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Impact of Inflation and Taxation on Interest Rates: A Survey of Recent Literature

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Contents

1/ The paper was completed during the summer of 1982 when the author was a consultant to the Fiscal Affairs Department. It is a part of a larger study on the subject of "Interest Rates and the Tax Treatment of Interest Income and Expenses" in preparation in the Department, with Ved Gandhi acting as the coordinator. Thanks are due to Ved Gandhi, Sheetal Chand, Jitendra Modi, and Menachem Katz for useful suggestions at various stages of the preparation of the paper, and Richard Lowe for his help in the preparation of the first draft. The final draft has improved greatly as a result of significant revisions made by John H. Makin and the author is extremely grateful to him. The author, however, bears full respons.bility for the contents of the paper.

1. Introduction

The effect of inflation on nominal interest rates, which was discussed extensively by Irving Fisher (1930), has received renewed attention in the economic literature since the early 1970s. The coincidence of rising inflation rates, rising nominal interest rates, and accelerating money growth, which characterized much of the 1970s, was difficult to explain without recourse to the Fisherian emphasis on the role of inflationary expectations in determining interest rates. Further, the exact way in which anticipated inflation affected interest rates was known to be important. Without considering taxes, Fisher made it clear that if a unit change in inflationary expectations resulted in an equal unit change in nominal interest rates, it was possible to infer that the expected real interest rate, a crucial determinant of investment and saving behavior, would remain constant. In such a case monetary changes that generated inflation and attendant inflationary expectations could be judged "neutral" or devoid of an effect on real economic activity or upon relative prices. Empirical investigations in this area like those of Gibson (1972), Lahiri (1976), and Carr, Pesando, and Smith (1976) often reported the estimated impact of expected inflation proxies on nominal rates to be significantly below unity, suggesting that higher anticipated inflation was associated with lower expected real rates.

Two explanations for this result were put forward by those who expected to see some form of the neutrality condition emerge as the "true" result. The first group cited measurement error in the proxy for expected inflation. Such measurement error could bias downward the estimated coefficient on anticipated inflation. Others, including Sargent (1972) and Levi and Makin (1978) pointed to the Mundell effect, whereby one would expect a rise in anticipated inflation to depress the expected real rate, thereby causing a less-than-unitary impact of anticipated inflation on nominal interest.

The question as to possible nonneutral effects of anticipated inflation and attendant monetary behavior became even more intriguing when a number of authors began to point out that after-tax real and nominal interest rates were what really affected economic behavior. (See Darby (1975), Feldstein (1976), and Tanzi (1976).) In particular, it was easy to show that as an income tax is levied on nominal interest earnings, if a rise in anticipated inflation is to leave constant the after-tax expected real interest rate, the nominal rate must rise by <u>more</u> than the rise in anticipated inflation. Specifically, the increase in the nominal rate must be $[1/(1-t)]$ times the rise in anticipated inflation where if t, the marginal tax rate on interest income, is 0.33, $[1/(1-t)]$ equals 1.5.

This discovery was both important and perplexing. It was important because a new neutrality criterion was established for independence from anticipated inflation of the expected after-tax rate. The estimated impact had to be well above the value of unity indicated by the Fisherian, no-tax analysis. Investigators were perplexed because most estimates of that impact were already significantly below unity and while the Mundell effect could account for results below unity given an expected value of unity, it could not account for the size of the gap between estimates significantly below unity and the value around 1.5 anticipated with taxes in the analysis.

Late in the 1970s another group of papers began to appear which took account of taxes and the Mundell effect and, by casting the analysis in a general equilibrium framework, were able to identify other variables which ought to appear along with some measure of anticipated inflation in an estimated interest rate equation. Levi and Makin (1978, 1979) derived an interest rate equation from a simple general equilibrium model that suggested the presence of output growth and inflation uncertainty along with anticipated inflation in the interest rate equation. Tanzi (1980b) included a measure of the stages of the business cycle and suggested that the rapid acceleration of inflation may have resulted in "fiscal illusion," whereby actions were based on perceived tax rates below those actually in effect as a result of growing differences between nominal market and real interest rates. Makin (1982, forthcoming 1983) considered the impact of various measures of the U.S. fiscal deficit, surprise changes in the money supply, inflation uncertainty, and anticipated inflation.

The upshot of this latter work is to reveal difficulties implicit in omitting significant explanatory variables from an interest rate equation. Once relevant variables are included, the estimated coefficient of anticipated inflation is about unity or slightly above, which, given operation of the Mundell effect, is a plausible value in a properly specified after-tax model. Of course explicit consideration of the role played by taxes in interpreting this result is crucial. Ignoring taxes on interest, the unitary coefficient on anticipated inflation would lead one to conclude along with Fisher that anticipated inflation does not affect the expected real rate of interest and that monetary changes and associated effects on anticipated inflation produce no real effects. With taxes explicitly considered, it is not possible to rationalize the coefficient around unity without recourse to the negative relationship between expected inflation and the (after-tax) expected real interest rate hypothesized by Mundell (1963).

The remainder of this paper presents a more thorough survey of the literature on the effect of inflation and taxation on interest rates. It also includes in the Appendix the effects of taxation and inflation on the real tax burden on individuals and corporations and their possible effects on the equilibrium interest rate. Other aspects of the effects of inflation and taxation on real variables are included in a subsequent paper. The survey starts with the theoretical analysis of interest rate determination and the classical Fisher effect, and follows with the derivation of the modified Fisher effect in a world with taxes. The theoretical section part is concluded by a discussion of other variables which affect the relationship between inflation and interest rates in a more general model. Since the emphasis is on inflation, taxation, and interest rates, the survey is generally restricted to a partial equilibrium analysis which centers on this relationship.

The major part of the empirical work in this area was done for the United States. We, therefore, deal separately with studies done for the U.S. economy and sort this literature according to its approach to the problem. Empirical work with U.S. data led researchers to different theoretical conjectures about individual and market behavior based only on a sample of one country. For that reason a comparison with empirical results for other countries is important, despite the fact that data on other countries may not be as detailed as those of the United States. An implicit (or explicit) assumption of many of the U.S. studies is that the interest is determined in an intervention-free competitive market. While this assumption may be questionable for the United States, it is much more so for some other Western countries.

