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ASSET RETURNS AND INFLATION*

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We estimate the extent to which various assets were hedges against the expected and unexpected components of the inflation rate during the 1953–71 period. We find that U.S. government bonds and bills were a complete hedge against expected inflation, and private residential real estate was a complete hedge against both expected and unexpected inflation. Labor income showed little short-term relationship with either expected or unexpected inflation. The most anomalous result is that common stock returns were negatively related to the expected component of the inflation rate, and probably also to the unexpected component.

The recent episode of high inflation rates has focused interest on the question of which assets, if any, provide effective hedges against inflation. In this paper we examine the qualities of a variety of assets as hedges against the expected and unexpected components of the inflation rate.

1. Hedging against inflation: Theory

Irving Fisher (1930) noted that the nominal interest rate can be expressed as the sum of an expected real return and an expected inflation rate. The proposition that expected nominal returns contain market assessments of expected inflation rates can be applied to all assets. Thus, if the market is an efficient or rational processor of the information available at time $t-1$, it will set the price of any asset j so that the expected nominal return on the asset from $t-1$ to t is the sum of the appropriate equilibrium expected real return and the best possible assessment of the expected inflation rate from $t-1$ to t. Formally,

$$E(\tilde{R}_{jt}|\phi_{t-1}) = E(\tilde{i}_{jt}|\phi_{t-1}) + E(\tilde{\Delta}_t|\phi_{t-1}), \tag{1}$$

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where $\tilde{R}_{jt}$ is the nominal return on asset j from $t-1$ to t, $E(\tilde{i}_{jt}|\phi_{t-1})$ is the appropriate equilibrium expected real return on the asset implied by the set of information ϕ_{t-1} available at $t-1$, $E(\tilde{\Delta}_t|\phi_{t-1})$ is the best possible assessment of the expected value of the inflation rate $\tilde{\Delta}_t$ that can be made on the basis of ϕ_{t-1}, and tildes denote random variables.

The story meant to be conveyed by eq. (1) is that the market uses ϕ_{t-1} to correctly assess the expected inflation rate and to determine the appropriate equilibrium expected real return on asset j, including perhaps a risk adjustment which differentiates the expected return on asset j from that on other assets. The market then sets the price of the asset so that its expected nominal return is the sum of the equilibrium expected real return and the correctly assessed expected inflation rate.

As a quantity theorist Fisher felt that the real and monetary sectors of the economy are largely independent. Thus, he hypothesized that the expected real return in (1) is determined by real factors, like the productivity of capital, investor time preferences, and tastes for risk, and that the expected real return and the expected inflation rate are unrelated. This assumption is convenient for our purposes because it allows us to study asset return–inflation relationships without introducing a complete general equilibrium model for expected real returns.

Given some way to measure the expected inflation rate, $E(\tilde{\Delta}_t|\phi_{t-1})$, tests of the joint hypotheses that the market is efficient and that the expected real return and expected inflation rate vary independently can be obtained from estimates of the regression model,

$$\tilde{R}_{jt} = \alpha_j + \beta_j E(\tilde{\Delta}_t|\phi_{t-1}) + \tilde{\varepsilon}_{jt}. \tag{2}$$

Since a regression estimates the conditional expected value of the dependent variable as a function of the independent variable, an estimate of the regression coefficient β_j which is statistically indistinguishable from 1.0 is consistent with the hypothesis that the expected nominal return on asset j varies in one-to-one correspondence with the expected inflation rate. Since the expected real return on the asset is its expected nominal return minus the expected inflation rate, an estimate of β_j which is indistinguishable from 1.0 is also consistent with the hypothesis that the expected real return on the asset and the expected inflation rate are unrelated.

