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3 Inflation, Income Taxes, and the Rate of Interest: A Theoretical Analysis

Income taxes are a central feature of economic life but not of the growth models that we use to study the long-run effects of monetary and fiscal policies. The taxes in current monetary growth models are lump sum transfers that alter disposable income but do not directly affect factor rewards or the cost of capital. In contrast, the actual personal and corporate income taxes do influence the cost of capital to firms and the net rate of return to savers. The existence of such taxes also in general changes the effect of inflation on the rate of interest and on the process of capital accumulation.[1]

The current paper presents a neoclassical monetary growth model in which the influence of such taxes can be studied. The model is then used in sections 3.2 and 3.3 to study the effect of inflation on the capital intensity of the economy. James Tobin's (1955, 1965) early result that inflation increases capital intensity appears as a possible special case. More generally, the tax rates and saving behavior determine whether an increase in the rate of inflation will increase or decrease steady-state capital intensity.

The analysis also shows that the net real rate of interest received by savers may be substantially altered by the rate of inflation. Section 3.3

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I am grateful to the University of California at Berkeley for the opportunity to prepare this paper while I was Ford Research Professor. The National Science Foundation supported the project on the effects of fiscal programs on capital accumulation and income distribution, of which the current study is a part. I am grateful for discussions with Stanley Fischer, Steven Goldman, and David Hartman.

1. Income taxes have been studied in *nonmonetary* growth models by Peter Diamond (1970, 1975), Feldstein (1974*a*, *b*), and Kazuo Sato (1967). Of course, the effects of inflation cannot be examined in such models.

discusses the desirability of adjusting the taxation of interest income to eliminate these arbitrary effects of inflation. The fourth section discusses the implications of this for the welfare effects of inflation and the optimal rate of growth of the money supply.

3.1 A Growing Economy with Inflation and Income Taxes

This section presents a one-sector neoclassical model of economic growth with inflation and income taxes. The model differs from that of Tobin (1965) in two fundamental ways: (1) the savings rate depends on the net real rate of return earned by savers; (2) there are personal and corporate interest income taxes as well as a lump sum tax.[2] Because the analysis of the model in section 3.2 will focus on comparative steady-state dynamics, only these steady-state properties will be discussed here.

The steady-state economy will be characterized by an inflation rate $\pi = Dp/p$ and a nominal interest rate of i. The real rate of interest is, by definition, $r = i - \pi$. In order to consider the effects of adjusting the tax treatment for the rate of inflation, separate tax rates will be specified for the real and inflation components of the nominal rate of interest. The personal income tax will tax real interest payments at θ_1 and the inflation component at θ_2. The net nominal rate of return is thus $i_N = (1 - \theta_1) r + (1 - \theta_2)\pi$. In our current tax law $\theta_1 = \theta_2$ so that $i_N = (1 - \theta)(r + \pi) = (1 - \theta)i$. With complete inflation indexation, $\theta_2 = 0$ and $i_N = (1 - \theta_1)r + \pi$; the net real rate of interest received by households is thus $r_N = i_N - \pi = (1 - \theta_1)r$.

The economy is characterized by an exogenously growing population

$$(1) \qquad N = N_0 e^{nt}$$

The labor force is a constant fraction of the population. Production can be described by an aggregate production function with constant returns to scale. The relation between aggregate output per capita (y) and aggregate capital stock per capita (k) is

$$(2) \qquad y = f(k)$$

with $f' > 0$ and $f'' < 0$. For simplicity, both technical progress and depreciation are ignored.

3.1.1 The Demand for Capital

The investment and financing behavior of firms is influenced by the corporate income tax. An important feature of the corporation tax is that the interest paid on corporate debt may be deducted by firms in calculating taxable profits while dividends paid on corporate equity may not be

2. In the more general model of David Levhari and Don Patinkin, the savings rate does depend on the rate of return but there are no corporate or personal income taxes.

deducted. Although the method of finance need not affect the analysis in models without a corporate income tax, it is necessary in the current model to identify the method of finance. Because the focus of the current paper is on the effect of inflation on the rate of interest, I will assume that all corporate investment is financed by issuing debt.[3] The tax deduction of interest payments may also be adjusted for inflation: let τ_1 be the tax rate at which the real component of interest payments is deducted and let τ_2 be the tax rate at which the inflation component can be deducted. The net rate of interest paid by firms is then $(1 - \tau_1)r + (1 - \tau_2)\pi$.[4]