2. Interest Rate Determination and the Fisher Effect

In a period of changing prices one has to distinguish between the nominal market rate and the real interest rate. As mentioned by Lutz (1981), the first theory of the relationship between inflation and interest rates was developed by Thornton (1802). This theory was formalized in the works of Irving Fisher (1896, 1930).

Using the theoretical framework of the loanable funds approach, Fisher concluded that the expected real interest rate is constant and that the nominal interest rate is equal to the expected real interest rate plus anticipated inflation. This analysis leads to the well-known Fisher equation:

$$i = r + \pi \tag{1}$$

where i = the nominal interest rate
r = the expected real interest rate
π = the expected rate of inflation.

If a rise in π leaves r unaffected it will result in an equal rise in i. This is the Fisher effect. Assumed independence of the expected real rate from expected inflation was questioned by Mundell (1963) and Tobin (1965). Mundell's argument is based on the negative impact of expected inflation on desired real money balances. Higher anticipated inflation reduces desired money balances. The resulting decline in wealth reduces consumption and stimulates increased saving. As a result, the equilibrium between higher saving and investment must occur at a lower expected real rate of interest, which induces real investment to rise to equal higher real saving.

Karni (1972) extends Mundell's analysis to the long-run by assuming that the long-run marginal efficiency of capital is constant and independent of the level of real balances. As a result, he shows that the equilibrium obtained by Mundell is short run and that in the long run the real rate of interest tends to converge back toward its original stationary-state level.

Tobin's (1965) analysis is also related to the effect of inflation on real money balances, with an emphasis on the cost of holding money balances as a liquidity premium for money. As inflation increases the nominal interest rate and the cost of holding money, it leads to a substitution from money to bonds and other assets in individuals' portfolios. This increases saving and reduces the real interest rate.

3. Effect of Taxation on the Fisher Equation

The incorporation of taxation on the relationship between inflation and interest rates was suggested independently by Darby (1975), Tanzi (1976), and Feldstein (1976). Darby assumed arbitrarily that the liquidity effect and the income effect, which operate through the demand function for nominal balances, acted to "exactly cancel in their effect on the real interest rate, so that the nominal interest rate increases in final equilibrium by exactly the increase in the rate of inflation." On the basis of this simplifying assumption, Darby restricts his analysis to the Fisher equation (1) and incorporates an income tax by assuming that borrowers and lenders are interested in a real after-tax interest rate, and that the latter variable is maintained constant in the equilibrium solution. He assumes (as in the U.S. system) that interest receipts are taxable and interest payments are deductible. Assuming further the same marginal tax rate, t, on borrowers and lenders Darby obtains a modified Fisher equation

$$i(1-t) - \pi = r^*$$

where r^* is the expected real after-tax interest rate, which is assumed to be constant and π is the expected rate of inflation.

Thus, the modified Fisher effect for a world with simple income tax is given as

$$i = \left(\frac{1}{1-t}\right) \quad [r^* + \pi]. \qquad (2)$$

Tanzi (1976) approaches taxes on nominal interest as one form of excess taxation, which is owing to the nominal characteristic of the U.S. tax system (as well as of many other Western countries). Tanzi shows that if one extends the Fisherian assumption to a world with tax, namely, that the required after-tax interest rate is constant, then the nominal interest rate will increase with inflation according to

$$i = \left(\frac{1}{1-t}\right) [r^* + \pi]$$

which is the same as the modified Fisher effect derived by Darby. Tanzi also shows that indexation of the tax system will lead to Fisher's classical results.

Feldstein's (1976) analysis starts with a model of a growing economy with inflation and an income tax wherein he observes that inflation and taxation tend to affect the equilibrium capital stock per capita. He considers implications of different tax rates on nominal and real income, as well as different tax rates for individuals and corporations.

However, for the U.S. corporate tax system of no indexation Feldstein approximates the impact of anticipated inflation on nominal interest as

$$di/d\pi = 1/(1-t) \qquad (3)$$

which is identical to the conclusion of Darby (1975) and Tanzi (1976) and is larger than $di/d\pi = 1$ suggested by the Fisher equation for $1>t>o$.

Gandolfi (1976) developed a model of loanable funds that determines the equilibrium interest rate, with emphasis on investment decision by firms. He recognized that while the imposition of a tax on profits has no effect on the Fisher equation when investment is financed by debt, a proportional income tax will cause a divergence between the after-tax real rate received by savers and the real rate paid by firms. In the latter case Gandolfi derived the Fisher effect with taxes:

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

He suggested also that this effect should be somewhat modified to take account of the Mundell real balance effect on saving.

The firm's ability to compensate the investor by more than the rise in the expected inflation rate is based on the fact that, owing to the tax deductibility of interest payments, the net marginal cost of interest to the firm increases only by

$$(1-tc)di/d\pi = (1-tc)\pi/(1-t)$$

where the corporate tax rate, tc, is equal to the personal tax rate, t. Viewed alternatively, the net increase in the cost of capital as a result of inflation equals the rate of inflation in equilibrium. This also equals the nominal increase in the net marginal return of investment. Formally, this equilibrium condition can be written as

$$1 + r^* (1+\pi) = 1 + i(1-t) \qquad (4)$$

where r^* is the real net marginal product of capital and t is the corporate tax rate, which is assumed to be the same as the personal tax rate, t. The equilibrium solution is

$$(\frac{1}{1-t}) [r^* + \pi + r\pi]. \qquad (5)$$

The first term is the real rate of return in a world with tax rate, t, in the absence of inflation, while the second and third terms are the modified Fisher effect (where the third interaction term is often omitted for simplicity).

The results above are modified if the nominal capital gains created by inflation are taxed at the capital gains tax rate, h. In this case, the basic equation (4) changes to

$$[1 + r^*]\ [1 + \pi(1-h)] = 1 + i(1-t). \tag{6}$$

From the firm's point of view, equation (6) yields

$$i = (\frac{1}{1-t})\ [r^* + (1-h)\pi + (1-h)r\pi]. \tag{6'}$$

The correction for inflation thus depends on the capital gains tax rate as well as on the regular (corporate and personal) tax rate. The combined effect of capital gains tax and corporate (and personal) income tax on interest rates outlined above was discussed in Feldstein and Summers (1978), Nielsen (1981), and Gandolfi (1982). The latter paper also discusses the relationship between inflation and the interest rate under alternative tax systems that differ in their treatment of capital gains and depreciation.

