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THE NON-ADJUSTMENT OF NOMINAL INTEREST RATES:
A STUDY OF THE FISHER EFFECT

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ABSTRACT

This paper critically re-examines theory and evidence on the relationship between interest rates and inflation. It concludes that there is no evidence that interest rates respond to inflation in the way that classical or Keynesian theories suggest. For the period 1860-1940, it does not appear that inflationary expectations had any significant impact on rates of inflation in the short or long run. During the post-war period interest rates do appear to be affected by inflation. However, the effect is much smaller than any theory which recognizes tax effects would predict. Furthermore, all the power in the inflation interest rate relationship comes from the 1965-1971 period. Within the 1950's or 1970's, the relationship is both statistically and substantively insignificant.

Various explanations for the failure of the theoretically predicted relationship to hold are considered. The relationship between inflation and interest rates remains weak at the even low frequencies. This is taken as evidence that cyclical factors or errors in measuring inflation expectations cannot account for the failure of the results to bear out Fisher's theoretical prediction. Rather, comparison of real interest rates and stock market yields suggests that Fisher was correct in pointing to money illusion as the cause of the imperfect adjustment of interest rates to expected inflation.

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The impact of protracted inflation on the economic system was one of Arthur Okun's central concerns. He rejected the classical paradigm in which expected inflation was neutral and had only minor effects. Rather, he emphasized the many non-neutralities which are associated with expected inflation in a price tag economy. He stressed the very long lags necessary for the economy to adapt to expected inflation and the infeasibility, even in the very long run, of full adaptation. As one example of his skepticism about the predictions of classical models, he devotes several pages in Prices and Quantities to a discussion of his doubts about the Fisher proposition that nominal interest rates should adjust so that real interest rates are unaffected by inflation.

This paper studies the long run relationship between interest rates and inflation during the previous one-hundred and twenty years of American experience. It concludes that there is little evidence that interest rates respond to inflation in the way the classical theories would suggest. Rather the relationship between interest rates and inflation was accurately characterized by Irving Fisher himself when he wrote that:

> The money rate and the real rate are normally identical; that is they will be the same when the purchasing power of the dollar in terms of the cost of living is constant or stable. When the cost of living is not stable the rate of interest takes the appreciation and depreciation into account to some extent but only slightly and in general indirectly. That is, when prices are falling, the rate of interest tends to be low, but not so low as it should be to compensate for the fall.
>
> (1930, p. 43)

After considering a variety of possible explanations for the anamolous behavior of interest rates, I am forced to conclude with Fisher that:

> Men are unable or unwilling to adjust at all accurately and promptly the many interest rates to changing prices levels...The erratic behavior of real interest rates is evidently a trick played on the money market by money illusion. The money rate of interest and still more the real rate are attacked more by the instability of money than by those more fundamental and more normal causes connected with income impatience and opportunity.

It appears to be difficult to reconcile the data with standard economic models of fully informed and rational agents.

The first section of this paper examines the theoretical relationship between rates of interest and inflation in both the short- and long-run. The analysis shows that almost any relationship is possible in the short-run, depending on the sources of shocks to the economy. However, theory issues strong predictions about the long-run relationship. In the absence of tax effects, interest rates should rise by about one point for each one point increase in the expected rate of inflation. The Tobin-Mundell effect which is often used to explain the failure of interest rates fully to adjust for expected inflation should, for plausible estimates of the relevant parameters, be of little empirical significance. The section also demonstrates that in the presence of a tax system anything like that prevailing in the post-war United States, the real pre-tax interest rate should rise significantly with inflation in the long run.

The second section examines historical data on the relationship between interest rates and inflation. Most previous empirical work in this area has focused on the correlation between short-term interest rates and various measures of expected inflation. The theory developed in the first section suggests that this emphasis is misplaced. The empirical analysis here focuses on the determinants of low frequency movements in the rate of interest. The use of band spectral regression techniques makes it possible to filter out the effects of transitory shocks and focus on long run factors. The results suggest that prior to World War II inflation had only a negligible impact on interest rates. While there is evidence of a significant response of interest rates to inflation during the Post-War period, there is no evidence that they have risen by as much as theory would predict in the presence of high marginal tax rates. Furthermore almost all of the significant association between interest rates and inflation during the post-war period can be traced to the 1965-71 period. Sample periods excluding this interval reveal only quite small effects of inflation on interest rates.

Various explanations have been put forward for the failure of interest rates to respond fully to inflation. Many of these explanations stress correlations associated with business cycle fluctuations. The statistical procedures used in this paper which focus on low frequency movements filter out the effects of these shocks. A remaining possibility is that low frequency movements in the rate of inflation are associated with other factors which also impact on real interest rates. The third section examines this possibility by focusing on the effect of fluctuations in the real rate of return on capital and the level of economic risk on interest rates. While both of these variables have significant effects on rates of interest, their inclusion does not alter the results regarding the effect of inflation.

The relationship between inflation and stock prices is examined in the fourth section. If inflation is systematically correlated with reductions in real interest rates, it should also be associated with declines in dividend yields and earnings price ratios. This prediction is not born out during any interval. If anything, inflation is positively related to stock yields. Joint analysis for the post-war period of the stock and bond markets suggests that the paradoxical response of the stock market to inflation is the mirror image of the puzzling behavior of the bond market. While bond prices have been anomalously high and stock prices surprisingly low, the market value of the corporate sector has borne a quite consistent relation to the stream of total after-tax earnings. These results provide some support for the Modigliani-Cohn hypothesis that financial markets exhibit inflation illusion.

The fifth and final section of the paper discusses some implications of the inflation illusion hypothesis. A body of existing work suggesting the prevalence of inflation illusion is discussed. Several reasons for the failure of market forces to overcome this illusion are then examined. An interpretation of recent economic history in terms of changing degrees of inflation illusion is then offered. Current high interest rates may reflect the delayed recognition by the market of the joint impact of inflation and taxation.

An appendix to the paper documents the failure of interest rates fully to incorporate inflation premiums using more standard techniques for modelling inflationary expectations.

I. Interest Rates and Inflation in a General Equilibrium Macroeconomic Model

This section describes a simple general equilibrium macroeconomic model in which the relationship between interest rates and inflation can be studied under a variety of assumptions. The model can be used to study the relationship between inflation and interest rates across long run steady states, and to study the short run relation between interest rates and inflation under Keynesian and classical assumptions. It incorporates a stylized but realistic depiction of the U.S. tax system. In this way it extends previous work on taxes and interest rates, Feldstein (1976), Feldstein and Summers (1978) and Darby (1975), by considering taxes in a dynamic general equilibrium context.

The model considered here is close to that described in Sargent (1979). It has the form:

$$C = C(Y^D, r(1-\Theta) - \Pi^e) + \varepsilon_1 \tag{1a}$$

$$Y^D = Y - T \tag{1b}$$

$$I = I(q)K \qquad I(1) = 0 \tag{1c}$$

$$G = \bar{G} \tag{1d}$$

$$Y = C + I + G \tag{1e}$$

$$L(r(1-\Theta), y) = \frac{m}{p} + \varepsilon_2 \tag{1f}$$

$$L_s = \bar{L} \tag{1g}$$

$$L_D = F_L^{-1}\left(\frac{w}{p}\right) \tag{1h}$$

$$\frac{\dot{w}}{w} = \alpha\left(\frac{L_D}{L_s} - 1\right) + \Pi^e \tag{1i}$$

$$Y = F(K,L)(1 + \varepsilon_3) \tag{1k}$$

$$q = \frac{F_k(1-\tau) - \lambda\Pi^e}{r(1-\Theta) - \Pi^e + \beta} \tag{1ℓ}$$

$$\dot{\Pi}^e = \lambda(\Pi - \Pi^e) \tag{1m}$$

Equation (1a) is a standard life cycle consumption function where consumption depends on disposable income, and the real after tax rate of return. For simplicity, real balance effects are neglected. Disposable income is defined as GNP less taxes, where it is implicitly assumed that labor taxes, which are lump sum since labor supply is inelastic, are adjusted to offset any endogenous changes in revenues from levies on capital income.

The investment equation (1c) relates the level of investment to the divergence between the after-tax marginal product of capital and the after tax interest rate, as reflected in Tobin's q. Equivalently investment can be thought of as depending on the ratio of the market value of the capital stock to its replacement costs. This theory, developed by Tobin (1969), can be rigorously justified in the context of a model with adjustment costs as shown by Abel (1978) and Hayashi (1981). The role of taxes is discussed in detail in Summers (1981a).

The value of q, the market price of existing capital goods, depends on the expected present value of their stream of profits. In this paper it is assumed that investors have static expectations about the marginal product of capital, F_K, interest rates and tax parameters. The more appealing rational expectations assumption is examined in Summers (1981 a,d). With static expectations, q is given by (1ℓ). The term β reflects the risk premium required to induce investors to hold equity claims. The tax system is summarized by three parameters; τ, θ, and λ. The parameter τ represents the effective tax rate on real capital income arising from the combination of corporate, dividend and capital gains taxes. The tax rate on interest income is given by θ. The effect of inflation on the tax system is captured by λ, which represents the effects of historic cost discrepancies, FIFO inventory accounting and the taxation of nominal capital gains. These interactions of inflation and taxes are discussed in detail in Feldstein and Summers (1979) and Summers (1981a).

