NBER WORKING PAPER SERIES

# HIDDEN STIMULI TO CAPITAL FORMATION: DEBT AND THE INCOMPLETE ADJUSTMENT OF FINANCIAL RETURNS

Robert S. Chirinko

Stephen R. King

Working Paper No. 1684

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 1985

This paper has benefitted from helpful comments and suggestions offered by Robert Eisner, Irwin Friend, Robert Gordon, Joel Hasbrouck, Richard Kopcke, George Kopits, Robert McDonald, John Wood, and seminar participants at Northwestern University and the Board of Governors. Financial support from the Social Science Research Council, Northwestern University, the Hoover Institution, and the National Science Foundation under Grant No. SES-8309073 is gratefully acknowledged. Remaining errors and omissions are the sole responsibility of the authors. The research reported here is part of the NBER's research programs in Economic Fluctuations and Taxation and projects in Government Budget and Taxation and Capital Formation. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #1684
August 1985

# Hidden Stimuli to Capital Formation: Debt and the Incomplete Adjustment of Financial Returns

## ABSTRACT

There is a common belief that the disappointing economic performance in the 1970s can be attributed in good part to the interaction of tax rules, inflation, and capital formation. In this paper, we reassess the relationships between inflation, the tax code, and investment incentives because previous results are based on a number of tenuous assumptions whose impact has not been fully appreciated. We also question the appropriateness of the conventional user cost formulation, and derive an alternative measure taking explicit account of the role of debt -- acquisition, retirement, and net-of-tax interest payments -- and the equityholders' ownership of the firm. Our numerical results show that previously reported disincentives for acquiring capital goods in general and against longer-lived capital in particular are attenuated, and in a number of cases reversed, under various sets of assumptions. Differences in results stemming from the conventional and modified user costs are highlighted, and are illustrated by a comparison of the U.S. Treasury's tax reform proposals under the two formulations.

Robert S. Chirinko
Committee on Policy Studies
University of Chicago
1050 E. 59th Street
Chicago, IL 60637
(312) 962-8400

Stephen R. King
Department of Economics
Stanford University
Stanford, CA 94305
(415) 497-2298

# Hidden Stimuli to Capital Formation: Debt and the Incomplete Adjustment of Financial Returns

Did the high inflation of the 1970s depress incentives for businesses to invest in plant and equipment? This question has been investigated in a number of studies utilizing variants of the conventional neoclassical user cost of capital, and a general conclusion emerging from this work, shared by policymakers (White House, 1981), is that the interaction of inflation with the existing tax code has reduced firms' incentives to acquire capital (Feldstein, 1982, 1983, Kopcke, 1981). Inflation affects investment decisions by causing variations in the value of tax depreciation deductions, the firm's discount rate, and the cost of debt (as we shall see, the latter two channels are not always identical).[1] In this paper, we reassess the relationship between inflation and investment incentives because previous results are based on a number of tenuous assumptions whose impact has not been fully appreciated. These include the adjustment of financial returns to inflation, the appropriateness of the capital structure invariance assumption, and the role of personal taxes. Calculations with a range of relevant parameters indicate that previously reported disincentives for acquiring capital goods are attenuated, and in a number of cases reversed, under various configurations of these key assumptions. Our simulations highlight that in an inflationary environment, incentives for acquiring longer-lived capital are depressed relatively more than those for shorter-lived assets only under a rather restrictive set of assumptions. Furthermore, we show that the results are extremely sensitive to the exact values of underlying parameters, which are unlikely to be known with any accuracy.

In conventional definitions of the user cost (Hall and Jorgenson, 1967), the firm's discount rate is defined by the opportunity cost of funds, a weighted average of the costs of equity and debt (including tax considerations) with weights depending on the leverage ratio. Brock and Turnovsky (1981) have shown recently that such a definition is appropriate when the firm maximizes with respect to the joint interests of bondholders and equityholders. However, in general, the interests of these agents with financial claims on the firm's capital may be in conflict. An alternative approach pursued in this paper is to assume that the firm maximizes with respect to the interest of equityholders and to view bondholders as supplying a factor of production (debt) for which they are compensated (interest plus principal). Our modified neoclassical model, derived rigorously in Section II, gives explicit attention to the acquisition and retirement of debt and to net-of-tax interest payments, and discounts the firm's cash flows by the net-of-tax return required by equityholders. Under some assumptions, the conventional and modified definitions are identical but, when they diverge, their implications for investment incentives can differ sharply. This divergence is illustrated in section IV by an examination of the implications of the U.S. Treasury's tax reform proposals (U. S. Treasury, 1984) under the conventional and modified user cost expressions. Section V concludes.

## II. The User Cost of Capital

In this section, we derive a modified expression for the user cost of capital giving explicit attention to the ownership of the firm and to the role of debt, and contrast our formulation with the conventional specification. The representative firm operates in the sole interest of its existing shareholders, and is assumed to maximize the present discounted value of its cash flow over an infinite horizon. The present discounted cash flow $(V(0))$ in period 0 of an untaxed and unlevered firm is

$$(1) \qquad V(0) = \int_0^{\infty} \exp(-\int_0^t \rho(s\ ,\ \pi)\ ds)\ \{p(t)\ F(L(t),\ K(t)) - w(t)\ L(t) - q(t)\ I(t)\}\ dt,$$

where $\rho(s\ ,\ \pi)$ is the equityholders' nominal discount rate, which may be related to the inflation rate $(\pi)$. 2/ The production function $(F(\cdot))$ depends on labor $(L(t))$ and capital $(K(t))$, and is assumed strictly concave and twice continuously differentiable. The firm operates in perfectly competitive markets, and faces exogenous prices for output $(p(t))$, labor $(w(t))$, and new capital $(q(t))$. To relate current investment $(I(t))$ to the existing stock of capital, we assume that capital depreciates at an exponential rate $(\delta)$ and hence is governed by the following differential equation,