In the absence of the corporation tax, the firm maximizes its profit by investing until the marginal product of capital is equal to the real rate of interest, $i - \pi$. Stated somewhat differently, the firm's capital stock is optimal when the marginal product of capital $[f'(k)]$ plus the nominal appreciation in the value of the capital stock per unit of capital (π) is equal to the nominal rate of interest:

$$f'(k) + \pi = i \tag{3}$$

The effect of the corporation tax on this optimality condition depends on the way that depreciation is treated by the law. Consider first the simple case in which capital lasts forever, i.e., in which there is no depreciation. The corporation tax then reduces the net-of-tax marginal product of capital to $(1 - \tau_1)f'(k)$. There is no tax on the unrealized appreciation of the capital stock. The firm maximizes profits by increasing the capital stock until the net nominal return on capital $(1 - \tau_1)f'(k) + \pi$ is equal to the net nominal rate of interest, $(1 - \tau_1)\, r + (1 - \tau_2)\pi$. The first-order optimum of equation (3) therefore becomes

$$f'(k) = r - \left(\frac{\tau_2}{1 - \tau_1}\right)\pi \tag{4}$$

If the capital stock does depreciate, $f'(k)$ can be interpreted as the marginal product of capital net of the cost of replacing the capital that has been used up in production. If the corporation tax allows the deduction of

3. It would, of course, be desirable to have a more general model in which corporate debt and equity coexist. The exclusion of equity in the current analysis and the full deductibility of corporate interest payments imply that the present value of corporation taxes is zero. The present model might therefore be regarded as an approximation to a model in which equity profits are intramarginal and all marginal investments are financed by debt (see Joseph Stiglitz 1973). Dale Henderson and Thomas Sargent (1973) studied the effect of inflation in an economy in which firms finance all investment by issuing equity. Because they use a short-run analysis with no accumulation of capital, their conclusions cannot be compared with those of the current analysis. After this paper was accepted for publication, Jerry Green, Eytan Sheshinski, and I (1978; chap. 4 below) developed a more general extension of the current analysis in which firms use an optimal mix of equity and debt finance.

4. In steady-state growth with fully anticipated inflation there is no need to distinguish between short-term debt and long-term debt.

the replacement cost of this depreciation, the net-of-tax marginal product of capital is again $(1-\tau_1)f'(k)$ and equation (4) continues to hold. I will use this condition to describe the demand for capital.[5]

3.1.2 Liquidity Preference

The real value of household assets is the sum of the real values of outside money (M/p) and corporate bonds (B/p):

$$A=\frac{M}{p}+\frac{B}{p} \tag{5}$$

Since outside money bears no interest, the ratio of money to bonds that households will hold is a decreasing function of the after-tax nominal rate of return on bonds, $i_N=(1-\theta_1)r+(1-\theta_2)\pi$. The real value of bonds (B/p) is also the real value of the capital stock (K). The liquidity preference relation can therefore be written in per capita terms as

$$\frac{m}{k}=L[(1-\theta_1)r+(1-\theta_2)\pi], L'<0 \tag{6}$$

where $m=M/pN$, the real money balances per capita. In steady state, m/k must remain constant. Equivalently, M/pK remains constant, i.e., the rate of growth of M is equal to the rate of growth of pK or $\pi+n$. Thus[6]

$$\pi=\frac{DM}{M}-n \tag{7}$$

3.1.3 The Supply of Savings

In steady-state growth, the supply of savings (S) is proportional to the households' real disposable income (H). The savings propensity may of course depend on the real net return that savers receive:

$$S=\sigma(r_N)\cdot H \tag{8}$$

Disposable income is equal to national income (Y) minus both the government's tax receipts (T) and the fall in the real value of the population's money balances $(\pi M/p)$.[7] The total taxes are the sum of the corporate tax, the personal interest income tax, and a residual tax that may be

5. The U.S. corporation tax does not allow replacement cost depreciation but partly offsets historic cost depreciation with accelerated depreciation schedules. An analysis of the effect of historic cost depreciation is presented in the paper by Feldstein, Green, and Sheshinski (1978; chap. 4 below).

6. Jerome Stein (1970) examined a more general Keynes-Wicksell model in which the adjustment of price to the excess demand for cash balances is not immediate. Stanley Fischer (1979*a*) explained that in the long run a steady rate of increase of the money supply will come to be anticipated, causing the Keynes-Wicksell behavior to converge to the familiar neoclassical behavior of equation (7). All of the results of the current paper will therefore continue to hold in a Keynes-Wicksell version of the current model.

