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The Irrelevance of Capital Structure for the Impact of Inflation on Investment

SHALOM HOCHMAN and ODED PALMON*

ABSTRACT

Studies concerning the effect of inflation on firms' investment decisions suggest that the form of financing is relevant in assessing the effect of inflation on investment. This paper demonstrates that when the equilibrium relationship between market rates of return on bonds and stocks is considered, the effect of inflation on investment is independent of the capital structure. The paper also shows that when the "Fisher effect" is assumed to hold, the cut-off rate of return on investment declines with anticipated inflation independently of the financing. However, if the real interest rate rises with inflation, inflation may increase the cut-off rate.

CORPORATE INVESTMENT DECISIONS ARE affected by inflation because the tax code does not provide perfect adjustments for inflation: real tax payments may vary with the inflation rate, even if fully anticipated inflation does not affect other pre-tax real flows. Three such effects have been commonly discussed in the literature. First, the real tax shield on depreciation decreases with inflation because depreciation allowances for tax purposes are based on historical costs rather than on current nominal values. This "depreciation effect" causes the pre-tax required real rate of return on investments to rise with the rate of inflation. Second, the real tax subsidy on interest deductions increases with inflation because firms are allowed to deduct interest expenses at nominal rates rather than at real rates. If the interest rate does not rise with inflation sufficiently to offset the increased tax shelter, the cut-off rate of return tends to decrease with inflation. This effect is termed, in this paper, the "interest effect." The third effect, the "capital gains" effect, may occur when inflation-induced nominal capital-gains on assets are subject to capital-gains tax. However, since firms do not pay capital-gains tax unless the asset is sold, these tax payments are deferred. The present value of these payments is presumed to be small and, therefore, the "capital-gains" effect has been ignored in most studies.[1]

Nelson [18] and others[2] implicitly assumed that firms are entirely equity-

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[1] A notable exception is a paper by Gandolfi [9].

[2] Nichols [19], Motley [16], Van Horn and Glassmire [20], Bradford [3], and Hai [9]. Some of these works, however, also considered the effect of unanticipated inflation on the value of the firm, an aspect which is not considered in the present paper. Since Nelson's assumptions are most comparable to Jaffe and Cross, the focus will be on his work.

financed and that the market required-real-rate-of-return on stocks is independent of the inflation rate. Nelson did not address himself to the "interest effect" and therefore, by considering the "depreciation effect" only, concluded that inflation depresses firms' demand for investment. Jaffe [13] considered a world in which the marginal investment is entirely debt-financed and the market-real-rate-of-interest on bonds is independent of the inflation rate (the "Fisher effect"). The focus of Jaffe's analysis was the "interest effect" and thus he limited his discussion to nondepreciating assets. Jaffe concluded that inflation lowers the cut-off rate of return, and suggested that firms' capital structure may be relevant to the effect of inflation on their investment decisions. Cross [4] extended Jaffe's analysis to include depreciating assets, and demonstrated that Jaffe's conclusion holds for most depreciating assets, the only exception being the special case of assets that last only one period (short-lived asset). In this special case, Cross showed that the "depreciation effect" exactly offsets the "interest effect" so that the cut-off rate of return is unaffected by inflation. In all other cases, Cross has demonstrated that the "interest effect" dominates the "depreciation effect," implying that the cut-off rate of return declines with inflation.

In summary, previous studies considered the financing of investments under two extreme sets of assumptions. One set of studies implicitly assumed that investments are entirely equity-financed and that the required real rate of return on stocks is independent of inflation. These studies concluded that inflation increases the cut-off rate of return, depressing firms' demand for investments. The second set of studies assumed that the marginal investment is entirely debt-financed and that the "Fisher effect" applies to interest rates on bonds. Studies of this type concluded that, in most cases, inflation lowers the cut-off rate of return, and thereby enhances the demand for investments. It is impossible to infer from these studies whether the contradictory results are due to the differences in the assumptions about the capital structure or due to the assumptions concerning the impact of inflation on market rates of return.