The intuitive interpretation of these results is that if a capital gains tax results in some reduction in returns to real assets because of inflation, the equilibrium rise required for returns on financial assets will be less.

It should be noted that the tax rate by itself tends to affect the the constant term on the Fisher equation, as that is often viewed as the expected real rate. Properly specified as in equation (6') the constant term becomes the expected after-tax real rate. It may not appropriately be viewed as a constant term if tax rates vary. Significant changes in tax brackets of representative investors, as with "bracket creep" discussed by Feldstein and Summers (1978), deserves careful attention in empirical work.

4. General Equilibrium Analysis of Inflation, Interest Rates, and Taxation

Darby's (1975) analysis, which leads to the modified Fisher effect, was based on a restricted partial equilibrium analysis in the loanable funds market. The analysis was extended in a general equilibrium framework in the recent works of Levi and Makin (1978, 1979) and Makin (1982, forthcoming 1983).

The main characteristic of Levi and Makin's analysis is that investment (and possibly saving) depends on the real after-tax interest rate, while demand for money depends on the nominal market rate. (It should be noted, however, that the relevant interest rate is the after-tax, rather than the before-tax, interest rate.) Using the above model (with the error mentioned) Levi and Makin derived a more complicated expression for the relationship between inflation and the interest rate, and were able to suggest a range for the marginal effect of expected inflation on the interest rate ($di/d\pi$) ranging between 0.857 and 1.333, compared with values of 1.0, as suggested by the Fisher equation, and 1.5, calculated by the modified Fisher equation (assuming $t = 0.33$).

In a subsequent empirical paper, Levi and Makin (1979) extended the model by including inflation uncertainty, σ, which is allowed to depress real investment and real income and, thereby, saving. They find that the negative impact on real investment is dominant as estimation reveals a significant negative relationship between inflation uncertainty and nominal interest.

Levi and Makin extend their analysis by adding the Phillips effect of positive relationship between inflation and growth. Assuming that inflation is not fully anticipated they also consider the Friedman effect of a positive relationship between the amount of inflation and uncertainty about inflation (measured by standard deviation of the distribution of inflation).

On the basis of their theoretical analyses, Levi and Makin suggested a modification of the simple relation between nominal interest and inflation as

$$i = \beta_o + \beta_1\pi_t + \beta_2\dot{y}_t + \beta_3\sigma_t + e_t \qquad (\beta_1>o;\ \beta_2,\ \beta_3<o)$$

where $\dot{y}$ is the growth in income in period t, and σ_t is a measure of inflation uncertainty, and e_t is an error term. Making some reasonable assumptions about parameter values, these authors conclude that estimating the simple relationship between the interest rate and expected inflation (and omitting the two other variables) leads to a misspecified model in which the coefficient is underestimated. Empirical tests tended to confirm effects hypothesized by Levi and Makin.

5. Empirical Tests of the Fisher Effect in the United States

An early empirical test of the Fisher effect was done by Fisher (1930) in conjunction with the development of his theory. More recent empirical works were initiated by Ball (1965) for the United Kingdom and Sargent (1972) for the United States.

Most of the early work on testing the Fisher hypothesis concentrated on identifying alternative measures of anticipated inflation upon which to regress nominal interest rates. Investigations include those by Sargent (1972), Yohe and Karnosky (1969), Gibson (1970, 1972), Fama (1975), Carlson (1977a, 1977b), and Nelson and Schwert (1977). As all these investigations have ignored the role of taxation, they will not be surveyed in detail here. Some further discussion of these papers may be found in Roll (1972) and Sargent (1976).

The role of taxes in empirical testing of the Fisher hypothesis was first cast into a general equilibrium framework by Levi and Makin (1978). They drew on the important earlier papers of Darby (1975), Feldstein (1976), and Tanzi (1976), which made explicit the economic fact that the behavior of investors depends upon expected after-tax real rates. When this reality was combined with a general equilibrium framework that determined interest rates, as well as prices, output, and employment, Levi and Makin (1978) were able to demonstrate that a coefficient of unity describing the impact of anticipated inflation on nominal interest was both plausible and reasonable in a world where taxes were considered. Implications of the model that indicated a need for inclusion of additional explanatory variables as well as anticipated inflation were supported by results reported in Levi and Makin (1979). These additional explanatory variables included output, growth, and inflation uncertainty as discussed earlier. More recently, surprise money growth and unanticipated fiscal deficits have also been shown to enter significantly into interest rate equations by Makin (1982, forthcoming 1983).

Tanzi (1980b), also includes explicit recognition of the role of taxes, together with roles played by explanatory variables and anticipated inflation in explaining the behavior of interest rates. First, he compares alternative models describing formation of inflationary expectations with the Livingston series on expected inflation. Next he substitutes alternative series on expected inflation into the Fisher equation and finds coefficients of about 0.6 on anticipated inflation with a six-month treasury bill as dependent variable. For 12-month treasury bills estimated coefficients on anticipated inflation are smaller and less robust.

Next, Tanzi suggests that important variables may have been left out of the regression indicated by the simple Fisher equation. He interprets the results in the context of the existing U.S. tax system and concludes that the results indicated possible "fiscal illusion" by individual investors in the market. In this view individuals are compensated enough to keep the real, before-tax interest rate constant but the effect of income taxes in reducing the net of tax expected real rate of interest was ignored. In a competitive market this assumption of fiscal illusion should also apply to borrowers, and in particular those in the corporate sector, in order to explain the nonadjustment of interest to inflation. The effect of fiscal illusion would be to observe inadequate changes in nominal interest rates relative to those required to keep constant the expected after-tax real rate in the face of a change in anticipated inflation.

Makin (1978) presents a model of an open economy in a world including taxes and flexible exchange rates, which considers equilibrium in the market for labor commodities, foreign exchange, and money. Using the equilibrum conditions in these markets, Makin derives the relationship between interest rates and expected inflation as

$$di/d\pi = 1/[(1-t)+\alpha]$$

where the added term α represents a set of parameters including elasticities of the demand for money, demand for imports, and supply of labor.