7. The capital loss on corporate bonds is just offset by the difference between the real and nominal interest rates paid by firms. There are no corporate retained earnings.

regarded as a lump sum or payroll tax. The government uses these tax receipts plus the increase in the money supply (DM/p) to finance its purchases of public consumption (G). Disposable income is therefore

$$H = Y - T - \frac{\pi M}{p} \tag{9}$$

$$= Y - G + \frac{DM}{p} - \frac{\pi M}{p}$$

Since $\pi = DM/M - n$,

$$H = Y - G + nM/p \tag{10}$$

If public consumption is a constant fraction of real national income ($G = \gamma Y$), per capita disposable income is

$$h = y(1 - \gamma) + nm \tag{11}$$

Per capita saving is therefore

$$s = \sigma(r_N)\cdot[y(1 - \gamma) + mn] \tag{12}$$

3.1.4 Growth Equilibrium

All savings must be absorbed in either additional capital accumulation or additional real money balances:

$$S = DK + DM/p \tag{13}$$

The constant ratio of capital to labor in steady-state growth implies that $DK = nK$. Similarly, the constancy of $m = M/pN$ implies that the rate of growth of (M/p) is nM/p. The requirement of equilibrium growth is therefore, in per capita terms,

$$s = nk + nm \tag{14}$$

or

$$\sigma(r_N)\cdot[(1 - \gamma)y + nm] = nk + nm \tag{15}$$

This completes the specification of the model. It is useful to collect now the six equations that jointly determine y, h, k, m, r, and π:

$$y = f(k) \tag{2}$$

$$h = y(1 - \gamma) + mn \tag{11}$$

$$\sigma[(1 - \theta_1)r - \theta_2\pi]\cdot h = nk + nm \tag{13'}$$

$$f'(k) = r - \left(\frac{\tau_2}{1 - \tau_1}\right)\pi \tag{4}$$

$$m = L[(1 - \theta_1)r + (1 - \theta_2)\pi]k \tag{6}$$

$$(7) \qquad \pi = \frac{DM}{M} - n$$

The exogenous variables are the rate of population growth n, and the government policy variables θ_1, θ_2, τ_1, τ_2, and DM/M.

3.2 The Effects of Changes in the Rate of Inflation

The model of section 3.1 will now be used to study the effects of inflation on capital accumulation and interest rates. Although the rate of inflation is endogenous, the model can be decomposed to obtain π as the difference between the two exogenous variables, DM/M and n. The analysis can then proceed to use the remaining five equations with π regarded as predetermined.

By appropriate substitution for y, h, m, and r and equation (13′), the growth equilibrium provides the basic relation between the equilibrium capital intensity and the steady-state rate of inflation:

$$(16) \qquad \sigma[(1-\theta_1)(f' + \pi r_2/(1-\tau_1)) - \theta_2\pi] \cdot[(1-\gamma)f + nkL] = nk(1+L)$$

where the arguments of L in equation (6) are not explicitly specified. Total differentiation with respect to k and π yields equation (17).

$$(17) \qquad \frac{dk}{d\pi} = \frac{(1-\sigma)nk[(1-\theta_1)\tau_2/(1-\tau_1)}{\sigma[(1-\gamma)f' + nL] - n(1+L)} \; \frac{+(1-\theta_2)]L' - h[(1-\theta_1)\tau_2/(1-\tau_1) - \theta_2]\sigma'}{-(1-\sigma)nkL'(1-\theta_1)f'' + h\sigma'(1-\theta_1)f''}$$

The denominator can be shown to be unambiguously negative if the savings rate is a nondecreasing function of the real rate of return, $\sigma' \geq 0$.[8] With this condition, the denominator is clearly negative if $\sigma[(1-\gamma)f' + nL] - n(1+L) < 0$. To show that this inequality is true, multiply by k and substitute $m = kL$ to obtain the equivalent condition

$$\sigma[(1-\gamma)kf' + nm] - (nk + nm) < 0$$

From equation (15),

$$nk + nm = \sigma[(1-\gamma)f + nm]$$

The required condition is therefore

$$\sigma[(1-\gamma)kf' + nm] < \sigma[(1-\gamma)f + nm]$$

8. This is equivalent to $\sigma'(r_N) \geq 0$ in the asset demand equation (8). In a life cycle model, this occurs if an increase in the real net rate of interest causes a postponement in consumption. In the simple two-period model in which all income is earned in the first period, $\sigma'(r_N) \geq 0$ is equivalent to an elasticity of substitution of the two-period utility function that is greater than or equal to one. Although I will only discuss the implications of $\sigma' \geq 0$, the opposite may be true and its implications deserve examination.

or $kf' < f$ which clearly holds. The sign of $dk/d\pi$ is therefore the opposite of the sign of the numerator.