In this paper we show that the effect of inflation on investment decisions is independent of the capital structure. This result is obtained by introducing an equilibrium relationship between market rates of return on bonds and stocks into the analysis. The equilibrium relationship is determined by the structure of personal and corporate taxes. We consider a tax system in which all firms are subject to the same corporate tax rate, while investors are subject to progressive tax rates. In the resulting equilibrium, firms may be financed by a combination of debt and equity, while most investors hold bonds only or stocks only. Under this tax structure it is shown that, when the "Fisher effect" holds (as in Jaffe and Cross), inflation enhances the demand for investments even under equity financing; however, when the real rate of return on stocks is assumed to be independent of inflation (as in Nelson) inflation depresses the demand for investments even under debt financing.[3]

In the following section we derive the cut-off rate of return as a function of exogenously given nominal market rates of return on bonds and stocks. It is

[3] Note that in the presence of taxes the "Fisher effect" cannot be assumed simultaneously with the assumption that the pre-personal-tax rate of return on stocks is unaffected by inflation.

demonstrated that the cut-off rates of return obtained in previous studies are special cases of the cut-off rate of return derived in this section. In Section II we introduce the equilibrium relationship between these two market rates of return and derive the effect of inflation on the demand for investments. Section III concludes the paper.

I. The Required Real Rate of Return on Investment

In this section we first express the value of an unlevered firm as a function of the level of investment, I, the real operating cash flow, y, and the annual rate of depreciation, d. The valuation expression is then extended to a levered firm, where α denotes the proportion of investment financed by debt. The value of the firm depends also on the following parameters:

π = the inflation rate;
i_b = the market (pre-personal tax) nominal rate of interest on bonds;
i_s = the market nominal rate of return required by stockholders;
t_c = the corporate income tax rate;
t_b = the personal tax rate on interest income from bonds; and
t_s = the personal tax rate on income received from holding shares of stock.[4]

Imposing the condition for optimal investment on the valuation formula yields an expression for the cut-off rate of return. It is demonstrated that the results obtained in previous studies are special cases of this expression. We conclude the section by deriving the effect of inflation on the cut-off rate of return and by decomposing this effect into the "depreciation effect" and the "interest effect."

Following Nelson, Jaffe, Cross, and others, it is assumed that inflation is fully anticipated and affects all prices at the same rate; that firms do not pay capital gains tax on the appreciation of their assets; that all future cash flows are certain; and that tax losses can be sold to other firms if the combined tax shields due to depreciation and interest expense exceed taxable income.[5] It is also assumed that i_b and i_s are exogenously given. For simplicity, a single period framework is used to demonstrate our results. It should be noted that in a world of certainty and no taxes both of these rates are equal the riskless rate of interest. However, in the presence of corporate and personal taxes these two pre-personal-tax rates-of-return are not usually equal. A discussion on the equilibrium relationship between i_b and i_s is presented in the next section.

First, consider a firm that is entirely equity-financed. At the beginning of the period the firm obtains $\$I$ from selling stock and it purchases an asset for this amount. At the end of the period, assuming that economic depreciation at historical cost is allowed for tax purposes, the nominal after corporate tax cash flows to the firm are: $(1 - t_c)y(1 + \pi)$ from production, $(1 - d)I(1 + \pi)$ from sale of the asset and $t_c dI$ from the tax shield on depreciation. The payment to

[4] In the presence of progressive personal tax rates, these rates vary across investors and should be denoted t_b^j and t_s^j for the jth investor. In this section, however, t_b and t_s denote, respectively, the tax rates that a representative bondholder and a representative stockholder pay on the income from their investments.