The remainder of the model is quite standard. Equation (1e) provides the income expenditure identity. A normal LM curve is specified in (1f). The workings of the labor market are generated by an inelastic supply of labor, (1g), a neo-classical labor demand curve holding that the real wage is equated to labor's marginal product, (1h) and a natural rate Phillips curve (1i). The terms ε_2 and ε_3 reflect respectively shocks to liquidity preference and aggregate supply. Equation (1m) holds that expectations about future inflation are formed adaptively.

The evolution of the economy described by (1a-m) will depend on the paths of the exogenous forcing variables g and m, along with the shocks ε_1, ε_2, and ε_3. At any point in time, the money and capital stocks along with the price level and inflationary expectation are predetermined. The equilibrium level of output and the interest rate can then be determined from equations (1a,c,e,l) along the lines of familiar IS-LM analysis.

The relationship between movements in inflation and interest rates will depend on the nature of the causal shocks. It is clear from (1i) and (1m) that the only shocks which can change the level of inflation or expected inflation will be those which also impact on the level of output. Barring unlikely coincidence, Figure 1 illustrates that such shocks will affect interest rates as well. Both variables are endogenous being jointly determined by G, m and the random shocks ε_1, ε_2 and ε_3. The correlation between them will depend on the sources of the shocks.

Consider first an aggregate demand shock as represented by an increase in ε_1 or G. The IS curve shifts right raising interest rates and output. This leads to increasing prices and rising inflationary expectations. The resulting reduction in real money balances raises interest rates still further. This continues until output is restored to its equilibrium level. However at this point the system is not in equilibrium because inflationary expectations are positive. Hence it overshoots and output, interest rates, and the rate of inflation all fall. The system oscillates towards an ultimate equilibrium with no inflation, a higher price level and interest rate, and a reduced capital stock. Note that during this adjustment process there is no reason to assume that real short term interest rates as measured on either an ex-ante or ex-post basis should remain constant.

An even more dramatic example is provided by a liquidity preference shock caused by either an increase in m or ε_2. Initially the LM curve moves right, and nominal interest rates fall as prices start to rise. Subsequently as prices rise reducing real money balances the rate of inflation declines and the interest rate rises.

Ultimately equilibrium is re-established at the initial interest rate and output level, with higher prices. Again, the path involves oscillations. Note that an observer following the response of the economy following such a shock would observe a negative Fisher effect as interest rates and inflation moved inversely.

These examples could be discussed in more detail and multiplied but they are sufficient to make the point at issue here. In any reasonable short run macro-economic model, the rate of inflation and the short run interest rate are determined simultaneously. The correlations between these variables will depend on the paths of the variables forcing the system. As a first approximation, demand shocks will tend to lead to a positive relation between interest rates and inflation while liquidity shocks lead to negative covariation. This suggests that there is little reason to expect any stable relation between short term movements in interest rates and inflation. The tendency, documented below, for the association to be weak suggests the relative importance of liquidity shocks.

The preceding discussion suggests that any sort of analysis of the movements of inflation and short term interest rates and inflation is not likely to be fruitful since both variables are endogenous. However, the model yields more explicit long run predictions. In any long run steady state inflation will always equal its expected value, and the capital stock will also remain constant so that the model reduces to:

$$C(F(K,L)-T,qK,r(1-\Theta)-\Pi) + \overline{G} = F(K,L) \qquad (3a)$$

$$F'(K,L)(1-\tau)-\lambda\Pi = (1-\theta)r - \Pi + \beta \tag{3b}$$

$$\Pi = \frac{\dot{m}}{m} \tag{3c}$$

Equations (3a) and (3b) determine the steady state capital stock and interest rate. Differentiating yields expressions for the long run effect of a change in the rate of expected inflation.

$$\frac{dr}{d\Pi} = \frac{(1-\lambda)\left[C_yF_k + C_w-F_k\right] - F''(K)(1-\tau)C_r}{(1-\theta)(C_yF_k + C_w - F_k)-F''(k)(1-\tau)C_r} \tag{4a}$$

$$\frac{dk}{d\Pi} = \frac{(\theta-\lambda)C_r}{(1-\theta)(C_yF_k + C_w-F_k)-F''(K)(1-\tau)C_r} \tag{4b}$$

Consider the special case where consumption is interest inelastic so $C_r = 0$. In this case, (4b) implies that inflation has no effect on steady state capital intensity so that (4a) reduces to

$$\frac{dr}{d\Pi} = \frac{(1-\lambda)}{(1-\theta)} \tag{5}$$

This condition is easily interpreted.[1] If the only non-neutrality in the tax system were the taxation of nominal interest rates, the rate of interest would rise by $\frac{1}{1-\theta}$ for eacy point of inflation so as to keep the real aftertax rate of interest constant. However, inflation also increases the taxation of equity income

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[1] Note that this result is fundamentally different from that of Feldstein, Green and Sheshinski (1978). The crucial tax rate here is the marginal personal tax rate on interest income, rather than the corporate rate. The difference arises because of the general equilibrium character of the model.

which drives down the required real interest rate. This accounts for the $(1-\lambda)$ term in the numerator of (5). Whether increases in inflation raise or reduce the pre-tax real interest rate depends on the relative size of θ and λ, measures of the extra taxes imposed on debt and equity income.

It is useful to consider briefly plausible magnitudes for these parameters. The value of θ can be inferred in either of two ways. Feldstein and Summers (1979) present an explicit calculation of the average marginal tax rate faced by the holders of interest bearing corporate assets concluding that it is about 40 percent. The somewhat lower tax rate faced by individuals is offset by the high rates imposed on life insurance companies and other intermediaries. The alternative method is to compare the yield on interest bearing taxable and non-taxable assets. Long term municipal bonds yields appear to be about one third less than those of otherwise comparable corporate issues. Gordon and Malkiel (1979) arrive at a somewhat smaller estimate of the tax rate on the basis of a comparison of otherwise identical taxable and tax-free corporate bonds. On balance it seems reasonable to assume that $\theta \doteq .33$.

The value of λ which reflects the extra tax imposed on equity income due to inflation is more difficult to estimate. Its four components attributable to historical cost depreciation, FIFO inventory accounting, taxation of nominal capital gains and an offset of the deductibility of nominal interest at the corporate level can be estimated from the data in Feldstein and

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[2] Note that the variable λ here included the effect of inflation on corporate interest deductions for tax purposes. It is therefore conceptually different from the concept employed in Feldstein (1980). In his notation λ here corresponds to $\lambda+\tau\sigma\pi$.

Summers (1979). According to the figures presented there, extra taxes due to historic cost depreciation and inventory accounting totalled $26.1 billion in 1979, while taxes on nominal capital gains were placed at $5.3 billion and the deductibility of nominal interest reduced taxes by $15.1 billion. Assuming a 6 percent rate of inflation, and the 1977 capital stock of $1684.4 billion this implies a value for λ of .14.

These parameter values imply that if savings are interest inelastic, $\frac{dr}{d\Pi^e}= 1.3$, significantly in excess of one. If savings are interest elastic, even this figure will understate the impact of inflation on interest rates. The real after tax return to savings will decline, reducing the capital stock, raising the marginal product of capital, leading to further increases in real interest rates. In the limiting case where savings are infinitely elastic with respect to the real after tax interest rate, $\frac{dr}{d\Pi^e}= \frac{1}{1-\theta} = 1.5$. This case corresponds to the frequently assumed "infinite horizon" model of consumption decisions. Summers (1981c) argues that realistically formulated life cycle models also imply a very substantial interest elasticity of savings.

The theoretically predicted value of $\frac{dr}{d\Pi^e}$ is surprisingly insensitive to the assumed interest sensitivity of savings. In terms of the loanable funds model of Feldstein and Summers (1978), this is because the supply and demand curves for funds are shifted upwards by approximately equal amounts.

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[3] The analysis here reaches a different conclusion from the earlier one, because it recognizes the effects of the interactions of inflation and taxation on the supply as well as the demand for loanable funds.

Several features of this analysis require discussion. The formulation adopted here implies that there is no Mundell-Tobin effect. In the absence of taxes, inflation has no effect on the level of capital accumulation. This is because the consumption function does not include either real money balances, or government transfers of money as an argument. This omission is of no empirical significance. Outside money holdings in the United States represent less than two percent of the value of the capital stock. Even if inflation increased enough to eliminate all money holding, and wealth holding was unchanged, so that the capital stock increased by an equal amount, the real interest rate would fall by only 6 basis points.

The model presented here ignores government indebtedness. This may be justifies in several ways. Barro (1974) shows that if agents have operative bequest motives, government bonds will not be net worth. In Summers (1981c), I show that as long as there are any families which meet this condition, Barro's result will continue to hold in the long run. Alternatively even if bonds are treated as net worth, the results here will contine to hold as long as they are perfect substitutes for private debt. Only in the special and unlikely case where bonds and money are perfect substitutes, does the analysis here require important modifications. this type are misleading as government debt should be treated as a form of outside money. This is mistaken since the interest rate will adjust to prevent portfolio substitution.