Using reasonable assumptions regarding those parameters, Makin evaluates the term α to be positive, and thus concludes that it reduces the effect of expected inflation on nominal interest rates compared with the modified Fisher effect. Viewed in this way, openness may help to account for findings of lower-than-anticipated effects of expected inflation on nominal interest rates. Further, the open economy term can be expected to vary from country to country, as can the tax effect that will depend, in turn, upon differences across countries in taxation of interest earnings, as well as upon differences in tax treatment of foreign exchange gains and losses.

The effect of inflation on long-term interest was estimated by Feldstein and Summers (1978). They first formulated a model of long-run inflationary expectations by estimating a Box-Jenkins ARIMA model of the inflation rate. 1/ Using the expectation derived from the model they found that a 1 per cent change in expected inflation increased the interest rate by 0.94 percentage point. This result, which is not consistent with the modified Fisher model, is explained by Feldstein and Summers by excess taxation of business in a nominal tax system, which overstates profits by evaluating inventory at historical costs and basing allowed depreciation allowances on historical costs. (See the Appendix for a full discussion of the effects of inflation on effective rates of taxation on individuals and businesses.) It should be noted that the results of Feldstein and Summers are not robust under alternative estimation procedures, and the criticism directed at the use of full sample data to generate a model of expectations for use within a sample applies to the ARIMA model used in the paper. (See Makin (1982) for a full discussion of such criticism.)

1/ ARIMA refers to an autoregressive integrated, moving-average model, which explains inflation in terms of its own past history.

Summers (1982) presents a comprehensive study of the relationship between interest rates and inflation. Using data on interest rates and inflation for the years 1860 to 1979, he demonstrates that the real rate of interest fluctuates significantly. The average real interest rate ranged from 19.8 per cent in the 1870s to -4.6 per cent in the 1940s. It is not surprising that R^2 in the regression between interest and inflation is very low. Using the prewar data and a band spectral technique, Summers finds also that there is a very weak relationship between the interest rate on commercial paper and the long-term interest rate.

For the postwar period data Summers finds a significant positive association between interest rates and inflation, but the coefficient is much lower than the predicted coefficient of 1.33, which is derived in a world including taxes. In summarizing these results, Summers also concludes that "perhaps there is some unmeasurable variable which is correlated with inflation and which affects required real returns." This conclusion is consistent with those of Fama (1981), Tanzi (1980b), and Makin (1982, forthcoming 1983). Summers also suggests the possibility of some form of money illusion in the financial markets. This idea of money illusion (or fiscal illusion) is consistent with analyses by Tanzi (1980b), and by Modigliani and Cohn (1979).

6. Studies on the Relationship Between Interest Rate and Inflation in Other Countries

As is true for most U.S. studies a majority of investigations for other countries find a coefficient on anticipated inflation close to or below unity, indicating in some cases underadjustment of nominal interest rates if expected after-tax real rates are to be maintained in the face of faster anticipated inflation. Part of this result may be due to varying degrees of openness alluded to by Makin (1978).

An early empirical investigation of the relationship between inflation and interest rates was done for the United Kingdom by Ball (1965). Ball examined the relationship between a long-term interest rate and a measure of liquidity (ratio of money to income) and expected inflation measured as a Koyck-type distributed lag on past rates of inflation. While the liquidity effect on the interest rate was negative and significant, the estimated effect of expected inflation was not significantly different from zero. It was negative for the pre-World War II period (1921-39) and positive for the post-World War II period (1947-61). It is interesting to note that Ball viewed the rate of inflation as the price of holding money and tested this price effect on the interest rate. He did not consider the issue of real and nominal interest rates that characterized later works.

Tests of the tax effect and inflation on interest rates in Canada were performed by Carr, Pesando, and Smith (1976). In a test of the modified Fisher effect for Canadian data for the period 1959 to 1972, these authors measured expected inflation using both a distributed lag model and a synthetic prediction based on the rational expectation hypothesis. Their results for alternative models indicate that the coefficient of anticipated inflation on interest rate tends to be about one for both long and short-term interest rates.

In a study of the Fisher effect for the Federal Republic of Germany, Siebke (1976) assumed a distributed lag relationship between interest and inflation and estimated the impact of expected inflation on interest rates using, alternatively, the Koyck transformation approach and the Almon lag procedure. The results in both cases indicated a long-run coefficient of one. The partial effect of inflation declined, however, when it was included jointly with the real changes in money supply.

In estimating the effect of price expectations on interest rates in Germany, Neumann (1977) developed a more general macromodel that included several markets, namely:

a. demand and supply for money;
b. demand and supply for domestic credit;
c. demand for foreign financial assets; and
d. identifying restrictions to complete the model.

Neumann found for the period 1960-72 that the coefficient of anticipated inflation on the interest rate (in a reduced form model) was less than unity in the short run.

An interesting finding reported by Neumann is that the Deutsche Bundesbank (the central bank of the Federal Republic of Germany) was active in the market, and the discount rate set by the bank was adjusted to anticipated inflation, as well as to the adjusted foreign interest rate (which represented an alternative investment (loans) opportunity to German savers (borrowers)). Furthermore, the foreign interest rate appeared to have an independent positive effect on the domestic interest rate in Germany.

While Neumann's results were calculated in a period of fixed exchange rates, his findings may have implications in the recent periods of flexible exchange rates. His results, and his discussion of central bank policy, may also be relevant to other countries.

In a recent study of interest rates in Japan, Kama (1981) used a distributed lag regression between interest rates and prices. He found that a 1 per cent increase in the consumer price index increased the call rate by 0.24 percentage points. The effect on the bond rate was even lower.

In a recent study of Argentina for the period 1964-76, Leiderman (1979) followed Fama's version of the Fisher hypothesis by regressing the inflation rate on the interest rate. He obtained a coefficient larger than one which indicated that the interest rate adjusted only partially to inflation, with an implied coefficient of 0.5.