[5] In a multiperiod model, this assumption may be replaced by the assumption that tax losses can be carried forward. We thank Robert Heinkel for bringing this point to our attention.

stockholders is

$$I + [(1 - t_c)y(1 + \pi) + (1 - d)I(1 + \pi) + t_c dI - I]$$

of which I is repayment of principal and the rest (i.e., the expression in the square brackets) is taxable income to the stockholders. Thus, stockholders' income, after personal tax, is

$$I + (1 - t_s)[(1 - t_c)y(1 + \pi) + (1 - d)I(1 + \pi) + t_c dI - I]$$

This income to stockholders is discounted by the after-personal-tax nominal-rate-of-return required by stockholders and thus the value of an unlevered firm, V_u, is

$$V_u = \frac{I + (1 - t_s)[(1 - t_c)y(1 + \pi) + (1 - d)I(1 + \pi) + t_c dI - I]}{1 + (1 - t_s)i_s} \tag{1}$$

Assume now that a firm raises \$$I$, consisting of αI in debt and $(1 - \alpha)I$ in equity. Note that since y is assumed certain, i_s is not a function of α. At the end of the period total payment to bondholders is $\alpha I(1 + i_b)$, on which they pay tax of $t_b \alpha I i_b$. Therefore, the after-personal-tax income to bondholders is $\alpha I[1 + (1 - t_b)i_b]$, and the value of the debt is

$$V_B = \frac{\alpha I[1 + (1 - t_b)i_b]}{1 + (1 - t_b)i_b} = \alpha I \tag{2}$$

Note that the after-personal-tax rate-of-interest on bonds serves now as the discount rate for payments to bondholders. This discount rate may differ from the rate used to discount cash flows to stockholders.[6] The after-corporate-tax payment to stockholders of the levered firm is

$$(1 - t_c)y(1 + \pi) + (1 - d)I(1 + \pi) + t_c dI - (1 - t_c)\alpha I i_b - \alpha I$$

of which $(1 - \alpha)I$ is non-taxable, and

$$(1 - t_c)[y(1 + \pi) - \alpha I i_b] + (1 - d)I(1 + \pi) + t_c dI - \alpha I - (1 - \alpha)I$$

is taxable. Thus, the after-personal-tax income to stockholders is

$$(1 - \alpha)I + (1 - t_s)\{(1 - t_c)[y(1 + \pi) - \alpha I i_b] + (1 - d)I(1 + \pi) + t_c dI - \alpha I - (1 - \alpha)I\}$$

and the value of the equity, V_E, is

$$V_E = \frac{(1 - \alpha)I + (1 - t_s)\{(1 - t_c)[y(1 + \pi) - \alpha I i_b] + (1 - d)I(1 + \pi) + t_c dI - I\}}{1 + (1 - t_s)i_s} \tag{3}$$

[6] These rates do not differ if bondholders and stockholders are marginal in the sense that they are indifferent between investing in bonds and stocks. In this case bondholders and stockholders may be the same individuals and the discount rates are the same. However, if bondholders and stockholders are inframarginal, they may not be considered identical individuals and, therefore, the discount rate differ.

Adding up (2) and (3) yields the value of the levered firm:

$$V_L \equiv V_E + V_B = \frac{(1-\alpha)I + (1-t_s)\{(1-t_c)[y(1+\pi) - \alpha I i_b] + (1-d)I(1+\pi) + t_c dI - I\}}{1 + (1-t_s)i_s}$$

and, using (1)

$$V_L = V_u + \frac{\alpha I(1-t_s)[i_s - (1-t_c)i_b]}{1+(1-t_s)i_s} \tag{4}$$

Setting $\partial V_L/\partial I = 1$, the pre-tax required real rate of return, net of depreciation, is [7]

$$\rho = \left(\frac{\partial y}{\partial I}\right)^* - d = \frac{(1-\alpha)i_s + \alpha(1-t_c)i_b - \pi(1-dt_c)}{(1-t_c)(1+\pi)} \tag{5}$$

where $(\partial y/\partial I)^*$ is the minimum increase in the real cash flow (gross of depreciation) that a dollar of investment should generate.