It is important to clarify the reason why the model cannot be manipulated to yield predictions about the short run relationship between interest rates and inflation but does have implications for the long run relation. The reason is that the model implies that in the long run the level of inflation is determined only by the rate of money growth. This is an implication of virtually all macro-economic models. Unless the long run rate of money growth is determined by the same real factors which impact on output and the interest rate, this implies that inflation is in effect determined exogenously in the long run. In the next section, we turn to an empirical analysis of the long run relationship between inflation and interest rates.

There does not seem to be any obvious reason for expecting a correlation between the rate of money growth and any real factors. If there were any systematic factor, equation (3b) implies that it must involve either effects on the real marginal product of capital or on the risk premium. Both these possibilities are considered in the empirical work reported in Section 3 below.

II. Interest Rates and Inflation: The Historical Record

At the outset it is useful to examine some simple averages of inflation and interest rates over a long period. Table 1 records decadal averages of the rates of inflation, along with nominal and real interest rates. No clear relationship between inflation and nominal interest rates emerges. In five of the twelve decades considered, the real interest rate was actually negative. These decades were the periods with the most rapid rates of inflation. Conversely, the real interest rate is highest in the deflationary decades. The lack of a relationship is confirmed by the regression using decadal data reported at the bottom of the table. Over the long term less than one eighth of changes in the rate of inflation are incorporated into interest rates. Changes in the decadal rates of inflation explain none of the variance in observed interest rates. A similar conclusion emerges using a test suggested by Fisher himself. The variance of the real return far exceeds that of the nominal return. If nominal rates incorporated expected inflation, they should vary, while real rates should remain fairly constant.

It might be objected that breaking up the passage of time into decades is arbitrary. Furthermore the results might be distorted by aberrant wartime experiences. Table 2 displays average rates of inflation and interest rates over the course of business cycles as defined by the NBER. Wartime cycles are omitted. Averages are taken from trough to trough. Very similar results emerge when the averages are calculated on a peak to

Table 1

Trends in Inflation and Interest Rates*

Period	Average Yields on Commercial Paper[a]	Average Inflation Rate	Average Real Rate
1860-69	7.1	5.5	1.5
1970-79	6.5	-3.4	9.8
1880-89	5.1	-2.1	7.2
1890-99	4.6	0.3	4.2
1900-09	4.8	2.5	2.3
1910-19	7.7	8.3	-3.6
1920-29	5.1	-0.9	6.0
1930-39	1.5	-2.0	3.6
1940-49	0.9	5.5	-4.6
1950-59	2.6	2.2	0.4
1960-69	4.6	2.5	2.1
1970-79	7.2	7.4	-0.22

Regression of 12 Decadal Averages:

$$R_t = \underset{(.69)}{4.43} + \underset{(.16)}{.05\pi_t} \qquad \bar{R}^2 = -.09$$

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*All figures are computed as arithmetic averages of monthly data.

[a] For the period 1860 through 1918, the data corresponds to the 2-3 month rate in MacCauley. From 1919 to 1979 we use the 4-6 month commercial paper rates from the Federal Reserve.

[b] From 1860 to 1918, the figures are derived from the Warren-Pearson Wholesale Price Index. From 1919 to 1979, we used the non-seasonally adjusted CPI from BLS.

Table 2

Cyclical Averages of Inflation and Interest Rates*

Period	Average Yields on Commercial Paper	Average Rate of Inflation	Average Real Rate
1867:12-1870:11	8.02	-5.52	13.54
70:12 - 79:2	6.51	-4.53	11.04
79:3 - 85:4	5.31	-0.00	5.32
85:5 - 88:3	4.93	0.11	4.82
88:4 - 91:4	5.13	-0.64	5.77
91:5 - 94:5	5.12	-6.34	11.46
94:6 - 97:5	4.19	-1.33	5.51
97:6 - 00:11	4.02	6.28	-2.26
1900:12 - 04:7	4.77	1.49	3.28
04:8 - 08:5	5.29	1.90	3.39
08:6 - 11:12	4.25	1.32	2.93
12:1 - 14:11	5.05	1.51	3.54
19:3 - 21:6	6.72	3.98	2.75
21:7 - 24:6	4.94	-1.13	6.07
24:7 - 27:10	4.04	0.61	3.42
27:11 - 33:2	3.84	-5.69	9.53
33:3 - 38:5	1.02	2.04	-1.02
45:10 - 49:9	1.15	7.30	-6.15
49:10 - 54:4	2.06	2.58	-0.52
54:5 - 58:3	2.79	1.89	0.90
58:4 - 61:1	3.46	1.17	2.29
61:2 - 70:10	5.01	2.91	2.10
70:11 - 75:2	6.89	6.83	0.06

$$R_t = \underset{(.35)}{4.66} - .15\pi_t \qquad \bar{R}^2 = .07$$

* All figures are computed as arithmetic averages of monthly data. Each period represents an NBER cycle measured from trough to trough.

peak basis. Once again no strong relation between inflation and nominal interest rates and inflation emerges. The regression using cyclical units as observations suggests that interest rates fall by 11 basis points with each one point increase in the rate of inflation.

These results cannot be attributed to the effects of the zero floor on nominal interest rates in conjunction with deflation. If all the years where prices fell are removed from the sample and cyclical averages are taken using the remaining data, very similar results emerge.

The traditional approach to the study of the relationship between interest rates and inflation involves estimation of equations of the form:

$$R_t = \beta_0 + \beta_1 \Pi_t^e + u_t \tag{6}$$

where the principal empirical difficulty is the measurement of Π^e. Investigators have employed a wide variety of proxies for Π^e, based on autorepressive expectations, survey evidence, and rational expectations. The analysis in the preceding section suggests that estimation of (6) may not be meaningful even if inflationary expectations could be properly measured. The crucial issue is the error term u_t in equation (6). Since expected nflation responds to the same underlying economic forces which impact on short term interest rates, there is every reason to suppose that u_t is correlated with Π_t^e. The simultaneity in (6) cannot be avoided by the mechanical application of instrumental variables. Any variable which is correlated with inflationary expectations will also be correlated with real activity and therefore with interest rates. The problem with equation (6) is logical rather than statistical. One cannot usefully ask about the causal influence of one simultaneous determined variable on another.

In light of these considerations, it may not be surprising that equations like (6) yield results which do not appear to bear out the Fisher relationship. Nor is it surprising that the results are highly unstable through time. The estimated parameter β_1 does not bear any consistent relationship to the taste and technological parameters which are usually assumed to be stable through time.

Some recent work on the Fisher Effect has avoided specifications like (6). Fama (1975) estimates equations of the form in monthly data, using the one month treasury bill rate:

$$\Pi_{t+1} = \alpha_0 + \alpha_1 r_t + u_t \qquad (7)$$

He shows that if one is willing to accept the assumption that the required expected real interest rate ρ is constant, then rational expectations implies that $\alpha_0 = -\rho$ and $\alpha_1 = 1$. He finds evidence consistent with these assumptions for the 1954-71 period. In the appendix to this paper, I show that Fama's results are an artifact of his choice of sample period. This should not be surprising. It is well known that output fluctuates. In any model like the one presented in the first section of the paper, it is impossible to generate serially correlated fluctuations in output without also generating serially correlated movements in the ex-ante real rate of interest, except by assuming arbitrary and unlikely correlations between the shocks. The success of Fama's tests for the 1954-71 period is probably closely related to the unprecedentedly low amplitude of business cycle fluctuations during this interval.

More recent work by Fama and Gibbons (1979) has applied the random coefficients technique to (7) and allowed α_0 to evolve according to a random walk. This procedure, which amounts to imposing a particular serial correlation structure on the residuals u_t, does not avoid the logical problems just discussed. The procedure imposes the highly implausible restriction that variations in u_t and α_0 are uncorrelated. In fact, the same shocks which lead to changes in inflation also affect interest rates.

Yet another approach to studying the relationship between inflation and interest rates is suggested by the work of Mishkin (1981) who studies the relationship between lagged inflation and the real ex-post return on treasury bills. He is careful, however, to stress that no causal interpretation can be placed on his results.

The analysis in Section I suggested that while the short run relationship between inflation and interest rates was quite arbitrary, theory yielded quite precise predictions about the relationship between interest rates and inflation across different steady states. The essential reason for this difference is that the model implies that steady state inflation is determined only by the rate of money growth. The model like most well specified macro-economic models exhibits approximate superneutrality in the absence of taxes. Hence real interest rates should be essentially unaffected by changes in the rate of inflation. This suggests that if each observation represented a steady state corresponding to some level of money growth, equation (6) should hold with $\beta \cong 1$ in the absence of taxes. Of course in time series data on a single country observations corresponding to steady states under different monetary regimes cannot be isolated. However statistical techniques are available which filter out the high frequency movements in the variables. The band spectral regression procedure developed in Engle (1974) allows the user to estimate regression coefficients at different frequencies. The hypothesis implied by the preceding discussion is that the long run (low frequency) relationship between interest rates and inflation is stronger than the high frequency relationships which dominate movements over the course of the business cycle. Robert Lucas (1980) makes a similar argument to justify the testing of the quantity theory using filtered data.