$$(2) \qquad \dot{K}(t) = I(t) - \delta K(t).$$

The cash flow potentially available to shareholders is affected by an income tax, a tax credit, and depreciation allowances on investment expenditures. An income tax is assessed at rate $\tau_c(t)$ against the firm's revenues less labor costs, and is reduced by a tax credit $(k(t))$ extended on the purchases of investment goods. The effective price of capital goods is further lowered by depreciation allowances granted against taxes and based on both current and past investments,

$$(3) \qquad TD(t) = \tau_c(t) \int_{-\infty}^{t} D(t - s, s, L)\, q(s)\, I(s)\, ds, \quad t \epsilon [0,\infty)$$

where $D(t - s, s, L)$ are tax depreciation allowances per dollar of investment made $t - s$ periods ago according to the tax code in effect in period $s$ for an asset with life $L$. Equation (3) can be rearranged to isolate those factors that depend on current decisions and those that are predetermined at time $T$ (Hayashi, 1982),

$$(4a) \qquad TD(t) = z(t, \rho(t, \pi), L)\, q(t)\, I(t) + A(t, 0, L),$$

where

$$(4b) \qquad z(t, \rho(t, \pi), L) = \int_0^{\infty} \{\exp(-\int_0^{s} \rho(t + u, \pi)\, du)\, \tau_c(t + s)\, D(s, t, L)\} ds,$$

$$(4c) \qquad A(t,0,L) = \tau_c(t) \int_{-\infty}^{0} D(t - s, s, L)\, q(s)\, I(s) ds. \quad t \epsilon [0,\infty).$$

The expression for $z(t, \rho(t, \pi), L)$ represents the present discounted value of current and future tax depreciation allowances flowing from a dollar of investment in period $t$,[3] and (4c) is the total value of tax depreciation allowances claimed at time $t$ on capital assets purchased before time $0$.

Debt finance is introduced into the model by augmenting the firm's cash flow problem with the acquisition and retirement of debt and net-of-tax interest payments. A firm that finances a proportion $(b(t))$ of its investment with debt will have its cash flow incremented by

$$(5)\qquad (1 - k(t) - z(t))\, b(t)\, q(t)\, I(t),$$

where the capital outlay $(q(t)\, I(t))$ is lowered by the tax credit $(k(t))$ and tax depreciation allowances $(z(t))$. We assume that debt is retired at an exponential rate $(\gamma)$. In period $t$, the cash flow devoted to retirements is the amount of debt issued at time $s$, $((1 - k(s) - z(s))\, b(s)\, q(s)\, I(s))$, multiplied by the "survival" factor $(\exp - \gamma(t - s))$ and the retirement rate $(\gamma)$, and summed from time $t$ backward is,

$$(6)\qquad \int_{-\infty}^{t} (1 - k(s) - z(s))\, b(s)\, q(s)\, I(s)\, \gamma \exp(-\gamma(t - s))\, ds.$$

Interest payments at time $t$ are the product of the amount of debt issued at time $s$ surviving at time $t$ and the interest rate $(i(s, \pi))$ prevailing at time $s$, summed from time $t$ backward, and multiplied by one less the tax rate at time $t$ (reflecting the tax deductability of nominal interest payments),

$$(7)\qquad (1 - \tau_c(t)) \int_{-\infty}^{t} i(s, \pi)\, (1 - k(s) - z(s))\, b(s)\, q(s)\, I(s) \exp(-\gamma(t - s))\, ds.$$

Following our treatment of tax depreciation allowances (4), we isolate those debt-related factors that depend on current decisions and those that are predetermined at time $t$. Summing (6) and (7) yields the net cost of current and past investment:

(8a) $$\hat{q}(t)\ I(t) + B(t, 0),$$

where,

(8b) $$\hat{q}(t) = q(t)\ (1 - k(t) - z(t))\ \{1 + b(t)\ [\frac{(1 - \tau_c(t))\ i(t, \pi) + \gamma}{\rho(t, \pi) + \gamma} - 1]\},$$

(8c) $$B(t, 0) = (1 - \tau_c(t)) \int_{-\infty}^{0} i(s, \pi)\ X(s, t)\ ds + \gamma \int_{-\infty}^{0} X(s, t)\ ds,$$

(8d) $$X(s, t) = (1 - k(s) - z(s))\ b(s)\ q(s)\ I(s)\ \exp(-\gamma(t - s)). \quad t \varepsilon [0, \infty).$$

Equation (8b) is the purchase price of a unit of new capital less tax credits and deductions and the financial advantage of utilizing $b$ percent of debt for the marginal investment. The latter effect is represented by the term in braces,[4/] and vanishes in the case of an all equity firm $(b(t) = 0)$. Of the terms in braces, the minus one represents the benefit of issuing one dollar of debt and is balanced by the costs per dollar: the net-of-tax interest and retirement payments both discounted by $(\rho(t, \pi) + \gamma)$. This term represents the "gain from leverage" (c.f., Miller, 1977) accruing to the firm on its marginal debt. If financial policy eliminates arbitrage profits between the net-of-tax cost of borrowing and the firm's discount rate, then the term in braces becomes zero, and the potential advantage to shareholders of debt-financing, resulting from the tax deductability of the firm's interest payments, would be eliminated.

Equation (8c) represents net-of-tax interest and debt retirement payments at time $t$ on debt acquired at time $s$ surviving at time $t$ $(X(s, t))$. When integrated from zero to infinity and discounted by

$\rho(t, \pi)$, $B(t, 0)$ is the market value of the firm's debt. This result holds for any time paths of the variables, but becomes readily apparent when we assume $i(t, \pi)$, $\tau_c(t)$, and $\rho(t, \pi)$, are constant over time, in which case, the market (MV(0)) and face (FV(0)) values of debt at time t are:

(9a) $$MV(0) = [((1 - \tau_c)\ i(\pi) + \gamma)/(\rho(\pi) + \gamma)]\ FV(0),$$

(9b) $$FV(0) = \int_{-\infty}^{0} (1 - k(s) - z(s))\ b(s)\ q(s)\ I(s)\ \exp(\gamma s)\ ds.$$

If interest rates adjust fully to eliminate arbitrage opportunities, then the term in braces in (9a) becomes unity, and the face and market values of debt are identical.