Testing the efficiency of the financial market, however, Leiderman could not reject the null hypothesis of market efficiency in a sense that the interest rate used all the information about the subsequent prices that are available in past price data. (Note that Nelson and Schwert's (1977) criticism of Fama (1975) regarding the power of such a test applies also to this case.)

Finally, in a recent comparative study for nine industrial countries, Mandelker and Tandon (1981) extended Fama's approach to test interest rates as predictors of inflation for the period 1966-79. The results indicated that some of the coefficients were on the order of 1 for most of the countries, particularly when the regression was restricted to periods with no wage/price controls. These results led Mandelker and Tandon to conclude that movements in short-term interest rates can serve as a proxy for changes in anticipated inflation. The results also indicated that the constant term which they interpreted as an estimate of the real interest rate is not significantly different from zero, and often is negative. The results suggest also that for the Netherlands there is no relationship between the interest rate and inflation. In Japan the interest rate adjusts only partly to inflation, while in Germany the implied coefficient of the interest rate on anticipated inflation is about 2.

The results for Japan, with an implied adjustment coefficient of 0.6, are consistent in direction with the findings of Kama (1981), while the results for Germany are different from those reported by Neumann (1977) for an earlier period. Since the inflation in Germany was lower than for other countries, it is possible that Mandelker and Tandon's results reflect the policy of the Deutsche Bundesbank to raise its discount rate in response to higher foreign interest rates. If this is true (but was not tested) it is consistent with the policy described by Neumann.

7. On the Volatility of Interest Rates

The increased volatility or variability of interest rates for the United States in recent years has led economists to study their determinants and their impact on the behavior of economic units (see, for example, Friedman (1982) and Walsh (1982)). An interesting and relevant question for this paper to address is the effect of inflation and taxation on the variability of the interest rate. This effect is analyzed by Makin and Tanzi (1982) and their arguments are reproduced below. When taxes are considered, recall that the aim is to define as the investor's objective an after-tax real rate r*, written as

$$r_t^* = i_t(1-\tau) - \pi_t(1-\tau') \qquad (7)$$

where τ is the perceived marginal tax rate on interest income, i_t and τ' is a representative perceived marginal tax rate on returns from alternative (to interest-bearing) assets, which is assumed to equal, on average, the expected inflation rate, π_t. Transposing equation (7) to place i_t on the left-hand side gives

$$i_t = (\frac{1}{1-\tau})\ [r_t^* + (1-\tau')\pi_t]. \tag{8}$$

Turning to the question of interest rate volatility, an expression for the variance of interest rates, based upon equation (8) is given by

$$\sigma_i^2 = (1/1-\tau)^2\ \sigma_{r*}^2 + ((1-\tau')/(1-\tau))^2\ \sigma_\pi^2 + 2((1-\tau')/(1-\tau)^2)\ \theta_{r*_\pi}\ \sigma_{r*}\sigma_\pi \tag{9}$$

where σ_x^2 denotes variance of variable x ($x = r^*,\pi$) and θ_{r*_π} is the coefficient of correlation between r^* and π. Notice that when taxes are ignored as in equation (1), the variance of i is written as

$$\sigma_i^2 = \sigma_r^2 + \sigma_\pi^2 + 2\theta_{r_\pi}\sigma_r\sigma_\pi. \tag{10}$$

The effects of considering tax rates are evident from comparing equations (9) and (10). Ignoring the effects of possible correlation between r^* and π ($\theta_{r*_\pi} = 0$ for now), volatility of after-tax real rates unambiguously produces <u>more</u> volatility of i since for any $\tau > 0$ $[1/(1-\tau)]^2 > 1$. [As an example, given $\tau = 0.35$, $[1/(1-\tau)]^2 = 2.37$, or given an average tax rate of 35 per cent on interest income, a rise of 1 per cent in the variance of the after-tax real rate raises the variance of i by 2.37 times the effect of a rise in the variance of the real rate when taxes are ignored, as in equation (10).] Furthermore the higher is τ the greater will be the volatility of i, <u>ceteris paribus</u>. Of course, this argument assumes that there is no fiscal illusion so that tax effects are fully recognized by investors. Uncertainty over future tax policy can have a powerful impact on the observed volatility of i. Equation (9) suggests also that the effects of a rise in the variance of expected inflation upon the observed variance of i will be magnified as long as τ', the marginal tax rate on alternative assets, is below τ, the marginal tax rate on interest income.

Since theoretical considerations (the Mundell-Tobin effect) suggest a negative correlation between anticipated inflation and the real rate ($\theta_{r_\pi} < 0$), there will result some dampening of the effect of changes in variance of real rates and variance of anticipated inflation in both tax and nontax cases, but the dampening effect is reduced by consideration of tax effects for almost any conceivable values of relevant parameters. 1/

It is interesting to note that as empirical studies suggest a positive relationship between the rate of inflation and the variance of inflation, an increase in the average rate of inflation will lead to higher volatility of interest rates, which is further enhanced by the presence of taxes on interest earnings.

8. Concluding Comments

The paper summarizes the theory concerning the relationship between expected inflation and interest rates in a world with taxation following the initial framework developed by Fisher. Several extensions of the basic theory are discussed including the Mundell real balance effect, the Tobin substitution effect, formulations of a general equilibrium model from which to derive an interest rate equation as a reduced form, and an extension to an open economy.

The earlier postwar empirical studies discussed focus largely on a positive relationship between nominal interest rates and expected inflation. Later studies attempt to control for movements in the expected, after-tax real rate. In general, empirical studies reported apparent underadjustment of nominal interest rates to changes in anticipated inflation, especially in the light of the impact of taxes on interest earnings. In some instances indicated adjustments could only be rationalized by negative after-tax, expected real rates during periods of accelerating inflation.

1/ The effect of a rise in σ_r^{2*} upon σ_i^2 (where for convenience $\sigma_r^{2*} \approx \sigma_\pi^2$) is given by

$$\partial\sigma_i^2/\partial\sigma_r^{2*} = \frac{1+(1-\tau')[2\theta_{r^*_\pi} + (1-\tau')]}{(1-\tau)^2}$$

when tax rates are considered and, ignoring taxes, by

$$\partial\sigma_i^2/\partial\sigma_r^{2*} = 2(1 + \theta_{r^*_\pi}).$$

For $\tau = 0.35$; $\tau' = 0.25$; $\theta_{r^*_\pi} = -0.25$; the first of these equations equals 2.81 while the second equals 1.5. If $\tau' = 0$, the first equation becomes 3.55 and if $\tau' = \tau$ it becomes 2.6.