The first term of the numerator,

$$(1 - \sigma)nk[(1 - \theta_1)\tau_2/(1 - \tau_1) + (1 - \theta_2)]L'$$

is unambiguously negative because the demand for money is inversely related to the nominal rate of interest, $L' < 0$. If the savings rate is an increasing function of the real net rate of interest ($\sigma' > 0$), the sign of the second term and therefore of the entire numerator depends on the nature of taxation. In two important special cases, the second term is zero and therefore the numerator is negative:

1. *Full Tax Indexing*: There is full indexing of the taxation of interest income, i.e., the personal income tax is on the real rate of interest only ($\theta_2 = 0$), and the corporation tax allows a deduction only for real interest payments ($\tau_2 = 0$).
2. *Equal Tax Rates*: There is no indexing of the taxation of interest income but the rate of corporation tax is the same as the rate of personal income tax, i.e., $\theta_1 = \theta_2 = \tau_1 = \tau_2$.

In both these cases, $(1 - \theta_1)\tau_2/(1 - \tau_1) - \theta_2 = 0$ so that the second term is zero, the numerator is negative and $dk/d\pi > 0$. In these cases the sensitivity of the savings rate to the net rate of interest (σ') influences the magnitude but not the direction of the impact of inflation on equilibrium capital intensity. The direction of the impact reflects the reduction in desired liquidity that results from the higher nominal rate of interest that accompanies inflation. A smaller ratio of real money balances to capital implies that a larger fraction of savings is channeled into real capital accumulation. The resulting increase in capital intensity lowers the real net rate of interest; if savings respond positively to this rate of interest, there is a reduction in the rate of savings that partly offsets the portfolio composition effect but that cannot reverse its sign. This dampening effect of the savings response appears as the term $h\sigma'(1 - \theta_1)f''$ that increases the absolute size of the denominator.

Neither of the two cases considered above corresponds to the current situation in the United States. There is no indexing of the taxation of interest payments. The real and inflation components of the nominal interest rate are treated in the same way by both the personal and corporate income taxes: $\theta_2 = \theta_1$ and $\tau_2 = \tau_1$. Because of the progressivity of the personal income tax, a simple comparison of the corporate and personal income tax rates is not possible.[9] I will therefore consider the implications of both $\theta < \tau$ and $\theta > \tau$ where the common rate of income tax is denoted $\theta = \theta_1 = \theta_2$ and that of the corporate tax is denoted $\tau = \tau_1 =$

9. The actual problem of comparison is even more complex because individuals as well as corporations are borrowers.

τ_2. The analysis will assume that the savings rate is an increasing function of the net rate of interest; the reader can easily discover the implications of reversing this assumption.

When the corporation tax rate exceeds the personal tax rate, inflation induces an increase in the savings rate that reinforces the reduction in liquidity. To understand the nature of this reinforcing effect, recall from equation (4) that

$$r = f'(k) + \left(\frac{\tau_2}{1 - \tau_1}\right)\pi \tag{18}$$

With $\tau_2 = \tau_1$, the nominal rate of interest is

$$i = r + \pi = f'(k) + \frac{\pi}{1 - \tau} \tag{19}$$

Since the personal income tax is levied at rate θ on this nominal rate of interest, the real net rate received by savers is

$$\begin{aligned} r_N &= (1 - \theta)i - \pi \\ &= (1 - \theta)f'(k) + \left(\frac{\tau - \theta}{1 - \tau}\right)\pi \end{aligned} \tag{20}$$

At any given level of capital intensity, $f'(k)$ is a constant and the direct effect of an increase in π is to increase r_N whenever $\tau > \theta$. This increase in r_N induces a higher rate of saving and therefore greater capital accumulation. More formally, it is clear from equation (17) that increasing the value of τ causes an increase in $dk/d\pi$ whenever $\sigma' > 0$.

Equation (20) also shows that when the corporation tax rate is less than the personal tax rate, inflation induces a reduction in r_N and therefore in the savings rate. The net effect of inflation on capital intensity depends on the relative strength of the negative savings effect and the positive liquidity effect. There is no unambiguous a priori conclusion. Recall that inflation increases capital intensity if and only if the numerator of equation (17) is negative. With $\theta_1 = \theta_2 = \theta$ and $\tau_1 = \tau_2 = \tau$, this condition reduces to $dk/d\pi > 0$, if and only if,

$$h(\theta - \tau)\sigma' + (1 - \sigma)nk(1 - \theta)L' < 0 \tag{21}$$

A series of substitutions and manipulations shows that this condition is equivalent to

$$\frac{\eta_L}{\eta_S} > \frac{a}{(1 - \sigma)m} \cdot \frac{\theta - \tau}{1 - \theta} \cdot \frac{i_N}{r_N} \tag{22}$$