We recognize that distributions to existing shareholders are taxed at the personal level, and the net-of-corporate tax cash flow for the firm described in the above equations must be multiplied by one less the rate of taxation on equity $(\tau_e)$. Lastly, we assume that all prices grow at a constant and fully anticipated exponential rate, $\pi$. Combining these assumptions with (1), (2), (4), and (8), we obtain the following expression for the value of the firm to existing shareholders at time 0 as the discounted, net-of-tax cash flow,[5]

$$(10) \qquad V(0) = \int_0^\infty \exp(-\int_0^t \rho(s, \pi)\, ds + \pi t)(1 - \tau_e(t))$$

$$\{(1 - \tau_c(t))\ [p_0 F(L(t), K(t)) - w_0 L(t)]$$

$$- (1 - k(t) - z(t, \rho(t, \pi), L))\ q_0\ I(t)$$

$$- (1 - k(t) - z(t, \rho(t, \pi), L))\ b(t)\ q_0\ I(t)\ \{ \int_0^\infty$$

$$\exp(- \int_0^s (\rho(t + u, \pi) + \gamma)\ du\ [(1 - \tau_c(t + s))\ i(t, \pi)$$

$$+ \gamma]\ ds - 1.0\} + A(t, 0, L) - B(t, 0)]\}\ dt,$$

where $p_0$, $w_0$, and $q_0$ are the initial price levels and $I(t) = \dot{K}(t) + \delta K(t)$. Since both $A(t, 0, L)$ and $B(t, 0)$ are predetermined from time zero onward, they do not influence the firm's optimal choices. By calculating the Euler equation for capital from (10), we derive the following expression for the marginal revenue product of capital $(p_0 F_K(\cdot))$, which we define as the user cost of capital $(C(\pi))$, [6]

$$(11) \qquad p_0 F_K(\cdot) \equiv C(\pi) = \frac{q_0}{1 - \tau_c} (\rho(\pi) + \delta - \pi)(1 - k - z(\rho(\pi), L))$$

$$(1 + b[\frac{(1 - \tau_c)\ i(\pi) + \gamma}{\rho(\pi) + \gamma} - 1]).$$

By contrast, the conventional user cost of capital (Hall and Jorgenson, 1967; Brock and Turnovsky, 1981) can be written as

$$(12) \qquad C_c(\pi) = \frac{q_0}{1 - \tau_c} (\rho_c(\pi) + \delta - \pi)(1 - k - z(\rho_c(\pi), L)),$$

where the discount rate $\rho_c(\pi)$ is a weighted-average of the costs of debt and equity,[7/]

$$(13)\qquad \rho_c(\pi) = b(1 - \tau_c)\, i(\pi) + (1 - b)\, \rho(\pi).$$

Under any of the following conditions, the modified (11) and conventional (12, 13) user cost expressions are equal:

(14)
- no leverage $(b = 0)$,
- the elimination by the firm of arbitrage opportunities between the costs of debt and equity $(\rho = (1 - \tau_c)\, i)$;
- an equality between the rate of capital depreciation and the effective real retirement rate of debt $(\delta = \gamma + \pi)$ and an equality between the value of depreciation allowances $(z(\rho(\pi)) = z(\rho_c(\pi)))$. [8/]

When any of these conditions hold, the impact of inflation on investment incentives is the same under either user cost expression. In particular, the elimination of arbitrage opportunities implies that b does not enter either user cost formula; hence the firm's investment decisions and market value are invariant with respect to its capital structure.[9/] In the absence of (14), the choice of the user cost formula becomes important and the responses of investment incentives to inflation can diverage sharply.

## III. The Response of Investment Incentives to Inflation

In this section, we examine four inflation-related factors that can impact investment incentives. First, since depreciation allowances are based on historical costs, increases in inflation lead to a decline in the present value of these deductions $(z)$. Second, the costs of debt and equity may not adjust completely to inflation, thus reducing financing costs to the firm. These two effects will exist independently of the assumption concerning financial arbitrage and, in sub-section A, will be analyzed under the assumption of capital structure invariance. If capital structure invariance does not hold, then a third effect arises due to debt finance, and will need to be evaluated under both user costs. Fourth, defining the equityholders' discount rate $(\rho)$ net of personal taxes can affect the impact of inflation on investment incentives. The latter effects are assessed in sub-section B, given responses of nominal debt and equity returns to inflation that are roughly consistent with the data. The sensitivity of our calculations to variations in underlying parameters is examined in sub-section C.

### A. Capital Structure Invariance

With the elimination of arbitrage opportunities between the costs of debt and equity, we have the following equality,

$$(1 - \tau_c)\ i(\pi) = \rho(\pi). \tag{15}$$

To perform the calculations, we need to specify the response of either nominal interest or shareholders' discount rates to inflation. We choose to focus on the former because it is relatively easy to measure and has been studied extensively. If the real cost of debt to the firm is to remain constant, the $i(\pi)$ must rise by $(1/(1 - \tau_c))$, the modified Fisher effect highlighted by Darby (1975) and Feldstein (1976) and implied by the model of Miller (1977).[10/] The impact on investment incentives is reported in the upper panel of table I, and these figures represent the percentage changes in investment incentives at inflation rates of 3, 6, and 9 percent compared to the no-inflation case.[11/] Were the production function to have a constant elasticity of substitution of unity, these numbers would correspond exactly to the percentage change in the optimal capital stock. Hence a positive entry would correspond to an optimal capital stock larger than that at zero inflation. For a production function with less than unit elasticity, the change in the optimal capital stock would be smaller than the numbers in the table but of the same sign. Under capital structure invariance, the results are independent of leverage, and are presented for asset lives of 5, 10, 20, and 30 years.[12/] It is apparent that investment incentives are reduced for all asset lives by inflation's effect on the value of depreciation allowances with the greatest effects felt by longer-lived assets.