Resolution of the puzzle of apparent underadjustment of rates has been crucially related to the role played by introduction into the analysis of taxes on interest earnings. That step, which implied an adjustment coefficient of nominal interest rates to anticipated inflation well above unity in the simplest case, prompted investigators to pursue other avenues including the role played by taxes in rationalizing coefficients significantly below unity. The excessive gap between a theory which recognized the role of taxes and empirical findings led investigators such as Levi and Makin (1978) and Tanzi (1980b) to expand theory in a manner that expedited identification of relevant, additional explanatory variables in interest rate equations. Further progress in this direction has come in the wake of the Federal Reserve's new operating procedures, adopted in October 1979, and succeeding emphasis on control of the money stock, which, after passage of the Economic Recovery Act in August 1981, resulted in a "tight-money-easy-fiscal" stance for the United States. Makin (1982, forthcoming 1983) investigates the role of fiscal policy variables and unanticipated money supply changes in affecting real and, thereby, nominal interest rates, while simultaneously allowing for taxation of interest earnings.

A number of other steps have been required to bridge the gap between theory and actual behavior of interest rates. The role of tax considerations in such progress has centered on allowing for tax treatment of capital gains and losses on alternatives to financial assets. This line of investigation is suggested by the work of Tanzi (1982a) on money demand. Further promising avenues of investigation include tax treatment of foreign exchange gains and losses as, in an open economy setting, interest rates are determined simultaneously with exchange rates. Work by Levi (1977) represents a promising start in this direction.

Another explanation suggested by Feldstein and Summers (1978) for the nonadjustment of interest rates relates to the real effect of inflation on corporate profits due to tax treatment of depreciation of inventory and depreciation which tends to overstate profits. Under such circumstances, inflation may reduce the demand by firms for loans by reducing their ability to repay as well as their incentive to borrow money for investment projects. (See the Appendix for further discussion.) While the real cost of loans may decline with inflation, the real after-tax return from the use of a loan may also decline with inflation. This phenomenon may account for some apparent underadjustment of nominal interest rates to changes in anticipated inflation. The role of the negative relationship between inflation and corporate profits in affecting equilibrium and after-tax real returns merits further investigation.

A further explanation for underadjustment of nominal interest rates to changes in anticipated inflation suggested in the literature particularly by Tanzi (1980a, 1982b) and Summers (1981) is the existence of "money or fiscal illusion" in the market. This illusion is said to decline over time as investors become accustomed to a change in the inflationary environment. This hypothesis is inconsistent with the notion of fully rational agents generally assumed present in the efficient financial markets.

All of these considerations have been a part of the rapid progress in theoretical and empirical analysis of interest rate behavior. An important part of this progress has involved explicit recognition of the fact that actions of economic agents are governed by after-tax interest rates. What remains to be done is to incorporate after-tax treatment of foreign exchange gains and losses with interest rates (after-tax interest parity) into an open economy, general equilibrium setting. This approach will enable further analysis of implications for the differential impact of monetary and fiscal policies pursued at home and abroad of alternative tax treatment of interest earnings and payments and foreign exchange gains and losses.

9. Agenda for Research

It is typical to observe taxes levied on nominal magnitudes such as interest rates, nominal capital gains, and nominal net profit flows. This fact implies that inflation or deflation results in significant and often unintended changes in the real, after-tax rates of return or relative prices that govern economic behavior. The classical dichotomy whereby monetary changes that alter prices produce no real effects may well be valid in a world without taxes but invalid where there are taxes. An agenda for research involves explanation of the roles played by taxes in altering previously held views about economic behavior, particularly where those views are based upon analyses that ignore taxes. Specific questions in need of further investigation include the following:

a. How does the tax treatment of interest payments and receipts by individuals and corporations affect the real impact of aggregate monetary and fiscal policy measures at home and abroad?

b. How might widely employed arbitrage-equilibrium conditions such as interest parity be affected by consideration of tax treatment of interest payments and receipts and of capital gains and losses by various governments?

c. What are the implications for question (a) of incorporating answers to question (b) into a general equilibrium, open economy model designed to investigate effects of monetary and fiscal policy measures under alternative exchange rate regimes?

d. What are the implications of taxes for the theory of exchange rate behavior?

e. How might widespread use of indexed contracts in securities markets and labor markets alter the impact of inflation or deflation on real after-tax returns or relative prices?

Impact of Inflation on Personal and Business Income Tax

1. Personal income tax

The personal tax systems in most Western countries were defined until recently in nominal terms as far as personal deductions and tax tables were concerned. In this system inflation tended to affect the real tax burden on the individual and his saving behavior. As discussed earlier, the taxation of nominal interest income at the personal level is one of the reasons given for the modified Fisher effect of expected inflation on interest rates.

A comprehensive analysis of the effect of inflation on the personal tax in an international context is presented in a recent book by Tanzi (1980a). The book covers implications of the nominal tax system, discusses problems and solutions, and presents the experience of other countries with nominal tax systems. Several suggestions for adjustment and indexation are included in a conference volume on inflation and the income tax edited by Aaron (1976). Furthermore, discussions of the effect of inflation on personal tax burdens are included in a recent survey article by Nowotny (1980).

In this Appendix we will briefly present some aspects of the effects of nominally based personal taxes in inflationary periods and their possible effect on the supply and demand for loans. For a more general framework, we refer an interested reader to Tanzi (1980a), Aaron (1976), and Nowotny (1980).

In a study of the U.S. economy for the years 1947-79, Steuerle and Hartzmark (1981) have shown that the average tax rate (including federal, state, and local) increased during 1947-79 by 3.4 percentage points from 10.1 per cent to 13.5 per cent. Furthermore, the percentage of returns paying a marginal tax of 22 per cent or more increased from 10 per cent in 1961 to 36 per cent in 1979. These results may indicate that the recent reduction in the tax rate in the United States may be partly compensation for the increase in the rate during inflationary periods. A study of the United States by Joines (1981) indicates that the fraction of labor force whose income is subject to taxation increased between 1953 and 1975 from 74.5 per cent to 80.5 per cent. Also the marginal tax rate on labor income increased in that period from 21 per cent to 27 per cent.