where $\eta_L = - i_N L'/L$, the elasticity of the demand for real money balances relative to capital with respect to the nominal net rate of interest, and $\eta_S = r_N \sigma'/\sigma$, the elasticity of the savings rate with respect to the real net rate of interest.[10] Recall that $a = k + m$, total wealth per person, and that $r_N = i_N - \pi$. Note that (22) shows that $dk/d\pi > 0$ is more likely when the demand for liquidity is interest sensitive (η_L is large) and when savings behavior is not sensitive to the net yield (η_S is small). The required inequality is clearly satisfied in the cases that were previously considered: $\theta \leq \tau$ (or $\eta_S = 0$). But if $\theta > \tau$ and $\eta_S > 0$, the inequality in (22) may not be satisfied. When inequality (22) is false, an increase in the rate of inflation reduces equilibrium capital intensity. Consider therefore some plausible values for the right-hand side. At the end of 1974, total private wealth was approximately \$4 trillion. A useful empirical measure of the stock of outside money is the monetary base, the sum of currency in circulation and member bank reserves at the Federal Reserve Banks. At the end of 1974, the monetary base was approximately \$100 billion. With an average saving rate of $\sigma = 0.1$, the value of $a/(1 - \sigma)m$ is approximately 40.[11] If $\tau = 0.5$ and $\theta = 0.6$, (22) is equivalent to

$$(23) \qquad \frac{\eta_L}{\eta_S} > 10\frac{i_N}{r_N}$$

Starting from a situation in which there is no inflation (i.e., $i_N = r_N$), the introduction of positive inflation will increase capital intensity only if $\eta_L > 10\eta_S$. With a substantial rate of inflation, the condition for $dk/d\pi > 0$ is even more difficult to satisfy. From equations (19) and (20), we obtain

$$(24) \qquad \frac{i_N}{r_N} = \frac{(1-\theta)f'(k) + \left(\dfrac{1-\theta}{1-\tau}\right)\pi}{(1-\theta)f'(k) + \left(\dfrac{\tau-\theta}{1-\tau}\right)\pi}$$

If, for example, $\pi = f'(k) = 0.12$, equation (24) implies that $i_N/r_N = 0.144/0.024 = 6$. The inequality in (23) now implies that $dk/d\pi > 0$ only if $\eta_L > 60\eta_S$.[12]

10. If $r_N < 0$, η_S is not well defined. The inequality (22) can instead be written

$$\frac{L'/L}{\sigma'/\sigma} > \frac{a}{(1-\sigma)m} \cdot \frac{\theta - \tau}{1 - \theta}$$

when $\sigma' > 0$ even if $r_N < 0$.

11. Restricting attention to outside money ignores the role of private banks in creating liquidity. A broader measure of the money supply, defined as currency plus demand deposits, was \$285 billion at the end of 1974, implying $a/(1 - \sigma)m = 16$. However, most of the money supply measured in this was "inside money" and not appropriate to the current model.

12. There is substantial controversy about the magnitudes of η_L and η_S. In earlier econometric studies, I found $di/d \ln M$ was approximately 10, implying that η_L *is approximately* 0.01 (see Feldstein and Chamberlain, 1973, and Feldstein and Eckstein, 1970). The estimates of η_S range from negative to positive, but none of the estimates measures r_N correctly as the real net-of-tax rate of return. Obviously, even a very moderate positive value of η_S would exceed the η_L reported above.

The above examples are only illustrative. They nevertheless indicate that, in an economy with a relatively high rate of tax on interest income, an increase in the rate of inflation may decrease capital intensity. More generally, the presence of taxes may reduce or magnify a positive effect of inflation on capital intensity.

3.3 Effects of Inflation on Interest Rates

The relation of the interest rate to the rate of inflation is substantially influenced by the presence of the corporation and personal income tax. This is true even if inflation has no effect on the capital intensity of production. As a result, the real net rate of return earned by savers also generally depends on the rate of inflation.

The basic marginal productivity relation derived above,

$$r = f'(k) + \left(\frac{\tau_2}{1-\tau_1}\right)\pi \tag{25}$$

implies that the nominal rate of interest is

$$i = f'(k) + \left(\frac{1+\tau_2-\tau_1}{1-\tau_1}\right)\pi \tag{26}$$

and the real rate of return is

$$r_N = (1-\theta_1)f'(k) + \left(\frac{(1-\theta_1)\tau_2-(1-\tau_1)\theta_2}{1-\tau_1}\right)\pi \tag{27}$$

Consider first the effect of inflation on the nominal rate of interest. Irving Fisher originally explained that the nominal interest rate would rise by the rate of inflation, thus leaving the real interest rate unchanged. The force of his argument rests on the equivalence of the real interest, the cost of capital to the firm, and the real return to savers. Although all three would be equal in the absence of taxation, the current analysis has shown that this is not true in an economy with corporate and personal income taxes. Tobin's analysis (1965) modified Fisher's conclusion: because inflation reduces the demand for money balances, it increases capital intensity, lowers the real rate of return, and thus causes the nominal rate of interest to rise by less than the rate of inflation. Again this analysis ignores the effect of the personal and corporate income tax.[13]

13. Martin Bailey (1956) provides a similar analysis of the effect of inflation on the rate of interest through the change in money balances. His analysis is static and also ignores taxation.