It would, however, be misleading to consider only the effects of inflation on tax depreciation allowances (cf., Kopcke, 1981) when it is well-established that net-of-tax debt costs have also fallen with inflation. Kane, Rosenthal, and Ljung (1983), Peek and Wilcox (1983), Summers (1983), and Tanzi (1980), among others, have estimated that nominal interest rates have risen <u>at most</u> one-for-one with inflation. To investigate the ramifications of this incomplete adjustment, the bottom panel of Table I repeats the analysis under capital structure invariance but with $di(\pi)/d\pi = 1$. It remains the case that the "gain from leverage" term in (11) equals zero and $\rho(\pi) = \rho_c(\pi)$, so the calculations are independent of the leverage ratio (b), and of the debt retirement rate $(\gamma)$, and hence are identical between either user cost expression. In marked contract to the above results, investment incentives rise at all inflation rates, and the increases are greatest for the assets with longer lives. Taken together, the results in table I indicate that the deleterious effect on investment incentives due to historical cost depreciation are swamped by the stimulus arising from the incomplete adjustment of financial returns.

B. Debt and Personal Tax Rates

The arbitrage restriction employed in sub-section A carries with it the unfortunate implication that if $di(\pi)/d\pi = 1$, then the change in equityholders' nominal discount rate with respect to inflation is $(1 - \tau_c)$ or around .48. Such a sluggish response is contradicted by the empirical results of Fama (1981) and Hendershot and Hu (1980). In this sub-section, the capital structure invariance assumption is replaced with the empirically-based relation that both $\rho(\pi)$ and $i(\pi)$ move one-for-one with inflation.13/ Capital structure invariance may not hold in equilibrium because of large fixed transactions costs, a lack of a complete set of markets (Taggart, 1980), or restrictions on the type of debt securities that may be issued (DeAngelo and Masulis, 1980). The results with $d\rho(\pi)/d\pi = 1 = di(\pi)/d\pi$ are presented in Table II, and are calculated for leverage ratios of .25 and .75 and for both definitions of user costs.[14/] In both cases it is apparent that more highly levered investments suffer less disincentives from inflation than lower levered ones (as a consequence of the declining real after-tax cost of debt). Short lived assets are also seen to be less affected by inflation than long lived ones, except in the case of the conventional model at a high leverage rate. For a highly levered firm, investment incentives actually increase with inflation in the conventional model, reflecting the decrease in the post-tax discount rate (11). The apparent extreme sensitivity of investment incentives to inflation and leverage in the conventional framework has been noted previously by Hall (1981) but, as the results in the top panel of table II suggest, may be greatly overstated.[15/]

Table III assesses the fourth and final effect by defining the shareholders' discount rate net of personal taxes as implied by our derivation of the user cost in Section II. While recognizing that estimating the appropriate tax rate is a difficult matter, we assume that $\tau_e$ equals .20, thus $d\rho(\pi)/d\pi = (1 - \tau_e) = 0.8$ (alternative values of $\tau_e$ are examined in table IV). Again it is apparent that this conventional user cost measure greatly exagerates the effects of inflation and leverage on investment incentives, compared to the modified version. In both versions, however, taking account of taxes on equityholders does mitigate the negative effect of inflation on investment incentives by amplifying the incomplete adjustment of financial returns.

C. Sensitivity Analysis

Any numerical simulations are, by their very nature, only valid for the parameters chosen. So in table IV we examine the sensitivity of our results to two factors which appear most crucial and whose magnitudes are uncertain.

The first panel presents results comparable to those in the top right panel of Table IIIb, but with alternative equityholders' tax rates of 10 and 30 percent. These tax rates make a considerable qualitative difference to the results, since they change the effective discount rate of firms. When $\tau_e$ is 0.10, all entries in table IV.A are negative; but these changes in investment incentives become nearly zero, or positive, when $\tau_e$ equals 0.30. Since the "true" tax rate is unlikely to be known with any precision, these results cast doubt on the often proclaimed harmful effects of inflation and non-neutral tax rules on investment.

The final panel of Table IV investigates the sensitivity of the results to alternative assumptions about the adjustment of equity returns to inflation. It examines the impacts of 80% and 120% adjustment. Again it is seen that, even for our modified user cost, which is less sensitive than the conventional expression, the effects of inflation on investment incentives depends strongly on the exact assumptions made about the inflation adjustment of financial returns.

IV. The Treasury's Tax Reform Proposal

The above results highlight that calculations of investment incentives are sensitive both to a number of underlying parameters and to the user cost formulation. To illustrate this sensitivity, we next examine the tax reform plan presented by the U.S. Treasury (November 1984). The Treasury Proposal is designed to eliminate distortions among business assets and inflation rates by removing the investment tax credit, indexing and decelerating depreciation allowances, lowering the corporate tax rate, and allowing only the real part of interest payments to be deductible from pre-tax income.[16/] The models develped above can assess the extent to which the Proposal is consistent with the Reagan Administration's twin goals of enhancing investment incentives and adopting a tax code that is neutral between asset lives.[17/]

The incentive effects of the Treasury Proposal are shown in Table V, which contains the percentage changes in investment incentives resulting from the Tax Equity and Fiscal Responsibility Act (TEFRA) adopted in 1982 and from the Treasury Proposal, both relative to the tax code prevailing in 1979. Inflation and financing rates are based on observations for the latter part of 1984. Under either user cost formulation, the provisions of TEFRA substantially enhanced investment incentives. For both long-lived and, especially, short-lived assets, the Treasury proposal clearly imparts less stimulus than was forthcoming under TEFRA.

The calculations are based on the partial equilibrium assumption that the adoption of the Treasury Proposal would not, on its own, reduce financing rates. It is possible that the proposals might result in lower interest rates, as a consequence of the reduction of individual tax rates, restrictions on the tax-deductibility of personal borrowing, and the partial deductibility of dividend payments. If the proposal were to be accompanied by a two point reduction in financing rates, and no change in inflation, then the investment incentives would be as generous as under the Carter tax policy, for all lowly leverered assets. However, since the value of the debt deductions would be reduced by the exclusion of the nominal part of interest payments and by the lower corporate tax rate, highly levered assets would continue to be treated less favorably under the Treasury Proposal.