Aggregate figures of the effect of inflation on effective taxation may be misleading. Nowotny (1980) refers to empirical studies for various countries, these studies generally indicate that large family groups lost more than other groups because of the declining real value of the exemption. This change tends to have a regressive effect on income distribution. A recent calculation for the United States by Arak (1976) indicates that low-income families have lost significantly owing to the fact that personal exemptions and maximum standard deductions are fixed in dollar (nominal) terms.

Important effects of inflation on personal income tax depend on the taxation of nominal capital gains and nominal interest rate. As Tanzi (1976) emphasized, taxation of the nominal interest rate tends to increase the real tax on interest income owing to a tendency for nominal interest rates to rise by an amount insufficient to maintain stable after-tax real returns. Similarly, with a nominal capital gains tax, individuals may face a tax liability even though the price of taxable assets has declined in real terms.

As suggested by Hendershott and Sheng-Cheng Hu (1981), the treatment of interest costs as a deduction from taxable income for individuals, which is allowed in the United States and in some other countries, enables them to benefit from the nominal aspect of the tax system. This is true in particular for individuals with large debt payments on their assets (e.g., homeowners with mortgages). The benefit from interest rate deductibility, in particular on housing, tends to increase inequity in the distribution of income as the use of interest rate deductibility is more frequent among middle- and high-income families. Furthermore, the exclusion of income in kind in terms of housing services from taxable income, which is a norm in many Western countries, has a regressive effect on the distribution of income. The deductibility of interest payments may, in addition, discourage other forms of saving in favor of homeownership. An empirical study by Tanzi (1977) for the United States showed that the main beneficiaries of the tax treatment of nominal interest incomes and deductions were the middle-income classes. Both higher- and lower-income groups lost.

An important effect of inflation on the personal tax burden arises from taxation of nominal capital gains. As inflation increases the nominal value of assets, it creates capital gains which often may be associated with a real capital loss if the price of the asset is increased by a smaller percentage than the rate of inflation. Tanzi (1980a) discusses this problem and also presents some alternative solutions and procedures used by different countries to correct the effect of inflation.

For the United States an important component of the capital gains tax is the taxation of capital gains from the sale of corporate securities, while taxation of gains on housing can frequently be avoided. Feldstein and Slemrod (1978) claim that the capital gains tax on the sale of securities is excessive, as it is imposed on nominal gains that are largely associated with inflation and with much lower real capital gains. Using a sample of income tax returns that were submitted to the Internal Revenue Service in the fiscal year 1978, they calculated the real capital gains using a consumer price index deflator and found that the tax liability of real capital gains was only $601 million, while the actual tax paid was $1,173 million. The excess tax paid was $477 million, an increase of 70 per cent over the inflation-adjusted tax. Feldstein and Slemrod also pointed out the randomness of the rate under which individuals with the same real capital gains are required to pay taxes on very different nominal gains. Their main recommendation is to require individuals to pay taxes only on real capital gains.

Feldstein, Slemrod, and Yitzhaki (1980) and Feldstein and Slemrod (1980) discussed and empirically estimated the effect of capital gains taxes when high capital gains taxes prevent individuals from realizing real capital gains in their portfolios. They also discussed the different effects of taxes on different assets, which led to misallocation of asset holdings and investment and welfare costs associated with the nonoptimality of this allocation.

Personal income tax has an important effect on the supply of labor, as workers are interested in their after-tax income (see, for example, Macrae and Yezer (1976)). The inclusion of an income tax is important in theoretical derivation and empirical estimation of labor (supply schedules) and in determination of an equilibrium wage. The effect of inflation and taxation on the equilibrium wage was emphasized in a recent work by Tanzi and Iden (1981). The main idea is that in order to keep the same real wage in a period of inflation the after-tax wage should increase by the rate of inflation. In a progressive tax system, when we observe bracket creep, wage rates must increase by more than the rate of inflation to compensate the individual for the increase in his marginal tax rate (for a given real wage and real income). This will lead to an increase in real (before tax) wage rates paid by employers.

Tanzi and Iden (1981) suggest that the response of wage (W) to inflation (i) depends upon the average and marginal tax rates, i.e.,

$$(\Delta W/W) = (i-ta)/(i-t_M)$$

where $\Delta W/W$ is the change in wage rate, ta is the average tax rate, and t_M is the marginal tax rate on the wage increase. This effect of a nominal progressive tax system may have important macroeconomic implications.

2. Inflation and taxes on business income

Inflation also affects the real tax burden of corporations where the tax system is based on nominal values. This is true in most modern countries.

The problem of inflation accounting has attracted significant attention in accounting literature. In a summary of inflation accounting issues, Vasarhelyi and Pearson (1979) present the basic taxonomy with regard to the approach of historically-based accounting versus valuation- (or replacement-) based accounting, as well as a classification of the methods of research. Discussion regarding the reporting of inflation in the United Kingdom is given by Piper (1979), while a more general analysis of accounting treatment in continental Europe is given in Schoenfeld (1979). The survey of literature in this section deals with the economic implications of different accounting techniques rather than with the details of accounting methods.

On a theoretical level it is shown by Stiglitz (1981) that the real effect of taxes on firms in an inflationary economy is created primarily by a tax system that is not fully indexed for inflation. In particular, Stiglitz (1973) claims that a fully indexed tax system will have a neutral effect on the firm. Stiglitz's condition for a neutral system is

a. depreciation must be at replacement cost and the "correct" rate;

b. taxes on the interest rate apply only to the real interest rates, and only real interest rates are tax deductible; and

c. capital gains and losses are to be taxed (at full rates) on an overall basis rather than on a realization basis.

The above conditions are consistent with those in an earlier work by Sandmo (1975) that analyzed the effect of corporate taxes on investment incentives.

The main aspects of nominal corporate income taxes discussed in economics and accounting literature are (a) the treatment of depreciation and allowance for tax purposes; and (b) the treatment of value of the inventory stock and the implied cost of materials employed in the calculation cost of goods sold.