The central advantage of using band spectral techniques to study the relation between interest rates and inflation is that it makes it possible to filter out the high frequency variance in the variables which is not explicable in terms of the underlying theory. Just as it is common to exclude some periods (i.e. wars and strikes) because one's theory is not expected to hold, it is reasonable to exclude frequencies where the underlying theory is inapplicable. There are several other advantages as well. Because the variance in the right hand side variables in (6) comes only from low frequency movements the problem of modelling inflationary expectations vanishes. Low frequency variations in the rate of inflation are almost completely forecastable, so that the assumption that expected inflation can be proxied by actual inflation is warranted. Indeed, when the equations reported below were re-estimated with various proxies for expected inflation, the results were not significantly affected. A further virtue of the band spectral technique is that the results are insensitive to problems of data alignment and errors in variables. The former problem leads Fama (1975) to despair of the possibility of testing the Fisher effect using pre-WWII data.

This discussion has so far been somewhat vague as to the choice of interest rates. The argument that any high frequency relation between interest rates and inflation is possible, is best understood in terms of the short rate. The long rate which reflects expected short rates over a long horizon should be largely free of high frequency fluctuations. It therefore seems surprising that more of the empirical work on interest rates and inflation has not used long rates. Probably the reason is the difficulty of measuring long term inflationary expectations. At low frequencies one would expect long and short rates to exhibit similar movements. Both are exhibited in the empirical work represented below.

The 1860-1940 period

Most discussions of interest rates and inflation during the pre-WWII period focus on the Gibson paradox. The paradox is the observation that for this period in both the U.S. and Britain there appears to be a strong positive correlation between the price level and interest rates. Such a relationship is inconsistent with monetary theory which holds that the units in which money is measured should have no real effects.

One potential resolution of the Gibson paradox is the Fisher effect discussed in this paper. If, as Fisher argues, inflation expectations are formed with very long lags, there will be a strong positive correlation between the price level and the expected rate of inflation. To see this observe that:

$$P_t = \sum_{i=o}^{\infty} (p_{t-i} - p_{t-1-i}) \qquad (8)$$

where p_t is the log of the price level. Equivalently

$$P_t = \sum_{i=o}^{\infty} \pi_{t-i} \qquad (9)$$

It follows immediately that the price level will be highly correlated with any long term average of past rates of inflation.

This explanation for the Gibson paradox has been considered by several investigators, Sargent (1973a), Shiller and Siegel (1977) and Friedman and Schwartz (1980). These authors have tended to reject the Fisher explanation because the lag lengths which are required are regarded as implausible. Other explanations have been sought in terms of the Keynes-Wicksell effect and distributional effects. However, the logically separate question of the relationship or lack thereof between interest rates and inflation during this period has received much less attention. The relationship is of particular interest for this early period because the economy was relatively free of institutional interferences. Taxes were negligible, countercyclical stabilization policy had not yet been attempted, and there were fewer interferences with wage and price flexibility. The conditions of classical macro-models were much closer to being satisfied than they are today.

Before examining the data, it is instructive to review the results presented by Fisher (1930). Fisher began by examining the contemporaneous correlation between inflation and nominal interest rates. He found it to be negligible but that it could be improved substantially by taking a long run weighted average of past rates of inflation. Fisher however reported only on the correlation coefficient between his measure of expected inflation and the interest rate. He made no effort to estimate $\frac{dr}{d\Pi^e}$. Replication of Fisher's work using his data and his procedure for estimating inflation expectations (essentially a first degree Almon lag with an endpoint constraint at zero at 20 years) yields estimates of $\frac{dr}{d\Pi^e}$ which range from .03 for short term interest rates to .18 for long term rates. Thus, there is no sense in which his results can be said to demonstrate the empirical validity of the theory that bears his name. As the quotations in this paper's introduction attest, Fisher did not overstate his conclusions. It is later authors who have exaggerated the power of his evidence.

In Tables 3 and 4 the relationship between inflation and short and long term interest rates at various frequencies is examined for the entire 1860-1940 period, and various subperiods. Data on the rate of inflation for the period 1860-1918 are based on the Warren-Pearson wholesale price index. This is the only price index available which goes back this far on a monthly basis. For the more recent parts of the interval, 1919-1940, the CPI is used to estimate the rate of inflation. Data on short term interest rates are the rates on commercial paper reported in MacCauley (1937) for the period 1968-1918, and the Federal Reserve series for the 1918-1939 period. Long term yields come from MacCauley's series on railroad bonds for the 1860-1918 period and the Federal Reserve series for the 1918-1939 interval. The results were all obtained using monthly data. Only negligible changes were observed when the equations were re-estimated using quarterly or annual data.

The equations are estimated, filtering out movements above various frequencies. As Engle (1974) shows, if the data interval is of length p, OLS estimates reflect the variance at all cycle lengths greater than 2p. Here the OLS estimates are

Table 3

Commercial Paper Yield and Inflation, 1860-1939

Interval	Cycle Length	Constant Term	Slope Coeff.	R^2
1860-1939	OLS	4.92	.00 (.00)	.00
	> 1 year	4.92	.00 (.01)	.00
	> 3 years	4.90	.01 (.02)	.00
	> 5 years	4.88	.01 (.03)	.01
	> 10 years	4.83	.03 (.05)	.02
	> 20 years	4.49	.12 (.10)	.23
1870-1900	OLS	5.36	-.00 (.00)	.00
	> 1 year	5.37	-.02 (.02)	.01
	> 3 years	5.31	-.03 (.05)	.02
	> 5 years	5.37	-.03 (.07)	.02
	> 10 years	5.41	-.25 (.15)	.33
1900-1939 (excluding 1914-1918)	OLS	3.97	.00 (.01)	.00
	> 1 year	3.98	-.00 (.03)	.00
	> 3 years	3.94	.05 (.08)	.02
	> 5 years	3.91	.08 (.14)	.03
	> 10 years	3.90	.11 (.30)	.03
	> 20 years	3.72	.34 (.57)	.22

Note: Repression results are obtained using the band spectral procedure in the Troll Program. Data are described in the text.

TABLE 4

Long-Term Bond Yields and Inflation, 1860-1939

Interval	Cycle Length	Constant Term	Slope Coef.	R^2
1860-1939	OLS	4.48	-.00 (.00)	.00
	> 1 year	4.48	-.00 (.00)	.00
	> 3 years	4.49	-.00 (.01)	.00
	> 5 years	4.48	-.00 (.02)	.00
	> 10 years	4.43	.01 (.03)	.01
	> 20 years	4.31	.05 (.06)	.09
1870-1900	OLS	4.35	-.00 (.00)	.01
	> 1 year	4.36	-.02 (.01)	.03
	> 3 years	4.37	-.05 (.04)	.09
	> 5 years	4.37	-.06 (.06)	.10
	> 10 years	4.39	-.19 (.14)	.33
1900-1939 (excluding 1914-1918)	OLS	4.16	-.01 (.00)	.01
	> 1 year	4.17	-.02 (.01)	.03
	> 3 years	4.19	-.04 (.03)	.06
	> 5 years	4.23	-.09 (.06)	.17
	> 10 years	4.30	-.19 (.12)	.36
	> 20 years	4.28	-.17 (.25)	.26

Note: Repression results are obtained using the band spectral procedure in the Troll Program. Data are described in the text.

reported along with the results for cycle lengths of greater than 1, 3, 5, 10 and 20 years. The frequency of business cycles is about 5 years, so the results should provide a good reflection of the long run effects discussed in Section I.

No strong association between inflation and interest rates emerges at any frequency. While there is some tendency for the coefficient on inflation to increase as the cycle length rises, the differences are not statistically significant. For the entire 1860-1939 period, the highest estimate of the effect of inflation is in the low frequency commercial paper equations where the estimated coefficient is only .12. For the 1870-1900 period, the relationship is actually negative, using either the commercial paper rate or the long term bond rate. In all the equations, the R^2 is low, indicating that low frequency movements in inflation explain only a small part of variations in interest rates.

In tests not reported here, a variety of other sample periods were chosen. While the results changed somewhat depending on the inclusion of the WWI years, there was no evidence in any of the equations of a strong Fisher effect. As a further check, some of the equations were re-estimated using long distributed lags on inflation.It is sometimes argued that the failure of interest rates to adjust for inflation reflects the effects of deflation in conjunction with the zero floor on nominal interest rates. Dropping all years in which prices fell from the sample raised standard errors but had essentially no impact on the estimated coefficients. This had only a negligible effect on the results. The failure of interest to adjust to changes in inflationary expectations is confirmed in the Appendix using more standard techniques.

It is frequently argued that the failure of interest rates to adjust and incorporate inflation premia during the 1860-1940 period is the consequence of the different monetary standard which prevailed during that interval. The argument as expressed, for example, by Gordon (1973) is that under the Gold Standard, a stable level of prices, rather than of inflation, was anticipated. Hence, the argument continues, inflation led if anything, to expectations of future deflation. This argument provides a rationalization for the failure of regressions of interest rates on distributed lags of past inflation to yield estimates which imply significant Fisher effects. It does not apply to the results reported here which consider low frequency movements in the rate of inflation. Such movements were an important feature of the period. The decadal average of the rate of inflation varied between 5.5 percent during the 1860's and -2 percent during the 1880's. Far larger variations existed at cyclical frequencies. These fluctuations are usually traced to monetary forces, arising indirectly from the gold standard. Such variations represent exactly the sort of exogenous disturbance which should give rise to the Fisher effect.