To assess the neutrality of the proposed changes in the tax code (as they directly affect business fixed investment), we calculate the "tax wedge" between the net marginal product of capital, $(C - \delta)$ and the opportunity cost of funds $(\rho)$.[18/] The value in the table indicates the absolute amount that the net marginal product of capital must be raised (if positive) to accomodate tax effects: if no tax parameters were present, the wedge would be zero. As can be seen in Table VI, the wedge under the Carter tax policy (but with current financing rates) differs greatly between different assets. Under TEFRA, tax wedges are uniformly lower, especially for equipment, but substantial variation still remains. Eliminating this variation was one of the goals of the Treasury Proposal, but neutrality holds under only a limited set of circumstances. The conventional specification generates tax wedges that are stable across asset lives and, for a given life, among inflation rates (cf. columns (7) and (8)). However, neutrality does not hold under our modified user cost formulation. Variations among assets are particularly evident for the modified user cost and a high leverage ratio. With 5 percent inflation and a leverage ratio of .75, a 30 year asset must earn a return that is 3.6 percentage points higher than an asset purchased under the same conditions but having a 5 year life. Were the marginal leverage ratio .25, the tax wedge would be only 2.1 percentage points.

## V. Summary

In recent years, much attention has been given to the supposed deleterious effects of inflation and existing tax rules on investment incentives. To analyze these relationships, we have developed a modified definition of the user cost of capital that takes explicit account of the ownership of the firm and of debt acquisition, retirement, and net-of-tax interest payments. Using this formula as well as the conventional expression, we have simulated the response of investment under a wide variety of assumptions and have found that,

> investment incentives are depressed when the sole effect of inflation is to lower the value of tax depreciation allowances (Table I.A);

- however, the incomplete adjustment of interest rates, coupled with a capital structure invariance assumption, imparts a major stimulus to capital formation (table I.B);

- when capital structure invariance is replaced by the empirically-based assumption that the nominal rates on debt and equity move one-for-one with inflation, investment incentives fall with inflation in the modified model, whereas for highly levered assets, the conventional model implies they rise with inflation (table II); in both models, investment incentives are enhanced somewhat, ceteris paribus, by debt financing;

- defining the shareholder's discount rate net of personal taxes, as implied by the user cost derivation, attenuates any negative effects of inflation on investment incentives (table III);

- lastly, the interaction of the tax code and inflation do not necessarily discriminate against longer-lived assets except under capital structure invariance and when nominal interest rates adjust completely to inflation (table I.A).

Hence, contrary to the claims of some authors, our results cast considerable doubt on the central role of inflation in reducing capital formation in the 1970s and in discriminating against longer lived assets. The paper ends by drawing attention to the high sensitivity of all measures of investment incentives to assumed parameters that are unlikely to be known in the aggregate with any accuracy. This, in itself, suggests caution in undertaking policy analysis on the basis of existing economic models.

## References

Aivazian, Varouj, and Callen, Jeffrey L., "Investment, Market Structure and the Cost of Capital," Journal of Finance 34 (March 1979), 85-92.

Auerbach, Alan J., "Wealth Maximization and the Cost of Capital," Quarterly Journal of Economics 93 (August 1979), 433-446.

Bradford, David F., and Fullerton, Don, "Pitfalls in the Construction and Use of Effective Tax Rates," in Charles R. Hulten (ed.) Depreciation, Inflation, and the Taxation of Income from Capital (Washington, D.C.: Urban Institute, 1981), 251-276.

Brock, William A., and Turnovsky, Stephen J., "The Analysis of Macroeconomic Policies in Perfect Foresight Equilibrium," International Economic Review 22 (February 1981), 179-209.

Chirinko, Robert S., "New Estimates of Average Marginal Tax Rates on Dividends and Capital Gains," Cornell University Working Paper No. 289 (December 1982).

,"The Impact of the Inventory Profits Tax and Other Distortionary Business Taxes and Economic Welfare," Cornell University (December 1983).

Corcoran, Patrick J., "Inflation, Taxes, and the Composition of Business Investment," Federal Reserve Bank of New York Quarterly Review 4 (Autumn 1979), 13-24.

Darby, Michael R., "The Financial and Tax Effects of Monetary Policy on Interest Rates," Economic Inquiry 13 (June 1975), 266-276.

DeAngelo, Harry, and Masulis, Ronald W. "Leverage and Dividend Irrelevancy Under Corporate and Personal Taxation," Journal of Finance 35 (May 1980), 453-464.

Edwards, J.S.S., and Keen, M.J., "Wealth Maximization and the Cost of Capital: A Comment," Quarterly Journal of Economics 99 (February 1984), 211-214.

Fama, Eugene A., "Stock Returns, Real Activity, Inflation, and Money," American Economic Review 71 (September 1981), 545-565.

Feldstein, Martin, "Inflation, Income Taxes, and the Rate of Interest: A Theoretical Analysis," American Economic Review 66 (December 1976), 809-820.

, "Inflation, Tax Rules and Investment: Some Econometric Evidence," Econometrica 50 (July 1982), 825-862.

, "The Fiscal Framework of Monetary Policy," Economic Inquiry 21 (January 1983), 11-23.

, Dicks-Mireaux, Louis, and Poterba, James, "The Effective Tax Rate and the Pretax Rate of Return," Journal of Public Economics 21 (August 1983), 129-158.

, Green, Jerry, and Sheshinski, Eytan, "Corporate Financial Policy and Taxation in a Growing Economy," Quarterly Journal of Economics 93 (August 1979), 411-432.

, and Summers, Lawrence H., "Inflation and the Taxation of Capital Income in the Corporate Sector," National Tax Journal 32 (December 1979), 445-470.

Gordon, Roger H. and Malkiel, Burton G., "Corporation Finance," in Henry J. Aaron and Joseph A. Pechman (eds.), How Taxes Affect Economic Behavior (Washington: Brookings, 1981).

Gravelle, Jane G., "Effective Corporate Tax Rates and Tax Changes in the 97th Congress," Congressional Research Service (January 1983).