Note that, the market interest rate, i_b, and the market rate of return required by stockholders, i_s, are pre-personal-tax rates and are considered exogenous by the firm. Thus, Equation (5) implies that even in the presence of a progressive tax structure, ρ and the firm's investment decision-rule do not depend on the tax characteristics of its investors. The models that were analyzed by Nelson, Jaffe, and Cross are presented in Table I as special cases of Equation (5).

Differentiating (5) with respect to the inflation rate yields the effect of inflation on the cut-off rate of return:

$$\frac{\partial \rho}{\partial \pi} = \frac{1}{(1-t_c)}\left\{\frac{\left[(1-\alpha)\dfrac{\partial i_s}{\partial \pi} + \alpha(1-t_c)\dfrac{\partial i_b}{\partial \pi} - (1-dt_c)\right]}{(1+\pi)} - \frac{[(1-\alpha)i_s + \alpha(1-t_c)i_b - \pi(1-dt_c)]}{(1+\pi)^2}\right\} \tag{6}$$

This effect is comprised of the "depreciation effect" and the "interest effect." When the asset is nondepreciating ($d = 0$) the "depreciation effect" vanishes and therefore

$$\frac{1}{(1-t_c)}\left[\frac{(1-\alpha)\dfrac{\partial i_s}{\partial \pi} + \alpha(1-t_c)\dfrac{\partial i_b}{\partial \pi}}{1+\pi} - \frac{(1-\alpha)i_s + \alpha(1-t_c)i_b + 1}{(1+\pi)^2}\right] \tag{7}$$

is due to the "interest effect"; the remainder

$$\frac{dt_c}{(1-t_c)(1+\pi)^2}$$

[7] ρ is the analog of MP_k/P_k, the marginal real product of a \$1 of capital, in Jaffe [13] and Cross [4].

Table I

The Required Real Rates of Return on Investment under Equity and Debt Financing

Type of Asset	Financing: Equity (α=0)	Debt (α=1)
Nondepreciating Asset (d=0)	$\frac{i_s - \pi^a}{(1+\pi)(1-t_c)}$	$\frac{(1-t_c)i_b - \pi^b}{(1+\pi)(1-t_c)}$
Short-lived Asset (d=1)	$\frac{i_s - \pi(1-t_c)^a}{(1+\pi)(1-t_c)}$	$\frac{i_b - \pi^c}{1+\pi}$

[a] Implied from Nelson's analysis.
[b] Identical to Jaffe's Equation (1) and to Cross's Equation (4).
[c] Identical to Cross' Equation (3) for the case of a short-lived asset (i.e., a=1).

is due to the "depreciation effect." Note that the "depreciation effect" is larger, the higher is the depreciation rate (d) and the corporate tax rate (t_c). This result confirms the conclusions of Nelson and Cross that under inflation the cut-off rate of return is greater when assets are depreciating than when they are not depreciating. Expression (7) suggests that the "interest effect" may depend on the impact of inflation on market rates of return in equilibrium. This effect is discussed in the next section.

II. Equilibrium Between Market Rates of Return

Under certainty, the relationship between i_b and i_s depends only on the tax structure faced by investors and firms. We assume that all firms are subject to the same corporate tax rate, and that each firm may be financed by any combination of debt and equity, so that $\partial V_L/\partial\alpha = 0$. Therefore,

$$i_s = (1 - t_c)i_b \tag{8}$$

must hold.