We are also interested in the extent to which asset returns at t reflect the unanticipated component of the inflation rate between $t-1$ and t, $\tilde{\Delta}_t - E(\tilde{\Delta}_t|\phi_{t-1})$. To this end, we expand (1) as follows:

$$\begin{aligned} E(\tilde{R}_{jt}|\phi_{t-1}, \Delta_t) = {} & E(\tilde{i}_{jt}|\phi_{t-1}) + E(\tilde{\Delta}_t|\phi_{t-1}) \\ & + \gamma_j[\Delta_t - E(\tilde{\Delta}_t|\phi_{t-1})]. \end{aligned} \tag{3}$$

Estimates of (3) can be based on the regression model,

$$\tilde{R}_{jt} = \alpha_j + \beta_j E(\tilde{\Delta}_t | \phi_{t-1}) + \gamma_j [\Delta_t - E(\tilde{\Delta}_t | \phi_{t-1})] + \tilde{\eta}_{jt}. \tag{4}$$

An estimate of the regression coefficient γ_j which is statistically indistinguishable from 1.0 is consistent with the hypothesis that on average the nominal return to asset j varies in one-to-one correspondence with the unexpected inflation rate.

Fisher's model says that all assets should have a coefficient $\beta_j = 1.0$ for the expected inflation rate in (4), but to obtain hypotheses about the coefficient γ_j for the unexpected inflation rate, we must rely largely on intuition, and our intuition about γ_j is different for different assets. For example, since the nominal value of a treasury bill which matures at time t is fixed at $t-1$, the return on the bill from $t-1$ to t cannot react to the unexpected rate of inflation from $t-1$ to t. On the other hand, there is a general belief that real estate and common stocks are hedges against inflation, unanticipated as well as anticipated, so that γ_j for these assets should be positive. It is also widely believed [see, for example, Kessel and Alchian (1960)] that income from human capital adjusts to both anticipated and unanticipated inflation, although possibly with a lag. For longer-term bonds, whose cash payoffs are fixed in nominal terms, the signs and magnitudes of γ_j in (3) and (4) depend on how the unanticipated inflation rate is related to changes in the discount rates that the market will use to price bonds in the future, a link that we investigate in some detail.

Since the unexpected rate of inflation is, by definition, uncorrelated with the expected rate of inflation, eq. (4) produces tests of the Fisher hypothesis that $\beta_j = 1.0$ which are identical to those that would be obtained from (2). We concentrate on models based on (4). When the tests suggest that $\beta_j = 1.0$, we say that the asset is a *complete hedge against expected inflation*: The expected nominal return on the asset varies in one-to-one correspondence with the expected inflation rate, and the expected real return on the asset is uncorrelated with the expected inflation rate. When $\gamma_j = 1.0$, the asset is a *complete hedge against unexpected inflation.* When the tests suggest that $\beta_j = \gamma_j = 1.0$, we say that the asset is a *complete hedge against inflation*: The nominal return on the asset varies in one-to-one correspondence with both the expected and unexpected components of the inflation rate, and the *ex post* real return on the asset is uncorrelated with the *ex post* inflation rate.

The fact that an asset is a complete hedge against expected and/or unexpected inflation does not imply that the real return on the asset has zero variance or even a small variance. Noninflation factors can generate variation in nominal returns which can be large or small relative to the variation in nominal returns associated with the expected and unexpected components of the inflation rate. In terms of equation (4), an asset might be a complete hedge against inflation, that is, both β_j and γ_j equal to 1.0, but inflation might 'explain' a small fraction of the variation in the asset's nominal return; that is, the variance of the disturbance $\tilde{\eta}_{jt}$, which in this case is the variance of the asset's real return, might be large relative to the variance of the expected and unexpected components of the inflation rate.

2. The data

2.1. The rate of inflation

We use the Bureau of Labor Statistics Consumer Price Index (CPI) to estimate the rate of inflation. The rate of inflation, Δ_t, is defined as the natural logarithm of the ratio of the values of the CPI at t and $t-1$. Given the assumption that the purpose of investment is eventual consumption, the use of an inflation rate for consumption goods is appropriate – a point clearly recognized by Fisher (1930, ch. I) in his development of the theory.