There are two subsidiary difficulties with the "monetary standard" explanation of the failure of the Fisher effect. The argument implies a negative correlation between the expected rate of inflation and the price level. Yet the Gibson paradox is the observation that the price level and interest are positively associated. The "monetary standard" explanation also fails to take account of agents' changing perceptions of the trend rate of growth of prices. As Barsky and Summers (1982) argue, a rational observer's inflation forecast would in fact have varied as much or more in the gold standard era as in recent times. It is difficult to understand why these variations were not reflected in movements in interest rates.

There are of course a number of problems with the data used here. The interest rates may include default premia and the inflation rate is unlikely to be measured accurately. However, it is unlikely that these factors are important in low frequency movements. The strong evidence against the Fisher proposition presented here for the pre-War period is particulary striking because of the ;aissez faire character of the economy. Nominal rigidities due to deposit ceilings, wage contracts, pension arrangements, or long term wage contracts were virtually non-existent. Taxes also were negligible. This suggest that failure of interest rates to fully incorporate inflation premia reflect something more fundamental then the effect of institutional non-neutralitites.

The Post War Period

The analysis in the first section of the paper suggests that it is reasonable to expect that $\frac{dr}{d\Pi^e} \overset{\sim}{=} 1.3$ in the Post War period. Estimates of this parameter for various intervals after WWII using both short and long term interest rates are reported in Tables 5 and 6. The short term interest rate is the treasury bill yield as reported by Ibbotsen and Sinquefield (1980), while the long term interest rate is measured by the government bond yield. Inflation is measured using the CPI. Variation in the choice of interest rate and inflation measures had only a negligible effect on the results.

The results for both short and long rates are broadly consistent. There is no evidence that interest rates have risen more than the rate of inflation. In almost every case the data reject the hypothesis that $\frac{dr}{d\Pi} = 1$ quite decisively. It appears that almost all the power in the Fisher relationship comes from the acceleration of inflation during the 1960's. When the equation is estimated for the 1970's or for the pre-1965 period (not shown) only a very weak relationship between interest rates and inflation emerges. Eliminating the controls period has little effect on the results.

It is noteworthy that the estimated impact of inflation on interest rates increases as the length of the cycle increases. For example, the coefficient on inflation in the long term interest rate regressions rises from .24 to .73 for the 1948-79 period. The hypothesis that the relation between interest rates and inflation is the same at all frequencies is decisively rejected by the data. However even at 10 year cycle lengths the full Fisher effect is not observed, much less the effect that is predicted in the presence of high taxes.

One issue which has not yet been addressed is the question of simultaneity even at the low frequencies considered here. If interest rates and inflation are jointly determined, inflation and the error term may be correlated in the regressions reported here, leading to biased estimates of the effects of steady inflation on interest rates. For such bias to explain, the anomalously low estimated effect of inflation on interest rates, it is necessary that inflation and the error term be negatively sorrelated. In this case, the extent of simulaneity bias can be banded by running the regression in the opposite direction. However, Griliches and Rings5and (1971) show that the"reverse regression" coefficient $\hat{\theta} = R^2/\hat{\beta}$. An upper bound on the effect of inflation of interest rates is given by $1/\hat{\theta}=\hat{\beta}/R^2$. In almost all cases, even this cound is less than unity. This suggests that simultaneous equations bias cannot account for the results obtained here.

It is natural to conjecture that the introduction of taxes has increased the value of $\frac{dr}{d\Pi}e$, explaining the difference between the pre- and post-war periods. However, until an explanation of its surprisingly low value is available, this conjecture remains speculative. The next sections examine some potential explanations of the paradoxical behavior of interest rates.

Table 5

Inflation and Treasury Bill Yields

Interval	Cycle Length	Constant	Coef. of Π	R^2
1948 to 1979	OLS	2.71	.29 (.02)	.34
	> 1 year	2.01	.47 (.05)	.57
	> 3 years	1.62	.57 (.08)	.71
	> 5 years	1.46	.62 (.11)	.75
	> 10 years	1.22	.68 (.17)	.80
	> 20 years	1.22	.68 (.33)	.90
1954 to 1979	OLS	2.70	.41 (.02)	.55
	> 1 year	2.00	.57 (.04)	.82
	> 3 years	1.88	.60 (.05)	.89
	> 5 years	1.92	.59 (.07	.89
	> 10 years	1.90	.60 (.12)	.89
1970 to 1980	OLS	3.71	.38 (.04)	.43
	> 1 year	2.21	.58 (.08)	.75
	> 3 years	1.71	.64 (.10)	.89
	> 5 years	1.64	.65 (.16)	.89
1954 to 1971	OLS	2.68	.31 (.03)	.29
	> 1 year	1.80	.68 (.09)	.64
	> 3 years	1.53	.79 (.12)	.81
	> 5 years	1.49	.81 (.18)	.81
	> 10 years	1.38	.86 (.30)	.86

Note: Band spectral repressions are performed using the Troll computer program. Data are described in the text.

Table 6

Inflation and the Yield on Long-Term Government Bonds

Interval	Length of Cycle	Constant	Coef. of Π	R^2
1948 to 1979	OLS	3.97	.24 (.003)	.30
	> 1 year	3.36	.40 (.05)	.50
	> 3 years	2.98	.50 (.09)	.63
	> 5 years	2.65	.59 (.12)	.70
	> 10 years	2.13	.73 (.14)	.87
1954 to 1979	OLS	4.03	.34 (.02)	.52
	> 1 year	3.44	.49 (.04)	.76
	> 3 years	3.29	.52 (.07)	.80
	> 5 years	3.10	.56 (.09)	.84
	> 10 years	2.76	.65 (.07)	.97
1970 to 1979	OLS	6.57	.15 (.02)	.29
	> 1 year	5.95	.23 (.05)	.52
	> 3 years	5.74	.26 (.12)	.56
	> 5 years	5.68	.26 (.16)	.61
1954 to 1971	OLS	3.88	.21 (.03)	.25
	> 1 year	3.27	.47 (.07)	.56
	> 3 years	3.10	.53 (.12)	.65
	> 5 years	2.96	.59 (.18)	.70
	> 10 years	2.82	.65 (.29)	.79

Note: Band spectral regressions are performed using the Troll computer program. Data are described in the text.

Section III Inflation and Other Determinants of the Interest Rate

The results in the preceding section demonstrate that there is only a very weak relationship between long swings in the rate of inflation and nominal interest rates. This result contradicts the prediction of the standard macro-economic model developed in Section I. That model holds that the long run rate of inflation is determined by the rate of money growth, which is exogenous. It implicitly assumes that fluctuations in the long run rate of growth of the money stock are independent of movements in the other forcing variables. This supposition may be warranted.

Equation (3.6) implies that the rate of interest in steady state is proximately determined by the risk premium β, and the marginal product of capital. If inflation is correlated with real shocks these should work through these two variables. When they are held constant, the Fisher effect should hold. This proposition is tested in the results reported in Table 7.

The major difficulty is finding proxies for the real return on capital and the level of risk. The top half of Table 7 reports results which use the variance of real stock market returns as a measure of risk. The variance of the returns, MARVAR, is calculated using the procedure suggested by Merton (1980). It is the mean squared real return for the 12 months bracketing each

Table 7

Inflation and Other Determinants of Interest Rates

Interval	Cycle Length	Constant	Π	MARVAR	R^2
1926-1979	OLS	2.68	.06	-.05	.08
			(.01)	(.01)	
	> 1 year	2.43	.13	-.03	.12
			(.05)	(.03)	
	> 3 years	2.32	.16	-.02	.13
			(.09)	(.06)	
	> 5 years	2.34	.16	-.03	.13
			(.15)	(.09)	
	> 10 years	2.38	.18	-.05	.15
			(.28)	(.09)	
1954-1979	OLS	2.46	.39	.15	.56
			(.02)	(.06)	
	> 1 year	2.10	.59	-.07	.82
			(.04)	(.10)	
	> 3 years	2.02	.63	-.13	.90
			(.06)	(.15)	
	> 5 years	2.29	.63	-.26	.90
			(.09)	(.26)	
	> 10 years	2.82	.71	-.67	.93
			(.17)	(.69)	

Interval	Cycle Length	Constant	Π	BTRR	VarGNP	R^2
1954-1979	OLS	-2.03	.72	.35	.40	.81
			(.10)	(.18)	(.42)	
	> 3 years	-2.65	.75	.39	-.34	.85
			(.12)	(.23)	(.51)	
	> 5 years	1.44	.65	.12	-1.01	.94
			(.12	(.23)	(.55)	
	> 10 years	3.20	.63	.00	-1.48	.97
			(.25)	(.59)	(1.75)	

		Constant	Π	ATRR	VarGNP	R^2
1954-1979	OLS	0.85	.68	.00	-.51	.80
			(.09)	(.00)	(.42	
	> 3 years	0.60	.70	.00	-.49	.84
			(.12)	(.00)	(.51)	
	> 5 years	1.64	.67	.00	-.90	.91
			(.10)	(.00)	(.47)	
	> 10 years	2.00	.67	.00	-1.10	.97
			(.19)	(.01)	(1.43)	

Note: Regressions estimated using the band spectral procedure. Data are described in the text.

observation. The notion here is that the attractiveness of debt securities should increase as the equity risks rise. If inflation is associated with greater real variability, this could lead to the negative association between inflation and real interest rates demonstrated in the preceding section.