In contrast, equation (26) implies that

$$\frac{di}{d\pi} = \frac{1 + \tau_2 - \tau_1}{1 - \tau_1} + \left(\frac{dk}{d\pi}\right) f'' \tag{28}$$

Fisher's conclusion that $di/d\pi = 1$ corresponds to the special case of no taxes and an interest insensitive demand for real money balances.[14] In Tobin's analysis this is modified by the fall in the marginal product of capital, $df'/d\pi = (dk/d\pi)f'' < 0$, where $dk/d\pi$ reflects a portfolio composition effect but no savings effect. The magnitude of this portfolio composition effect is, however, very small. Even if the relevant money supply is defined to include inside money, the value of the money stock is less than 10 percent of the value of real assets. Thus, even if some rate of inflation would completely eliminate the demand for money, the equilibrium capital stock would rise by less than 10 percent. With a Cobb-Douglas technology, the marginal product of capital would fall by less than one-tenth of its previous value. It is difficult therefore to imagine that the absolute value of the portfolio effect, $(dk/d\pi)f''$, exceeds 0.01.

In the more general case in which taxes are recognized, the nominal rate of interest may rise by substantially more than the rate of inflation. With no tax indexing, $\tau_2 = \tau_1 = \tau$, and

$$\frac{di}{d\pi} = \frac{1}{1 - \tau} + \left(\frac{dk}{d\pi}\right) f'' \tag{29}$$

With no change in capital intensity, $di/d\pi = (1 - \tau)^{-1}$; a corporate tax rate of $\tau = 0.5$ implies that the nominal rate of interest rises by *twice* the rate of inflation. The analysis of section 3.2 shows that $dk/d\pi$ may be greater or less than zero. The nominal rate of interest may therefore rise by either more or less than *twice* the rate of inflation.[15]

With tax indexing, $\tau_2 = 0$, and

$$\frac{di}{d\pi} = 1 + \left(\frac{dk}{d\pi}\right) f'' \tag{30}$$

Here with no change in capital intensity the original Fisherian conclusion that $di/d\pi = 1$ obtains. Section 3.2 also showed that with full tax indexing ($\theta_2 = \tau_2 = 0$), the sign of $dk/d\pi$ is determined by the portfolio composi-

14. Equation (17) shows that $\tau_1 = \tau_2 = \theta_1 = \theta_2 = 0$ and $L' = 0$ imply $dk/d\pi = 0$.

15. Recent empirical studies suggest that during the past decade the long-term corporate bond rate has increased by approximately the increase in the rate of inflation (see Feldstein and Chamberlain, 1973, Feldstein and Eckstein, 1970, and Robert Gordon, 1971). This is smaller than the steady-state increase suggested by the analyses above, especially since it was unlikely that there had been any substantial induced change in capital intensity during so short a period. The difference reflects the failure of the above analysis to allow for equity financing, historic cost depreciation, and personal capital gains taxation. In addition, the estimated $di/d\pi$ in the studies noted above may differ from the value of $di/d\pi$ in a sustained inflation.

tion effect and thus $(dk/d\pi)f'' < 0$. With full tax indexing of interest payments, the nominal interest rate will rise by slightly less than the rate of inflation.

Consider now the effect of inflation on the real net rate of interest received by savers. Equation (27) implies

$$\frac{dr_N}{d\pi} = \left[\frac{(1-\theta_1)\tau_2 - (1-\tau_1)\theta_2}{1-\tau_1}\right] + (1-\theta_1)\left(\frac{dk}{d\pi}\right)f'' \tag{31}$$

If there are no taxes and the demand for real balances is not sensitive to the rate of interest, equation (31) yields the Fisherian conclusion that the real return to savers is unaffected by inflation, $dr_N/d\pi = 0$. In two further special cases, the effect of inflation on the real net interest rate is limited to the relatively small portfolio composition effect: $(1-\theta_1)(dk/d\pi)f'' < 0$. If there is full tax indexing ($\theta_2 = \tau_2 = 0$) or equal tax rates for corporations and households ($\theta_1 = \tau_1$ and $\theta_2 = \tau_2$), the first term of equation (31) is zero and the sign of $dk/d\pi$ depends only on the portfolio composition effect.[16]

More generally, however, inflation can have a substantial effect on the savers' real net rate of return. If there is no indexing, equation (31) reduces to

$$\frac{dr_N}{d\pi} = \left(\frac{\tau-\theta}{1-\tau}\right) + (1-\theta)\left(\frac{dk}{d\pi}\right)f'' \tag{32}$$

If the corporate tax rate exceeds the personal tax rate, the first term is positive and the second term is negative.[17] The real net rate of return may either rise or fall. If the personal tax rate is higher than the corporate tax rate, the first term is negative. Section 3.2 showed that in this case $dk/d\pi$ can be either positive or negative. If $dk/d\pi > 0$, an increase in the rate of inflation reduces the saver's real net return. If $dk/d\pi < 0$, the change in r_N depends on the balancing of the two effects.