The relative amounts of debt to equity in the economy are determined by the suppliers of funds. Investors are subject to progressive taxes; let t_b^j and t_s^j denote investor's j marginal tax rates on interest-income and on income received from holding stock, respectively. Investors whose marginal tax rates are such that $(1 - t_b^j)/(1 - t_s^j)$ is greater than $(1 - t_c)$ hold bonds only, since their after-personal-tax income from bonds, $(1 - t_b^j)i_b$, exceeds (in equilibrium) their after-personal-tax income from stocks $(1 - t_s^j)i_s$. Similarly, investors whose marginal tax rates are such that $(1 - t_b^j)/(1 - t_s^j)$ is less than $(1 - t_c)$ hold stocks only.[8] For the ("marginal") investor whose tax rates t_b^* and t_s^* are such that he is indifferent to holding bonds and stocks

$$(1 - t_s^*)i_s = (1 - t_b^*)i_b \tag{9}$$

must, by definition, hold.

[8] This tax structure is similar to the world described by Miller [15]. Under uncertainty, i_s can be regarded as the certainty-equivalent of the yields on common stocks (see Barnea et al. [1]) and it is the analog of Miller's r_0—the rate of return on tax-exempt securities. The analog of Miller's r, the rate of interest on bonds, is i_b.

Combining (8) with (9) yields

$$(1 - t_c)(1 - t_s^*) = (1 - t_b^*) \tag{10}$$

which is Miller's [15] equilibrium requirement for the marginal investor.

It is important to note that the marginal investor and thus t_s^* and t_b^* are determined, in equilibrium, simultaneously with i_s and i_b. When the inflation rate changes, investors' personal tax rates may change as they are pushed into higher tax brackets. The change in the inflation rate may also induce marginal investors to hold bonds only or stocks only. Since t_b^* and t_s^* may be affected by inflation, the relationship between the changes in i_s and i_b that are caused by inflation cannot be derived from (9) without specifying how these tax rates change with inflation. However, since t_c does not change with inflation, equilibrium condition (8) is useful to derive the relationship between the changes that inflation causes in i_s and i_b.

We turn now to the derivation of the effects of inflation on the cut-off rate of return and on firms' demand for investment. Equilibrium condition (8) implies that

$$\frac{\partial i_s}{\partial \pi} = (1 - t_c)\frac{\partial i_b}{\partial \pi} \tag{11}$$

Incorporating (8) and (11) into (6) yields

$$\frac{\partial \rho}{\partial \pi} = \frac{1}{(1 - t_c)(1 + \pi)}\left[\frac{\partial i_s}{\partial \pi} - \frac{i_s + (1 - dt_c)}{(1 + \pi)}\right] \tag{12}$$

Since α does not appear in (12), it follows that the effect of inflation on the cut-off rate of return is independent of the capital structure. This result does not require any additional assumptions about the effect of inflation on market rates of return.

The impact of inflation on firms' demand for investment depends, however, on how inflation affects market rates of return. This is demonstrated by considering two alternative assumptions. First, following Jaffe [13] and Cross [4] we consider the assumption that the market real interest rate on bonds, r_b, is independent of the inflation rate (the "Fisher effect") and show that the cut-off rate of return declines with inflation. Then, following Nelson, we consider the alternative assumption that the (pre-personal-tax) real rate of return required by stockholders, r_s, is independent of inflation and demonstrate that, under this assumption, the cut-off rate rises with inflation.[9]

Assuming that the "Fisher effect" holds ($r_b = \bar{r}_b$), and since by definition $i_b \equiv$

[9] It can be shown that the cut-off rate of return increases with inflation when the after-personal-tax real rate of return on bonds or stocks is assumed independent of inflation. However, such assumption is not considered here for the following reasons. First, showing that the cut-off rate of return declines with inflation when the "Fisher effect" is assumed to hold, and that it increases with inflation under the alternative assumption, is sufficient to prove our proposition. Second, empirical studies have shown that the two alternative assumptions that are considered in the paper are more reasonable then the assumption that an after-personal-tax real rate of return is unaffected by inflation. Third, considering the two alternative assumptions facilitates comparisons with previous studies.

