaller change in the actual interest rate.

9.4 Conclusion

The primary emphasis of this paper has been on the interaction of taxes and inflation in determining the interest rate on long-term bonds. The current U.S. tax system makes the impact of inflation much more complex than it was in Irving Fisher's time. The basic Fisherian conclusion that anticipated inflation has no effect on real variables is no longer correct.

We began our analysis by calculating the interest rate that a firm can pay on a "standard investment" project if its investment is financed one-third by debt and two-thirds by equity. The deduction of interest payments in calculating taxable income implies that this maximum potential interest rate rises by more than the rate of inflation. Offsetting this is the use of historic cost depreciation, which makes the MPIR rise less than the rate of inflation. On balance, we find that the maximum potential interest rate rises by approximately the same amount as the rate of inflation, with the sign of the difference depending on the assumption about the relation between debt and equity yields.

Our econometric estimates of the relation between inflation and the long-term interest rate confirm that the nominal rate rises by approximately the rate of inflation. This implies that the real interest rate net of tax available to investors is reduced dramatically by inflation. For example, an investor who pays a 50 percent marginal tax rate will find that a real net-of-tax return that is 2 percent in the absence of inflation vanishes when there is a 4 percent rate of inflation.

The fall in the real net rate of interest received by investors also corresponds to a fall in the real net cost of debt capital to firms. It is wrong, however, to regard this as a major stimulus to investment. The analysis of the first section shows that an inflation-induced fall in the real net-of-tax rate of interest at which firms can borrow is not a stimulus to investment because, given the tax and depreciation rules, inflation also reduces by about as much the maximum real net-of-tax interest rate that they can afford to pay on a standard investment.

Although our analysis has emphasized the interaction between taxes and inflation, we have also been interested in the effects of corporate tax changes themselves. The results of section 9.1 showed that the changes in tax rates and depreciation rules during the past twenty-five years would, in the absence of inflation, have increased the maximum interest rate that firms could afford by about 2 percentage points. Our econometric estimates in section 9.3 suggest that the elasticity of the supply of funds to purchase corporate debt is great enough that the interest rate actually rises by only about one-fourth of the potential increase induced by changes in corporate rules. The tax changes that were designed to stimulate corporate investment were therefore not offset by the resulting increases in the interest rate.

We believe that we have a useful analytic method for studying the effect of alternative tax rules. By translating the changes in tax rules and inflation into corresponding changes in the maximum rate that firms can pay for capital, we can study the changes in investment incentives and in the response of market yields. We plan to extend our analysis to include a more general model of corporate finance and to study a wider range of problems.