The results do not bear out this hypothesis. The data do tend to suggest that increases in risk depress nominal interest rates. However this correlation cannot account for the non-adjustment of interest rates to inflation. The estimates of the effects of inflation are very close to those in preceding section.

The second half of the table reports the results of including proxies for the real rate of return on capital and an alternative risk measure. This necessitated the use of annual data. The marginal product of capital is alternatively proxied by the real pre-tax marginal product, BTRR and post-tax marginal product ATRR reported in Feldstein, Poterba, and Dicks-Miraeux (1980). These estimates are based only on the non-financial corporate sector. The risk measure is a moving 8 quarter variance of real GNP growth rates. The results suggest some impact of real returns and risk measure on interest rates. However, inclusion of these variables also has little impact on estimates of the effect of inflation on interest rates.

The results reported here are a very small sample of a large number of equations which were estimated in an effort to rescue the Fisher effect by including additional variables. All were unsuccessful. Perhaps there is some unmeasurable variable which is correlated with inflation, and which affects required real returns. This possibility is examined in the next section.

IV. Interest Rates and Equity Values

The empirical analysis in the previous section suggests that periods of high inflation are associated with low real interest rates. One line of explanation for this phenomenon holds that inflation is associated with the more fundamental factors that impact on real interest rates. The previous section which examined proxies for the real rate of profit and level of economic risk, showed that they do not account for the anomalous relation between inflation and interest rates. A more indirect approach to this question is through a study of the relation between inflation and alternative indicators of the real interest rate. The stock market provides a natural alternative indicator.

There are three possible ways to measure the real interest rate using stock market data. The most obvious and standard approach is through the use of holding period returns. The ex-post return on stocks should equal the required ex-ante rate plus a risk premium. The difficulty is that the enormous volatility of stock prices imply that ex-post returns are very noisy indicators. An alternative is the use of the earnings or dividend price ratio. The basic difficulty with both these measures is that they will be misleading if there are transitory movements in dividends or earnings. This difficulty should be less important in the low frequency range studied here. The choice between dividends and earnings is somewhat unclear. Earnings would seem preferable since the value of a firm's assets is the present value of their earnings stream. The dividend price ratio is also considered because

Table 5.8

Inflation and Equity Yields

Earnings Price Ratio

Sample Period	Constant	Slope	R^2
1871-1914	7.21	.06 (.08)	.03
1871-1940	7.58	-.10 (.06)	.12
1919-1940	6.97	-.02 (.11)	.01
1948-1979	6.91	.36 (.30)	.12
1954-1979	5.31	.49 (.16)	.54
1871-1979	7.66	.12 (.05)	.11

Dividend Price Ratio

Sample Period	Constant	Slope	R^2
1871-1914	4.74	-.13 (.04)	.38
1871-1940	4.98	-.03 (.02)	.05
1919-1940	5.03	-.03 (.03)	.11
1948-1979	4.03	.03 (.13)	.01
1954-1979	3.24	.10 (.06)	.30
1871-1979	4.82	-.03 (.02)	.04

it can be measured more accurately, and because there is some evidence that dividends are set on the basis of "permanent earnings".

Evidence on the relationship between low frequency movements in these variables and inflation is presented in Table 8. All the regressions are estimated filtering out cycles of length less than 5 years. The results indicate that for all the sample periods, there is no strong relation between inflation and dividend price ratios or earnings price ratios. During the Post-War period the relationship is positive and in some cases statistically significant. The failure of dividend and earnings price ratios to decline with inflation is surprising in light of the failure of nominal interest rates to adjust. This is especially true in the Post-War period when increases in inflation have been associated with sharp decreases in after tax real interest rates.

The lower part of the table examines the relation between the holding return on stocks and inflation. For all of the pre-War period it appears that the relationship was positive and statistically insignificant. Surprisingly it is negative during the Post-War period. This is largely a reflection of the disastrous performance of the market during the high inflation decade of the 1970's. These results provide some weak support for the view that something has depressed real rates of return during the 1970's. The behavior of earnings and dividend price ratios, however, suggests the opposite.

Table 8, cont.

Holding Period Returns

Sample Period	Constant	Slope	R^2
1871-1914	7.44	1.33 (.41)	.41
1871-1940	8.83	.82 (.33)	.20
1919-1940	14.65	.78 (.81)	.13
1948-1979	18.72	-1.61 (.57)	.44
1954-1979	17.65	-1.48 (.71)	.36
1871-1979	8.93	.55 (.27)	.09

Notes: All regressions are estimated using a band spectral technique which filters out all cycles of length less than 5 years. Standard errors are in parentheses.

The results raise the question of whether the puzzling behavior of the interest rates and the stock market are related. This question is examined in Table 9. The first column displays a crude proxy for the real after tax interest rate. Its value has declined sharply in recent years. The second and third columns present estimates of the earnings-price ratio on an inflation adjusted and unadjusted basis. The adjusted earnings-price ratio is derived from the S&P 500 ratio, after making adjustment for historic cost depreciation, FIFO inventory accounting, and the deduction of nominal interest payments in calculating profits. Details of the calculation are provided in Summers (1981d). Both display significant increases in the recent high inflation years.

The increasing value of the earnings-price ratio, coupled with the declining real interest rate, has substantially widened the spread between the expected return on debt and equity. It is interesting to ask whether the relationship of the total market value of the corporation to the stream of returns generated for investors has changed. This question is answered in the fourth column of the table. It shows that this ratio has not risen in recent years. The decline in real stock prices has offset the rise in bond prices associated with lower interest rates leaving the valuation of the corporate sector relative to the income it generates unchanged.

Table 9

Real Interest and Equity Returns

Year	After Tax[a] Real Interest Rate	Earnings-Price[b] Ratio	Inflation Adjusted Earnings-Price[c] Ratio	Post Tax[d] Market Value-Income Ratio
1955	.83	.079	.060	.047
1956	1.30	.073	.053	.034
1957	1.24	.076	.058	.035
1958	1.00	.059	.043	.030
1959	1.38	.056	.046	.035
1960	1.38	.057	.046	.034
1961	1.70	.046	.036	.030
1962	1.57	.058	.053	.041
1963	1.68	.055	.051	.041
1964	1.78	.053	.048	.045
1965	1.73	.056	.053	.048
1966	1.81	.066	.065	.053
1967	1.71	.056	.054	.047
1968	1.15	.055	.057	.039
1969	2.16	.059	.059	.034
1970	2.27	.062	.059	.031
1971	1.14	.052	.047	.032
1972	1.10	.052	.044	.038
1973	.650	.068	.064	.031
1974	-.4	.109	.094	.010
1975	-.36	.088	.069	.032
1976	-.42	.086	.059	.036
1977	-1.02	.104	.087	.040
1978	-.58	.115	.092	.039

a) Estimated as the municipal, bond rate minus a weighted average of the five previous years consumer price inflation rate.

b) Annual average of the S&P earnings-price ratio.

c) The S&P earnings-price ratio adjusted to calculate profits on an inflation adjusted basis as described in Summers (1980c).

d) Ratio of post corporate and individual tax earnings, as calculated by Feldstein and Poterba (1980), to market value of corporate debt and equity claims.

This phenomenon can be described in another way. The constancy of the income-value ratios in column four suggests that by historical standards the corporate sector is not mis-valued. Rather, the puzzle lies in the relative valuation of the two types of claims on corporate income. The spread between them has widened very substantially from 3.1 percent in 1965 to 9.8 percent in 1978. The entire puzzle lies in the increase in this spread. If the spread had remained constant at its 1965 values, the nominal municipal bond interest rate would have been 12.7 percent in 1978 rather than 6.9 percent. Since expected inflation rose by 5.5 percent between 1965 and 1978, and the interest rate was 3.3 in 1965, this figure would imply a very significant impact of inflation on interest rates.

The finding that inflation increases the spread between debt and equity yields strongly supports the view of Fisher (1930) and Modigliani and Cohn (1979) that investors suffer from money illusion. If, as the latter suggest, they confuse nominal and real interest rates in valuing stock, we would expect to see stock prices undervalued. Likewise bonds would be overvalued as their apparent attractiveness is overstated. An alternative explanation might hold that the risk premium required to get investors to hold equities increases with the rate of inflation. Efforts to explain earnings and dividend price ratios using the measures of risk discussed in the preceding section proved unsuccessful, casting some doubt on this conjecture. In any event, it is not clear that this hypothesis is operationally distinguishable from the inflation illusion hypothesis.