Depreciation allowances based on historical cost tend to underestimate the real cost of the use of capital services by the firm. This has two effects:

a. The accumulated depreciation fund is lower than the replacement cost and will not be sufficient to replace the old machines.

b. The fact that costs of capital service are underestimated leads to overestimation of the real profits of the firm. As a result, the tax liability of firms increases in real terms without an increase in real economic profits. Therefore, after-tax profitability declines.

In inventory valuation, the cost of materials is calculated on the basis of either the first-in-first-out (FIFO), or the last-in-first-out (LIFO) methods. In the FIFO method the costs of materials, which are based on historical purchase prices, are underestimated and real profits are overstated. This again leads to an excessive tax on corporations in a period of inflation. In the LIFO method, costs of materials are evaluated in current (or last) prices and thus represent approximately the replacement value of the materials used. This aspect of accounting practices in the United States was discussed by Davidson and Weil (1976), Shoven and Bulow (1975), and Fabricant (1978) in reference to the proposal by the Financial Accounting Standard Board. More recent discussions are presented by Feldstein and Summers (1978), Arak (1980), and Gonedes (1981).

A discussion of inventory valuation methods used in Scandinavia and several Western European industrial countries with regard to the question of how to eliminate inflation from inventory accounting is presented in Strömberg (1977/78).

With regard to the effect of taxation and inflation on depreciation allowances, it is shown that the use of book-value rather than replacement-value depreciation tends to reduce the real value of the depreciation allowance compared with the allowance in a stable economy. This leads some authors to suggest replacement cost depreciation rather than historically-based depreciation (see, for example, Davidson and Weil (1976)). Other authors, such as Landskroner and Levy (1979) have suggested and discussed methods of accelerated depreciation in which expenditures on assets are depreciated (and deducted from income before tax) over shorter periods of time. While both methods tend to increase the present value of depreciation allowances and reduce the tax burden on corporations, they differ in some ways. First, on a theoretical level using replacement cost depreciation, the present value of the depreciation allowance is not unaffected by inflation, as the discount factor of the depreciation stream also increases with inflation. As a result, the net present value of replacement cost depreciation declines with inflation. On the other hand, accelerated depreciation may increase the present value of the depreciation allowance compared with noninflationary situations. As a result, government tax receipts from the business sector will decline in real terms. 1/

As a practical matter, the use of accelerated depreciation is easier to apply as the calculation of replacement value is sometimes very difficult and may require some arbitrary assumptions (e.g., how to determine the component of price increase when the new machines are more expensive as well as better quality). Many governments use accelerated depreciation, and the U.S. Government has included such measures in the Economic Recovery Tax Act of 1981.

Two other aspects of the effect of taxation and inflation on the taxation of corporate income are the deductibility of nominal interest expenses and the capital gains tax. While the taxation of nominal interest rate leads to excess taxation of lenders, it tends to benefit borrowers who can deduct their full interest payment from their taxable income. This is particularly true when the interest rate is not fully adjusted according to the modified Fisher effect. To illustrate this point consider the case where interest is adjusted according to the classical Fisher effect, $i = r+\pi$, where r and i are the real and nominal interest rates and π is the expected inflation rate equal here to the actual inflation rate. The after-tax interest rate for borrowers will

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1/ It should be noted that the implicit (or explicit) assumption of this discussion is that the government does not want to use inflation as a method of increasing business (and household) taxes. This assumption is not always realistic.

decline from $r(1-t)$ to $i(1-t) = r(1-t) - \pi t$. The actual gain is much higher if the firm has long-term debts and the current inflation was not expected (so that the interest on its loans does not reflect the expected inflation). As suggested by Feldstein and Summers (1978), firms in the United States have benefited significantly from their net debt positions.

With regard to capital gains taxes, Feldstein and Summers (1978) argue that taxes paid by stockholders on capital gains and dividends, as well as taxes on interest payments by suppliers, should be considered as part of a corporation's overall tax.

In a detailed calculation for the year 1977, Feldstein and Summers determined that while the direct corporate tax was 42.5 per cent of the corporate income taxation on dividends, interest income and capital appreciation raised the tax rate to 66.3 per cent. The extra tax attributable to inflation was about 60 per cent of the corporate tax for the years 1973-77. The results of the significant increase in the corporate tax burden due to inflation are not consistent with the study by Gonedes, who for the period 1947-74 finds that the tax-effects hypothesis "that income tax will vary directly with the rate of inflation" is not supported by the data. He explains these "surprising results" for a nominal tax system by saying that a "partial indexation" was attained by alternative options, such as liberalization of depreciation rules. An additional reduction in taxes was attained by the increased use of debt-induced tax shields.

In evaluating excess taxation of the corporate sector, we should consider several implications. First, excess taxation on corporations and preferential treatment of housing may be an important cause of the decline in the stock market and the decline in corporate investment in the decade of the 1970s.

Second, the induced reduction in profitability also reduced the demand for investment and the derived demand for loans by business firms. This reduction in corporate loan demand in real terms suggests that the real return to savers will decline with an increase in the rate of inflation and that the nominal interest rate will rise by less than is predicted by the modified Fisher effect. The reason will be a drop in the real rate induced by a negative shift on corporate loan demand in turn caused by the harmful effect of inflation on profits.

Finally, the excess taxation on corporations is a source of funds to finance government expenditures, and it may be viewed as another form of "inflation tax" that is added to other taxes that are collected by the government to finance its operations. A reduction in the excess taxation of corporations without a change in government budget expenditures leads to an increase in the budget deficit, a reduction of planned expenditure, or a need to increase another source of taxes (e.g., an increase in the direct rate of personal or corporate tax).

APPENDIX

A recent estimate by the office of tax analysis in the U.S. Treasury reported by Auerbach (1982) indicates that a proposal to correct corporate taxation by a method of accelerated depreciation (the Economic Recovery Tax Act of 1981) may lead, when enacted in 1986, to a loss of $55 billion in corporate taxes and, if so, it will largely eliminate the corporate tax as a source of government revenue. (For comparison, corporate taxes paid in 1980 were about $65 billion.)

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