$(1 + r_b)(1 + \pi) - 1$, our assumptions imply that

$$i_s = (1 - t_c)[(1 + \bar{r}_b)(1 + \pi) - 1] \tag{13}$$

and, therefore, that

$$\left.\frac{\partial i_s}{\partial \pi}\right| \bar{r}_b = (1 - t_c)(1 + \bar{r}_b) \tag{14}$$

Substituting (13) and (14) into (12) yields

$$\left.\frac{\partial \rho}{\partial \pi}\right| \bar{r}_b = \frac{-t_c(1 - d)}{(1 - t_c)(1 + \pi)^2} \tag{15}$$

Note that the cut-off rate of return for investments in short-lived assets ($d = 1$) is, as Cross concluded, independent of inflation. Equation (15) implies also that the cut-off rate of return declines with inflation for any other asset ($d < 1$). In particular, this result holds for a nondepreciating asset ($d = 0$), which is the case that Jaffe analyzed. Contrary to Jaffe, however, our result is independent of the capital structure. The explanation for this result is that inflation reduces the cost of borrowing because the market interest rate is assumed independent of inflation while the real tax subsidy on interest charges increases with inflation. In addition, the required real rate of return on stocks declines with inflation as necessary to maintain equilibrium condition (8), further reducing the cost of capital. Our result differs from Nelson's conclusion that inflation depresses firm's demand for investment under equity financing. This suggests that Nelson's conclusion depends crucially on the assumption that the required real rate of return on stocks is independent of inflation.

Next, following Nelson, we assume that the required real rate of return on stocks, r_s, is independent of the inflation rate ($r_s = \bar{r}_s$). Since

$$i_s \equiv (1 + \bar{r}_s)(1 + \pi) - 1 \tag{16}$$

it follows that

$$\left.\frac{\partial i_s}{\partial \pi}\right| \bar{r}_s = (1 + \bar{r}_s) \tag{17}$$

Substituting (16) and (17) into (12) yields

$$\left.\frac{\partial \rho}{\partial \pi}\right| \bar{r}_s = \frac{dt_c}{(1 - t_c)(1 + \pi)^2} \tag{18}$$

Equation (18) implies that, except for the case of a nondepreciating asset ($d = 0$), inflation increases the cut-off rate of return and thus depresses firm's demand for investment. This result is more general than Nelson's because it is independent of the capital structure, while Nelson's is limited to equity-financed investments. Furthermore, this result emphasizes that the conclusions of Jaffe and Cross depend on the assumption that the market real rate of interest is independent of inflation.

III. CONCLUSION

In this paper we have shown that the effect of inflation on firms' demand for investment depends on the impact of inflation on market rates of return and not on the firm's capital structure. Empirical findings have shown that the market real rate of interest on bonds is less affected by inflation than the real rate of return on stocks. The studies by Yohe and Karnosky [21], Feldstein and Eckstein [7], and Fama [5] all indicate that the "Fisher effect" is a good approximation of the effect of anticipated inflation on interest rates on bonds.[10] Feldstein and Eckstein, for example, state that "a permanent one percent increase in the annual rate of inflation . . . would increase the interest rate by .97 percent." (p. 366). In contrast, Bodie [2], Jaffe and Mandelker [11], and Nelson [17] found that the real rate of return on common stocks declined substantially in the last two decades. Given these empirical findings our model would suggest that inflation enhanced firms' demand for investment. Initially, this conclusion may seem counter intuitive; however, it may be better understood if other real effects that may accompany inflation are considered. As Fama [6] pointed out, inflation may be partially caused by expectations of a decline in the level of real activity in the economy. The decline in real activity brings about a decline in the real rate of return on common stocks and in the level of investment (but not necessarily a decline in the interest rate). In this case, the effect suggested in this paper merely mitigates the negative effect caused by real changes in the economy. Thus, inflation may be negatively correlated with the rate of return on stocks and with the level of investments, even when inflation per se enhances firms' demand for investment.

[10] For further references see Kreicher [14].

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