V. Conclusions

The empirical analysis in this paper demonstrates that US interest rates do not appear to systematically incorporate inflation premiums in the way that classical monetary theories suggest. The data for the 1860-1940 period indicate no tendency for interest rates to increase with movements in expected inflation. For the Post-War period theory suggests that interest rates should have increased much more than point for point with inflation in the presence of taxes. The data suggests some tendency for interest rates to adjust to changes in expected inflation, but far less than is predicted by the theory. These conclusions hold at low frequencies and thus primarily reflect the effects of changes in inflation caused by movements in the long run rate of money growth. The implied strong negative relationship between inflation and real interest rates is not explicable in terms of changes in either proxies for the marginal product of capital the risk premium. Furthermore, it appears that increases in the rate of inflation are associated with a widening of the spread between the real ex-ante return on bonds and stocks.

These facts taken together at least raise the possibility that some form of money illusion infects financial markets. All are explicable by the hypothesis that for the Pre-War period agents ignored inflation in making financial calculations. As the average inflation rate increased during the Post-War period, investor sophistication increased and the market partially but not fully reflected the impact of changes in inflation. This hypothesis

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These facts taken together at least raise the possibility that some form of money illusion infects financial markets. All are explicable by the hypothesis that for the Pre-War period agents ignored inflation in making financial calculations. As the average inflation rate increased during the Post-War period, investor sophistication increased and the market partially but not fully reflected the impact of changes in inflation. This hypothesis also accounts for several other puzzles. Efforts to estimate Phillips curves on any data generated prior to 1965 consistently generate the conclusion that long run inflation is not neutral. More generally, the failure of market participants to understand the effects of inflation is the most plausible explanation for the abundance of nominally rigid institutions. Do purchasers of annuities wish less insurance when the rate of inflation increases? Did borrowers and lenders in the mortgage market desire the effective shortening of maturities which has resulted from increasing inflation? These are just prominent examples of the general failure to adopt contractual provision which are neutral to inflation. The absence of private indexing arrangements has not been satisfactorily explained.

How unlikely is it that market participants should be unaware of the distinction between nominal and real interest rates? It is noteworthy that it was not until the 20th centruy that the distinction was even introduced into economic analysis. There is little evidence in mainstream economic writings in the 1950's and 1960's of an awareness of this distinction. Almost universally, it was believed that low interest rates were both the short and long run consequence of easy money policies. The distinction between nominal and real interest rates is constantly confused in investors' sources of information. Modigliani and Cohn (1979) described an informal survey of brokerage letters supporting this proposition.

These considerations suggest the plausibility of some form of inflation illusion infecting financial markets. One major piece of evidence which casts doubt on the inflation illusion hypothesis is the behavior of house prices in recent years. James Poterba (1980) and I (1981) have suggested that the interaction of inflation and taxes can account for the boom in house prices in recent years. If home buyers displayed substantial inflation illusion, high nominal interest rates should have choked off housing demand, and led to a decline in real prices. One would expect inflation illusion to be much more prevalent among the relatively unsophisticated, liquidity constrained purchasers of homes, than among the investors in the stock and bond markets. The failure of housing construction to increase as predicted by models which emphasize tax effects may imply that increasing construction costs are the real reason for house price appreciation. It is also possible that the boom in home prices represents a speculative bubble. Furthermore, it is possible that investors form expectations about real interest rates on an asset from its past price behavior. This would imply a low real rate on housing and a high real rate on stocks at the present time.

In considering the suggestion that financial markets are inefficient because of inflation illusion, it is important to examine what market forces should be pushing towards the restoration of efficiency. The fundamental implication of the view developed in Modigliani and Cohn (1979) and supported here, is is the myriad constraints the capital market imposes on borrowing. By artificially limiting the demand for funds, these restrictions which bite more sharply when inflation is high, tend to reduce interest rates below the level they would otherwise attain.

This analysis may help illuminate the reasons for the current high level of interest rates. In 1965, the AAA bond rate was 4 percent. The long run model developed in the first section implies that the increase of 8 points in the inflation rate which has taken place in the interim should have raised bond rates by about 11 points. This yields a 15 percent rate which is close to what is observed in the market as this is written. It is just possible that current high interest rates reflect investors finally shedding their inflation illusion. The dismal performance of the stock market in recent months, remains inexplicable on this view.

that as the rate of inflation increases the expected real return on stocks relative to bonds should rise. This inefficiency would be corrected if increases in inflation led sophisticated investors to borrow and buy stock, or shift some of their portfolio to equity. Both of these strategies involve taking on additional risk. Indeed, it seems impossible to devise a strategy for profitting from inflation illusion which does not involve taking an additional risk. This is because of the absence of safe real assets **or** nominal assets with risk characteristics similar to common stock. This factor places limits on the extent to which any individual will be willing to invest to take advantage of the inefficiency. If investors are fairly inflexible about the amount of risk they are willing to bear, it may require a very large number to eliminate the tendency of market prices to reflect inflation illusion.

Several other factors suggest that inflation illusion is not readily succeptible to elimination by market forces. The very set of financially sophisticated investors who could most profit from its presence are trained to believe in its non-existence. More seriously, focusing on nominal yields may be individually rational, if collectively undesirable. The holder of a nominal mortgage should not purchase an indexed bond. For any individual it may be rational to compare nominal yields. This is particularly true where constraints expressed in nominal terms are present. Examples include institutions or individuals who are permitted to spend "income" but not to "dip into capital". A third factor limiting the ability of market forces to overcome inflation illusion

Appendix

A number of authors using data on the Post World War II period have estimated equations which they have interpreted as providing evidence in favor of the Fisher hypothesis. From the perspective of this paper, these equations are not well specified. and are not likely to be stable. This appendix verifies this conjecture using two standard procedures for modelling expectations. It also demonstrates that the anomalous results obtained in the paper are not the consequence of the use of the band spectral technique.

The basic equation to be estimated is of the form:

$$R_t = \beta_0 + \beta_1 \Pi^e_t \qquad \text{(A-1)}$$

where the principal empirical difficulty is the measurement of Π^e.

The Keynesian model holds that inflationary expectations at a point in time are predominantly a function of past rates of inflation. This implies that:

$$\Pi^e_t = \sum_0^T w_i \Pi_{t-i} \qquad \text{(A-2)}$$

Under this assumption the relationship between interest rates and inflation can be inferred from the distributed lag relation:

$$r_t = \beta_o + \beta_1 \sum_o^T w_i \Pi_{t-i} \qquad \text{(A-3)}$$

if the additional identifying restriction:

$$\sum_{o}^{T} w_i = 1 \qquad \text{(A-4)}$$

is imposed. This restriction is necessary if a constant rate of inflation maintained for T periods is to lead to an equal expected rate of inflation. However as Sargent (1971), (1973) and others have pointed out, it may not be appropriate if inflation follows any other stationary stochastic process, e.g. , if inflation rates follow the process:

$$\Pi_t = \rho\Pi_{t-1} + u_t \qquad \text{(A-5)}$$

then the optimal autoregressive predictor of inflation will have $\Sigma w_i = \rho$. Since the assumption here is that inflation expectations are based on arbitrary rules rather than rational forecasts, this point is neglected here. Rational expectations are considered below. In estimating (A-3) many investigators constrain the w_i to lie on some simple curve. This approach is undesirable if the goal is just to estimate the sum of the lag coefficients as is the case here.

The second assumption about expectations examined in the empirical work below is that inflationary expectations are rational. This case can be treated easily using a procedure due to McCallum (1976). The assumption of rationality implies that:

$$\Pi_t = \Pi^e_{t-1,t} + u_t \qquad \text{(A-6)}$$

where u_t is uncorrelated with any information available at time t-1. If u_t were correlated with any information available at time t such information could be used to improve the formation of π_t^e. Consider the regression equation where the realized rate of inflation π_t is used as a proxy for the expected rate. That is:

$$R_t = \beta_o+\beta_1\Pi_t-u_t \qquad \text{(A-7)}$$

Equation (A-6) implied that (A-7) meets the conditions of the classical errors in variables problem. Consistent estimates are obtainable if there exist instruments correlated with the expected rate of inflation, but uncorrelated with any expectational errors. The assumption of rationality implies that any information available at time t-1 meets these criteria. In particular, lagged values of inflation are suitable instruments. Thus the rational expectations assumption is implemented below by estimating equation (A-7) using lagged values of inflation as instruments.

Fama (1975) has developed an alternative approach to studying the relationship between interest rates and inflation. He begins by postulating that the expected real interest rate is constant. In this case:

$$r_t = \rho+\Pi_t^e \qquad \text{(A-8)}$$

where ρ is the expected real interest rate. The assumption that ρ is constant enables us to write:

$$\Pi_t^e = r_t-\rho \qquad \text{(A-9)}$$

The assumption of rational expectations embodied in (12) allows us to estimate the relation.

$$\Pi_t = \alpha_o+\alpha_1 r_t+u_t \qquad \text{(A-10)}$$

The joint assumptions of a constant real rate and rational expectations imply that $\alpha_1 = 1$ and that u_t is serially uncorrelated. Fama (1975) reports that he obtains results consistent with these assumptions for the 1954-71 period. The robustness of this conclusion is examined below by extending his tests to other sample periods.

In Table A-1, the relationship between inflation and short and long term interest rates is examined for the 1860-1940 period, using the techniques described above for measuring expectations.