Hall, Robert E., "Tax Treatment of Depreciation, Capital Gains, and Interest in an Inflationary Economy," in Charles R. Hulten (ed.) Depreciation Inflation, and the Taxation of Income from Capital (Washington: Urban Institute, 1981), 149-166.

, and Jorgenson, Dale W., "Tax Policy and Investment Behavior," American Economic Review 62 (June 1967), 391-414.

Hayashi, Fumio, "Tobin's Marginal q and Average q," Econometrica 50 (January 1982), 213-224.

Hendershott, Patric H., and Hu, Sheng-Cheng, "Government Induced Biases in the Allocation of the Stock of Fixed Capital in the United States," in George M. von Furstetenberg (ed.) Capital, Efficiency and Growth (Cambridge: Ballinger, 1980), 323-360.

Kane, Alex, Rosenthal, Leonard, and Ljung, Greta, "Tests of the Fisher Hypothesis with International Data: Theory and Evidence," Journal of Finance 38 (May 1983), 539-564.

King, Mervyn and Fullerton, Don (eds.), The Taxation of Income From Capital: A Comparative Study of the U.S., U.K., Sweden and West Germany (Chicago: University of Chicago, 1984).

Kopcke, Richard W., "Inflation, Corporation Income Taxation, and the Demand for Capital Assets," Journal of Political Economy 89 (February 1981), 122-131.

Miller, Merton H., "Debt and Taxes," Journal of Finance 32 (May 1977), 261-275.

Peek, Joe, and Wilcox, James A., "The Postwar Stability of the Fisher Effect," Journal of Finance 38 (September 1983), 1111-1124.

Summers, Lawrence H., "The Nonadjustment of Nominal Interest Rates: A Study of the Fisher Effect," in James Tobin (ed.) Macroeconomic, Prices and Quantities (Washington: Brookings, 1983), 201-241.

Taggart, Robert A., "Taxes and Corporate Capital Structure in an Incomplete Market," Journal of Finance 35 (June 1980), 645-659.

Tanzi, Vito, "Inflationary Expectations, Economic Activity, Taxes and Interest Rates," The American Economic Review 70 (March 1980) 12-21.

U.S. Department of the Treasury, "Tax Reform for Fairness, Simplicity, and Economic Growth: The Treasury Department Report tc the President, Summary of Proposals," (November 27, 1984).

White House, America's New Beginning: A Program for Economic Recovery (Washington, 1981).

## Footnotes

1/ Inflation may also create artificial inventory profits, but proper analysis of the relationship between this channel and investment incentives requires a different framework (Chirinko, 1983) than that presented in this paper.

2/ Aivazian and Callen (1979) have shown that the equityholders' discount rate will be the appropriate criterion to guide investment if the firm is in a perfectly competitive industry or in steady-state equilibrium.

3/ It should be noted that $z(\cdot)$ depends on the path of current and future values of $\rho$ and that (4) can be derived only when (3) is embedded in a discounted cash flow expression (e.g., (10)).

4/ To derive (8b), we assume that $\tau_c(t)$, $i(t, \pi)$, and $\rho(t, \pi)$ are constant from $t$ onward. These assumptions could be abandoned, and the debt term at time $t$ would become

$$\int_0^{\infty} \{ \exp(-\int_0^{s} (\rho(t + u, \pi) + \gamma))du \; (1 - \tau_c(t + s)) \; i(t, \pi) + \gamma \} \; ds.$$

Note the similarities between this expression and (4b).

5/ In an elaboration of Auerbach's (1979) result concerning wealth maximizing shareholders, Edwards and Keen (1984) have shown that "policies that maximize shareholder wealth can always be characterized as policies that maximize equity value" (p. 212).

6/ The user cost of capital is strictly relevant only in the steady state, and we need to assume that the rates of personal and corporate taxation, the investment tax credit, interest, and discount rates are constant from time 0 onward.

7/ Rather then representing a marginal value, the parameter $b$ in (13) is the average leverage ratio. Since our simulations relate to the steady-state, this difference is immaterial to the interpretation of the results.

8/ The latter equality would exist under a tax system that allowed immediate expensing of capital expenditures $z(\rho(\pi)) = z(\rho_c(\pi)) = \tau_c$), such as currently prevails in the United Kingdom.

9/ This result would not hold if b were determined endogenously, a modification that could be straightforwardly implemented. Following Feldstein, Green, and Sheshinski (1979), we could assume that the interest rate increases with the firm's debt-equity ratio and, with the appropriate transition equation relating the stock and flow of debt, could derive an optimal path for b from an optimal control framework. We have chosen not to pursue this extension because, doing so would have necessitated examining the sensitivity of our results to a number of arbitrary specifications of the relationship between the interest rate and the debt-equity ratio. Our assumption of a constant debt-equity ratio, while only an approximation, is not at odds with ratios observed since the middle of the 1970s (Gordon and Malkiel, 1981, Table I).

10/ In Miller's Figure 1, replace $r_o$ by $(r_0 + \pi)$.

11/ A number of other parameters are needed for the calculations. The investment tax credit rate (k) is taken as 6.7%, 10%, and 5% for assets with 5, 10, and 20-30 year lives, respectively. (Thus we recognize that approximately one-half of structures, as defined in the National Income and Product Accounts, enjoy the benefit of the investment credit (Corcoran, 1979).) The exponential rate of debt retirement ($\gamma$) is chosen at 0.2, implying that 95% of debt will be retired after 15 years. The corporate income tax rate ($\tau_c$) is set constant at 52%: a 48% marginal Federal rate plus 4%, which is the average amount of income taxes paid to State and Local governments from 1970-1979 (Feldstein, Dicks-Mireaux, and Poterba, 1983, Table 3). The equity tax rate ($\tau_e$) was estimated as the average of marginal tax rates facing different classes of dividend receipients. The results of this paper are based on values of .20 and .30 reflecting, respectively, whether transactions or market value weights were used in constructing the averages (Chirinko, 1982). We assume throughout that, at zero inflation, the rate of interest is 3 percent. This number is not atypical of the ex-post real return obtained in the 1970s. The reported results are quite insensitive to the actual magnitudes.