The case in which $dk/d\pi = 0$ illustrates the potential magnitude of the effect of inflation on r_N when $\theta > \tau$. If the marginal product of capital is $f'(k) = 0.12$ and the personal tax rate is $\theta = 0.6$, the net rate of return in the absence of inflation is $r_N = (1-\theta)f' = 0.048$. If the corporate tax rate is $\tau = 0.5$, a 12 percent rate of inflation reduces r_N by 0.024 to half of its previous value, $r_N = 0.024$.

16. Recall that equation (17) and the discussion in section 3.2 established that either of these conditions makes $dk/d\pi > 0$.

17. Section 3.2 showed that $\tau > \theta$ implies $dk/d\pi > 0$.

This substantial sensitivity of r_N to inflation is a result of our tax system. Equations (32) and (17) show that without taxes ($\theta = \tau = 0$), r_N is unaffected by inflation except for the small liquidity effect on capital intensity.[18] A tax system in which the effective tax rate on capital income changes with the rate of inflation is arbitrary and inequitable.[19] If the definition of taxable interest income is altered to tax only the real interest ($\theta_1 > 0$, $\theta_2 = 0$) and to allow companies to deduct only the real component of interest payments ($\tau_1 > 0, \tau_2 = 0$), the return to savers will remain constant except for the liquidity effect; this is seen for $\tau_2 = \theta_2 = 0$ in equations (31) and (17). Complete indexing in this way also keeps unchanged the ratio of the tax paid to the net return. The magnitude of the possible changes in effective tax rates and net yields under our current tax system indicates the importance of revising the definition of taxable income and expenses to neutralize the effects of inflation.

3.4 The Welfare Effects of Inflation

Studies of the welfare effects of anticipated inflation have focused on the distortion in the demand for money that results from inflation.[20] More recently, Edmund Phelps has pointed out that the revenue from inflation permits a reduction in other distorting taxes so that some inflation is part of an optimal set of taxes when lump sum taxation is not possible. These studies have been done with a basic model in which there are no interest income taxes. The current analysis suggests an additional important effect of inflation on economic welfare: inflation changes the distortion in saving that is due to the tax on interest income.

The corporation tax and the personal interest income tax introduce a differential between the marginal productivity of capital [$f'(k)$] and the real net rate of return received by savers (r_N). Equation (27) implies that with no indexing this relation is

$$r_N = (1-\theta)f'(k) + \left(\frac{\tau-\theta}{1-\tau}\right)\pi \tag{33}$$

The differential between r_N and $f'(k)$ depends on the tax rates and the rate of inflation. If $\tau > \theta$, a positive rate of inflation can reduce the distorting effect of taxation. With $\pi = [\theta(1-\tau)/(\tau-\theta)]f'(k)$, the net

18. With $L' = 0$, r_N is constant.

19. A number of recent discussions have emphasixed that real tax liabilities should be independent of inflation. This has prompted proposals to adjust the income tax by the consumer price index so that the progressivity of the rate schedule does not cause inflation to increase real tax burdens. There have also been proposals to change the taxation of capital gains by adjusting the "cost" basis for changes in the consumer price index.

20. The analysis of this issue began with Milton Friedman (1942) and Martin Bailey (1956). Subsequent contributions are discussed in Robert Clower (1971), Harry Johnson (1971), and Edmund Phelps (1973).

rate of return to savers is equal to the marginal product of capital. If, however, $\tau < \theta$, a positive rate of inflation increases the differential between $f'(k)$ and r_N.

Phelps stressed that the increase in money that causes inflation is also a source of government revenue that permits a reduction in distortionary tax rates.[21] With a corporation tax and a personal interest income tax, the effect of inflation on government revenue is more complex. With no indexing of interest income, a rise in nominal interest payments increases revenues from the personal income tax but decreases revenues from the corporation tax. Total tax payments will rise with an increase in nominal interest payments if $\theta > \tau$ and will fall if $\theta < \tau$.