Neither the results using the Keynesian nor the classical assumptions provide support for the view that interest rates adjust fully to incorporate inflation premiums. In no decade does the estimate of $\frac{dr}{d\Pi^e}$ for commercial paper exceed .34. The estimate for the entire period is only .04 based on the Keynesian assumption, all eight decadal estimates of $\frac{dr}{d\Pi^e}$ are negative. The longer period results are almost as unfavorable. The results are not substantially altered when longer lags are assumed in the formation of inflation expectations. The long rate results are equally unfavorable to the Fisher effect. The rational expectations estimates are again consistently negative while the Keynesian expectations estimates are always statistically insignificant. Every equation for either the short or long rate rejects the conclusion that $\frac{dr}{d\Pi^e} = 1$ with t statistics in excess of 10. Thus the data overwhelmingly refute the hypothesis that nominal interest rates adjusted to insure the neutrality of inflation.

Table A-1

Decadal Estimates of $dr/d\pi^e$ Prior to World War II

(Standard errors in parentheses)

Period	Commercial Paper		Long Rate[c]	
	Keynesian[a]	Rational[b]	Keynesian	Rational
1860-69	-0.01 (0.02)	-0.01 (0.02)	-0.02 (0.01)	-0.01 (0.03)
1870-79	0.34 (0.07)	-0.05 (0.05)	0.11 (0.06)	-0.23 (0.10)
1880-89	0.04 (0.02)	-0.02 (0.02)	0.10 (0.01)	-0.26 (0.06)
1890-99	0.01 (0.07)	-0.03 (0.04)	0.02 (0.02)	-0.14 (0.02)
1900-09	0.03 (0.08)	-0.02 (0.03)	-0.12 (0.02)	-0.08 (0.02)
1910-19	0.02 (0.01)	-0.01 (0.01)	0.06 (0.01)	-0.11 (0.02)
1920-29	0.04 (0.05)	-0.16 (0.03)	-0.14 (0.03)	-0.86 (0.27)
1930-39	-0.17 (0.03)	-0.10 (0.02)	-0.23 (0.03)	-0.30 (0.05)
1860-1913	0.03 (0.01)	0.03 (0.02)	0.03 (0.01)	-0.31 (0.08)
1914-1939	0.07 (0.02)	0.02 (0.02)	0.05 (0.01)	-0.38 (0.05)
1860-1939	0.04 (0.01)	0.04 (0.02)	0.04 (0.01)	-0.36 (0.06)

---

[a] Indicates the sum of the coefficients in the ordinary least squares regression of the CP rate on 8 lagged quarters of inflation.

[b] Coefficient yielded by regression of CP on current inflation where 8 lagged rates of inflation are used as instruments. This two-stage procedure, relevant to estimating an equation with an unobservable but rationally formed expectations variable is described in the text.

[c] Long rate used is represented by the Railroad Bond yield in MacCaulay from 1860-1918, and the Federal Reserve AAA bond yield from 1919-1979. In the OLS regression, 20 lagged quarters of inflation were used. In the two-stage procedure, the realized 10 year inflation rate (annualized), starting at time t, was instrumented using 20 lagged values of quarterly inflation.

Similar conclusions emerge from an extension of Fama's tests to the pre-war period. Results of this exercise are reported in Table A-2. In seven of the eight decades the coefficient on the interest rate is negative. Only the weakness of the statistical tests precludes rejection of the Fisher hypothesis. The predictive power of interest rates in explaining inflation is negligible. The estimated values of the ex-ante real interest rate are ludicrous, ranging from -1.1 during the 1870's to 51.9 during the 1910-19 period.

The Post-War Period

The analysis in the first section of the paper suggests that one could expect $\frac{dr}{d\Pi^e} > 1$ in the post-war period. Estimates of this parameter for intervals after WWII are presented in Table A-3. The regression procedures are the same as those in the pre-war analysis. The short rate is proxied by the rate on Treasury bills while the AAA bond rate is used as a measure of the long rate. Re-estimating the equations using alternative interest rates had no important effect on the results, nor did the use of monthly or annual data.

The results for both the short and long rates are broadly consistent. There is no evidence that interest rates have risen more than the rate of inflation. In only a few instances, the data is unable to reject the hypothesis that $\frac{dr}{d\Pi^e} = 1$, and in no case is it impossible to reject $\frac{dr}{d\Pi^e} = 1.3$ at a very high level of confidence. The results differ substantially across subperiods. It appears that almost all of the power in the interest rate-inflation relation comes from the acceleration of inflation during the 1960's. The data for the 1940's and 1950's reveal no statistically significant

Table A-2

Regressions of the Inflation Rate, π_t, on the Short-Term Rate of Interest[a]

(Standard errors in parentheses)

Period	Constants	R_t	R^2	DW
1860-69	71.50	-8.66 (3.34)	0.13	1.57
1870-79	-1.11	0.02 (1.32)	-0.02	1.82
1880-89	5.17	-1.47 (2.27)	-0.01	1.76
1890-99	7.31	-1.25 (1.54)	-0.01	1.95
1900-09	14.40	-2.35 (1.49)	0.04	2.31
1910-19	51.90	-8.80 (2.96)	0.17	1.22
1920-29	13.80	-3.03 (0.47)	0.50	1.03
1930-39	3.20	-3.22 (0.75)	0.30	1.06
1860-1913	9.30	-1.30 (0.80)	0.01	1.55
1914-1939	3.60	-0.25 (0.68)	-0.01	0.87

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[a] All regressions were run OLS. The relevant inflation rate for 1860 through 1918 is the realized 3 month rate of change in prices. For 1919 to 1939, it is the realized 6 month rate of change.

Table A-3

Post-War Estimates of $dr/d\pi^e$

(Standard errors in parentheses)

	3-Month T-Bills[a]			AAA Rate	
Period	Autoregressive	Rational	Period	Autoregressive	Rational
1947-79	0.35 (0.05)	0.38 (0.05)	1946-69	-0.26 (0.05)	0.72 (0.08)
Omitting Controls[b]	0.33 (0.05)	0.35 (0.06)			
1947-55	-0.04 (0.02)	-0.03 (0.02)	1946-55	-0.08 (0.01)	-0.32 (0.05)
1956-65	-0.16 (0.17)	0.05 (0.15)	1956-65	0.07 (0.25)	0.22 (0.06)
1966-75	0.35 (0.66)	0.47 (0.07)			
Omitting Controls[b]	0.38 (0.08)	0.51 (0.13)			
1950-59	0.00 (0.10)	0.00 (0.08)	1950-59	-0.07 (0.07)	0.55 (0.37)
1960-69	0.85 (0.08)	0.77 (0.10)	1960-69	0.82 (0.05)	0.58 (0.06)
1970-79	0.47 (0.08)	0.51 (0.06)			
Omitting Controls[b]	0.49 (0.13)	0.55 (0.09)			

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[a] See Table 2 for explanation of regression procedures. Three month bills were used here in order to be consistent with Table 5 (see footnote a, Table 5). The difference between these results and those obtained using the commercial paper rate are statistically insignificant.

[b] For these regressions, we omitted the 12 observations 1971:3 through 1974:2.

inflation effects. The regressions for the 1970's also exhibit effects of inflation which are significantly smaller than those found for the entire period. Fama (1975) argues that the price level is mismeasured during the controls period. Omission of this interval has no significant effect on the results. Hence the inflation-interest rate nexus appears to be very weak during the 1970's. It seems difficult to escape the conclusion that even viewed from a purely post-war perspective the strong inflation-interest rate relationship during the 1960's was an aberration.

Somewhat more favorable results (Table A-4) were obtained using the Fama procedure. The results for the whole period are consistent with $\frac{dr}{d\Pi^e} = 1$ although the low Durbin-Watson statistic is troublesome. The hypothesis that $\frac{dr}{d\Pi^e} = 1.3$ as predicted by theory is again refuted. The failure of the Fisher relationship in the 1950's and 1970's again emerges clearly. These results do not exactly parallel Fama's because of the use of quarterly data. However, the results for sample periods comparable to this closely parallel those he reports. It seems reasonable therefore to conclude that the failure of these tests outside his sample period casts doubt on the robustness of his conclusion.

Table A-4

Regressions of Quarterly Inflation Rate on 3-Month T-Bills Rates

(Standard errors in parentheses)

Period	Constant	R_t	$\bar{R}^2$	DW
1947-79	-0.31	1.14 (0.12)	0.37	1.18
Omitting Controls[b]	-0.06	1.04 (0.14)	0.31	1.19
1947-55	6.33	-2.94 (1.82)	0.04	1.37
1956-65	0.85	0.32 (0.33)	0.00	1.80
1966-75	-3.32	1.59 (0.24)	0.51	1.53
Omitting Controls[b]	-0.43	0.96 (0.26)	0.30	1.74
1950-59	2.06	-0.18	-0.02	1.06
1960-69	-1.82	1.12 (0.14)	0.61	2.07
1970-79	-2.78	1.66 (0.19)	0.65	1.87
Omitting Controls[b]	-2.31	1.56 (0.23)	0.61	1.85

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[a] All regressions are estimated OLS using quarterly data.

[b] For these regressions, we omitted the 12 observations 1971:3 through 1974:2.

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