12/ The rate of economic depreciation ($\delta$) and the assumed asset lifetime (L) are clearly not independent, and we choose $\delta$ such that at the end of L years 90 percent of the asset has been depreciated. Hence $\delta = 1 - \exp(\ell n(0.1)/L)$. The $z(\cdot)$ (tax depreciation) function uses the sum-of-years-digits method for asset lives 5 and 10 years, and 150 percent-declining balance method with a switch to straight line after one third of the asset's life has passed for 20 and 30 year assets. Asset lives used in calculating z have been reduced by 20 percent to accord with practices under the Treasury Department's asset depreciation range system.

13/ The quarterly (Q6) and annual (A6) regressions of Fama (1981) imply that $d\rho(\pi)/d\pi = 1$, while the calculations of Hendershott and Hu (1980, pp. 336-339) imply a value of 0.87.

14/ Feldstein and Summers (1979) have argued that the tax subsidy to debt finance resulting from the deductability of nominal interest payments is largely offset by the taxation of nominal interest receipts accruing to bondholders. Such general equilibrium considerations imply that the nominal interest rate should move significantly more than the observed point-for-point with changes in the inflation rate and, in assessing investment incentives in the 1970s, we believe it is more useful to utilize observed, though still unexplained, relationships in a partial equilibrium model.

15/ In their careful study of effective tax rates, King and Fullerton (1984) find a significant amount of dispersion with respect to inflation (Figure 7.1). These calculations are based on the conventional user cost formula (altered to reflect taxes on wealth and inventories), and the dispersion may be attenuated in the modified user cost, especially since the proportion of investment projects financed by debt varies greatly (Appendix A). Since, in their study, the costs of debt and equity finance differ, our modified user cost would seem to be the appropriate formula.

16/ The Indexing feature of the Proposal calls for the undepreciated asset value to be adjusted upwards by the rate of inflation. However, when the rate of inflation exceeds the depreciation rate, which is most likely the case for longer-lived assets, the inflation adjusted value can explode. In our simulations, we avoid this problem by requiring that the inflation-adjusted, undepreciated asset value not exceed the purchase price of the asset, and that depreciation occurs over a maximum period of 65 years.

17/ We are not assessing the effects of all aspects of the Treasury Program (for example, we ignore the changes in the tax treatment of inventories) but merely those of paramount importance to business fixed investment.

18/ Some studies compute effective tax rates by dividing this tax wedge by either $(C - \delta)$, or $\rho$. As noted by Bradford and Fullerton (1981), effective tax rates may flucuate wildly, since either of these denominators may approach zero. We therefore report the tax wedge which is not susceptible to this behavior.

Table I

Percentage Changes in Investment Incentives With The Capital Structure Invariance Assumption

A. $di(\pi)/d\pi = 1/(1 - \tau_c)$

| Asset Life | Inflation Rate | .03 | .06 | .09 |
|---|---|---|---|---|
| | | (1) | (2) | (3) |
| 5 | | - 6.2 | -11.2 | -15.3 |
| 10 | | - 9.9 | -17.0 | -22.2 |
| 20 | | -17.2 | -26.5 | -32.1 |
| 30 | | -19.5 | -28.5 | -33.4 |

B. $di(\pi)/d\pi = 1$

| Asset Life | Inflation Rate | .03 | .06 | .09 |
|---|---|---|---|---|
| | | (1) | (2) | (3) |
| 5 | | 1.0 | 2.4 | 4.2 |
| 10 | | 2.0 | 5.4 | 10.1 |
| 20 | | 3.3 | 11.5 | 25.9 |
| 30 | | 7.4 | 25.2 | 61.3 |

NOTE: All entries are calculated as the ratio of the user cost of capital at a zero inflation rate to the user cost for the indicated inflation rate, less one, multiplied by 100. The calculations are based on either (11) or (12) and on the parameters discussed in fns. 11 and 12.

Table II

Percentage Changes in Investment Incentives Without
The Capital Structure Invariance Assumption

$$di(\pi)/d\pi = 1 = d\rho(\pi)/d\pi, \ \tau_e = 0$$

A. Modified

| Asset Life | Inflation Rate | b = .25 .03 | .06 | .09 | b = .75 .03 | .06 | .09 |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| 5 | | - 4.4 | - 8.2 | -11.3 | - 1.7 | - 3.2 | - 4.6 |
| 10 | | - 7.5 | -13.1 | -17.3 | - 4.8 | - 8.4 | -11.1 |
| 20 | | -12.4 | -19.6 | -24.0 | - 9.9 | -15.2 | -18.3 |
| 30 | | -13.2 | -19.8 | -23.6 | -10.7 | -15.5 | -17.9 |

B. Conventional

| Asset Life | Inflation Rate | b = .25 .03 | .06 | .09 | b = .75 .03 | .06 | .09 |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| 5 | | - 4.2 | - 7.0 | -10.4 | -0.9 | -1.3 | -1.2 |
| 10 | | - 6.4 | -11.1 | -14.4 | -1.1 | -1.0 | 0.3 |
| 20 | | -10.4 | -16.0 | -19.0 | -2.1 | -0.2 | 5.2 |
| 30 | | -10.6 | -15.0 | -16.4 | 0.0 | 6.7 | 20.4 |

Note: Entries are calculated as described in the note to Table I. Panel A is based on (11); Panel B on (12).