Since nominal interest payments per capita are ik, the net tax revenue on these payments is $(\theta - \tau)ik$. The change in net revenue from this source when inflation increases is therefore

$$(34) \qquad \frac{d[(\theta - \tau)ik]}{d\pi} = \frac{\theta - \tau}{1 - \tau}\left\{k + [\pi + (1 - \tau)\cdot(f' + kf'')]\left(\frac{dk}{d\pi}\right)\right\}$$

Since the sign of $f' + kf''$ depends on the form of the production function, the sign on the right-hand side of (34) cannot be unambiguously determined without further restrictions. In the most plausible case,[22] $[\pi + (1 - \tau)(f' + kf'')] > 0$ so that the change in net revenue is negative if $\tau > \theta$ and $dk/d\pi > 0$. Section 3.2 showed that $\tau > \theta$ does imply $dk/d\pi > 0$ and therefore that inflation reduces tax revenue. In the opposite case of $\theta > \tau$, an increase in inflation may increase revenue.[23]

The relation between the effect on revenue and the effect on the differential between $f'(k)$ and r_N should be noted. When $\tau > \theta$, a small positive rate of inflation reduces the differential between $f'(k)$ and r_N but also causes a reduction in tax revenue from this source. Although the distortion in the supply and demand for capital is reduced, the fall in net revenue requires an increase in tax rates that increases distortion else-

21. Phelps used a model in which the tax is levied on wage income and distorts the labor-leisure choice. The current model could easily be extended to include such a tax. Tax-induced changes in labor supply are equivalent to changes in the labor force participation rate and would not alter the effects of inflation on the capital intensity of production or the rate of interest. See Feldstein (1974*b*).

22. Note that kf''/f' is the elasticity of the marginal productivity of capital with respect to the capital intensity. With Cobb-Douglas technology, this is $\alpha - 1$ and $[\pi + (1 - \tau)(f' + kf'')]$ is unambiguously positive. Unless the elasticity of substitution is very great, the sign of $[\pi + (1 - \tau)(f' + kf'')]$ will be positive.

23. If $\theta > \tau$, net revenue will increase with inflation if $dk/d\pi > 0$. Section 3.2 showed that $\theta > \tau$ leaves the sign of $dk/d\pi$ uncertain. If the portfolio composition effect dominates the savings effect, $\theta > \tau$ does imply $dk/d\pi > 0$. In this case, an increase in inflation caused an increase in tax receipts.

where. Conversely, when $\tau < \theta$, a positive rate of inflation exacerbates the distortionary differential between $f'(k)$ and r_N but may yield an increase in tax revenue that permits a reduction in other distortionary taxes.

Of course, if the corporation tax and the personal income tax are fully adjusted so that they recognize only real interest payments, there is no effect of inflation on either the differential between $f'(k)$ and r_N or on the net tax revenue.[24] A more complete adjustment by the government would also provide interest-bearing money that would eliminate both the liquidity and revenue effects of inflation. But until such changes are made, determining the optimal steady-state rate of inflation requires balancing at least three effects of inflation on economic welfare: (1) the welfare loss that results from reduced liquidity; (2) the change in welfare that results from the increase or decrease in the differential between the marginal product of capital and individuals' marginal rate of substitution; and (3) the change in other distorting taxes that results from the increase or decrease in the net tax revenue in response to inflation. With this broader model of economic effects, it is no longer possible to conclude as Friedman (1969) did that the optimal rate of inflation is negative or as Phelps did that the optimal finance of government expenditures should include a heavy tax on liquidity through a high rate of inflation. A full evaluation of the optimal rate of inflation with our current tax rules is a subject for another study.

3.5 Conclusion

This paper has explored the impact of inflation in a growing economy. The presence of the corporate and personal income taxes substantially alters the effect of inflation on the capital intensity of production, the market rate of interest, and the real net return to savers. The existing theories of the optimal rate of anticipated inflation must be revised in light of these effects. The analysis also suggests that recent proposals to adjust the tax rules for inflation should be modified to include a specific adjustment for the inflation premium in the rate of interest.

There are several directions in which this research might usefully be extended. First, the model of financial behavior was highly simplified. It might be enriched to include corporate equity finance, household borrowing, and the use of inside money.[25] Second, the current paper focuses only on the steady-state effects of fully anticipated inflation. An analysis of the transition path would be valuable. Third, a model with two sectors

24. There will be a small effect on tax revenue because of the increase in capital intensity that results from the change in portfolio composition.

25. A model with equity finance is presented in Feldstein, Green and Sheshinski (1978; chap. 4 below).

would allow an analysis of the problems considered by Duncan Foley and Miguel Sidrauski (1971) as well as the issues raised by a tax that is limited to the corporate sector.

With a richer analytic structure, it would be both possible and necessary to introduce evidence with which to quantify the effects that have been discussed. The problem of inflation is likely to remain with us for a long time to come. It is important to improve our analytic understanding of its effects and to adjust our institutions accordingly.