## Table III

### Percentage Changes in Investment Incentives Without The Capital Structure Invariance Assumption

$di(\pi)/d = 1, \; d\rho(\pi)/d\pi = (1 - \tau_e), \; \tau_e = .20$

#### A. Modified

| Asset Life | Inflation Rate | b = .25<br>.03 | <br>.06 | <br>.09 | b = .75<br>.03 | <br>.06 | <br>.09 |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| 5 | | - 2.4 | -4.4 | - 5.9 | -0.7 | -1.3 | -1.7 |
| 10 | | - 4.0 | -6.8 | - 8.5 | -2.4 | -3.8 | -4.4 |
| 20 | | - 6.7 | -9.8 | -10.6 | -5.1 | -6.9 | -6.5 |
| 30 | | - 6.8 | -7.4 | - 5.9 | -4.5 | -4.4 | -1.6 |

#### B. Conventional

| Asset Life | Inflation Rate | b = .25<br>.03 | <br>.06 | <br>.09 | b = .75<br>.03 | <br>.06 | <br>.09 |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| 5 | | -2.2 | -3.9 | -5.2 | 0.2 | 0.1 | 0.8 |
| 10 | | -3.3 | -5.3 | -6.3 | 0.1 | 1.4 | 3.9 |
| 20 | | -5.3 | -6.9 | -6.0 | 0.0 | 4.1 | 12.3 |
| 30 | | -4.2 | -3.2 | 1.5 | 2.8 | 13.0 | 32.6 |

NOTE: Entries are calculated as described in the note to Table I. Panel A is based on (11); Panel B on (12).

Table IV

Percentage Changes in Investment Incentives Without
The Capital Structure Invariance Assumption

Sensitivity Analysis With The Modified User Cost

b = .75

| | A. $\tau_e = .10$ | | | B. $\tau_e = .30$ | | |
|---|---|---|---|---|---|---|
| Asset Life / Inflation Rate | .03 | .06 | .09 | .03 | .06 | .09 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 5 | - 1.2 | - 2.3 | - 3.2 | -0.3 | -0.3 | -0.1 |
| 10 | - 3.6 | - 6.1 | - 7.9 | -1.1 | -1.2 | -0.6 |
| 20 | - 7.6 | -11.3 | -12.8 | -2.5 | -1.9 | 1.0 |
| 30 | - 7.7 | -10.3 | -10.6 | -1.1 | 2.5 | 9.6 |

| | C. $d\rho(\pi)/d\pi = .8(1 - \tau_e)$ | | | D. $d\rho(\pi)/d\pi = 1.2(1 - \tau_e)$ | | |
|---|---|---|---|---|---|---|
| Asset Life / Inflation Rate | .03 | .06 | .09 | .03 | .06 | .09 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 5 | 0.9 | 2.0 | 3.4 | - 2.4 | - 4.4 | - 6.3 |
| 10 | 0.6 | 2.1 | 4.4 | - 5.2 | - 9.0 | -11.9 |
| 20 | 0.0 | 3.1 | 8.8 | - 9.8 | -15.1 | -18.2 |
| 30 | 2.1 | 9.0 | 20.7 | -10.3 | -15.0 | -17.1 |

NOTE: Entries are calculated as in Table III except for the indicated changes in parameters.

Table V

Percentage Change in Investment Incentives
Relative to the 1979 Tax Code
$i = .11,\ \rho = .12,\ \pi = .05,\ \tau_e = .0$

A. Modified User Cost

| Asset Life | Tax Program | b = .25 TEFRA | b = .25 Treasury | b = .75 TEFRA | b = .75 Treasury |
|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) |
| 5 | | 14.0 | - 5.7 | 13.5 | -11.6 |
| 10 | | 18.3 | - 8.0 | 17.7 | -13.8 |
| 20 | | 14.4 | 5.2 | 14.0 | - 1.4 |
| 30 | | 13.5 | 6.9 | 13.0 | 0.2 |

B. Conventional User Cost

| Asset Life | Tax Program | b = .25 TEFRA | b = .25 Treasury | b = .75 TEFRA | b = .75 Treasury |
|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) |
| 5 | | 15.7 | - 6.3 | 19.5 | -13.3 |
| 10 | | 18.9 | -10.1 | 20.0 | -20.5 |
| 20 | | 14.0 | 0.6 | 11.5 | -17.0 |
| 30 | | 13.4 | 0.7 | 11.2 | -21.2 |

Note: All entries are calculated as the ratio of the user cost of capital under the 1979 tax code to the user cost for the indicated tax program, less one, multiplied by 100. Panel A is based on (11), and Panel B on (12). Our characterizations of the 1979 and TEFRA tax programs follow Gravelle (1983), and the Treasury's plans (U.S. Treasury, 1984).

Table VI

Tax Wedges Under Various Tax Regimes
(Percentage Points)

A. Modified

| | | b= .25 | | | | b=.75 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Asset Life | Tax Regime | Carter $\pi$=.05 | TEFRA $\pi$=.05 | Treasury $\pi$=.05 | Treasury $\pi$=.0 | Carter $\pi$=.05 | TEFRA $\pi$=.05 | Treasury $\pi$=.05 | Treasury $\pi$=.0 |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 5 | | 1.8 | -3.7 | 4.5 | 4.4 | -3.2 | -7.9 | 2.1 | 1.5 |
| 10 | | 2.5 | -1.9 | 5.1 | 4.9 | -0.7 | -4.6 | 3.4 | 3.0 |
| 20 | | 7.6 | 4.5 | 6.4 | 6.3 | 4.9 | 2.2 | 5.2 | 4.9 |
| 30 | | 8.1 | 5.5 | 6.7 | 6.3 | 5.7 | 3.5 | 5.7 | 5.1 |

B. Conventional

| | | b= .25 | | | | b=.75 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Asset Life | Tax Regime | Carter $\pi$=.05 | TEFRA $\pi$=.05 | Treasury $\pi$=.05 | Treasury $\pi$=.0 | Carter $\pi$=.05 | TEFRA $\pi$=.05 | Treasury $\pi$=.05 | Treasury $\pi$=.0 |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 5 | | 1.4 | -4.6 | 4.4 | 4.5 | -4.2 | -10.5 | 1.7 | 1.8 |
| 10 | | 1.4 | -3.1 | 4.5 | 4.5 | -4.0 | - 7.8 | 1.8 | 1.8 |
| 20 | | 5.7 | 3.0 | 5.6 | 5.7 | -0.5 | - 2.2 | 2.8 | 2.8 |
| 30 | | 6.1 | 3.8 | 5.9 | 5.6 | -0.2 | - 1.6 | 3.3 | 2.8 |

Note: All entries are calculated as the user cost of capital less the exponential rate of depreciation less the real discount rate, taken as 5.0 percent Further details of the user costs from which these are derived can be found in the note to Table V.