In 1953 the Bureau of Labor Statistics increased the coverage of the CPI sample of goods and the frequency with which prices of individual goods are collected. Thus, the CPI data since January 1953 provide a more current and comprehensive measure of inflation than did earlier data. In August 1971 the government imposed price controls which discouraged increases in quoted prices of goods. The effective prices of goods and services increased during this period because of longer average purchase delays and increases in other costs of search in purchasing goods. When price controls were phased out in 1973 and 1974, the changes in the measured prices of goods in the CPI probably overstated the true inflation rate, as producers switched to prices as a means of rationing output among consumers. Thus, it is likely that from August 1971 until sometime in late 1974 the CPI was not a good measure of the cost to consumers of obtaining goods and services, so for the most part we concentrate on the period from January 1953 through July 1971. Fama and Schwert (1977b) discuss in detail the time series behavior of the CPI and its major components during this period.

2.2. Returns on assets

The return on an asset is the change in the price of the asset from $t-1$ to t plus the cash flow paid to owners of the asset during the period, all relative to the price of the asset at $t-1$. For common stocks, we use returns on an equally-weighted portfolio of all New York Stock Exchange (NYSE) stocks and on a value-weighted portfolio of NYSE stocks, labeled s_{et} and s_{vt}, respectively. Both series are from the Center for Research in Security Prices of the University of Chicago. Like the inflation rate, the common stock returns are continuously compounded. In general, continuous compounding is used in calculating asset returns.

Returns on U.S. treasury bills with one to six months to maturity, denoted B_{1t} through B_{6t}, are derived from the Salomon Brothers quote sheets. The details of the calculations are described in Fama (1976b, ch. 6). Data for bills with one to three months to maturity are available since January 1953, while data for bills with four to six months to maturity are available since March 1959. Since bills pay no coupons, the return on a bill depends only on the change in its price from $t-1$ to t.

Returns on longer-term U.S. government bonds are based on indices constructed by Bildersee (1974). We use his indices to compute returns to bonds with from one to two years to maturity, D_{1t}; from two to three years to maturity, D_{2t}: from three to four years to maturity, D_{3t}; and from four to five years to maturity, D_{4t}. The statistical properties of these bond returns are analyzed in Fama and Schwert (1977a).

The return to privately held residential real estate, r_t, is measured as the rate of inflation of the Home Purchase Price component of the CPI. The Home Purchase Price index is based on the purchase prices of homes with mortgages newly insured by the FHA. To control for fluctuation in the quality of units in the sample, average prices for different quality classes are combined with fixed weights and the index is expressed as a price per square foot. However, the data have some deficiencies. The index is available only as a three month moving average. The FHA reports the sale price at the time the home is insured, so a lag of one to three months may occur between the date when the price is determined and the date when it is reflected in the index. In addition, there is a one month lag between the time that the FHA collects the data and the time when they show up in the CPI. Finally, FHA-insured housing is not a representative sample of all owner-occupied residential real estate. Nevertheless, the Home Purchase Price index seems to be the best available quality adjusted index of transaction prices for real estate.[1]

Ideally, we would like to have a measure of the return to real estate net of expenses but including the value of the service flows to owner-occupied housing. Owner-occupied housing differs from other assets such as stocks and bonds in that the 'dividend' return on housing is received in kind, so the relevant data are not available. Our hope is that our measure of the capital gain return to real estate, r_t, provides an adequate proxy for the variation of the total return to real estate, though not of the level of the total return.

Finally, since there is a general presumption that nominal income from human capital changes to reflect inflation, we include it in our tests. All of our other asset returns include changes in capital values, but these are not available for

[1]The Home Purchase Price index is described in 'Housing Costs in the Consumer Price Index', *Monthly Labor Review* (February 1956), pp. 189–196, and 'Housing Costs in the Consumer Price Index', *Monthly Labor Review* (April 1956), pp. 442–446. B.L.S. Bulletin No. 1517, 'The Consumer Price Index, History and Techniques' (1966), describes the construction of the entire CPI in detail.

Table 1

Means, standard deviations and autocorrelations of monthly nominal rates of return, January 1953 – July 1971.[a]

Asset	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Mean	Standard deviation
Treasury bills														
B_{1t}	0.97	0.95	0.93	0.91	0.88	0.85	0.83	0.81	0.78	0.74	0.72	0.70	0.0026	0.0013
B_{2t}	0.91	0.88	0.86	0.83	0.81	0.76	0.74	0.73	0.71	0.68	0.66	0.64	0.0029	0.0014
B_{3t}	0.83	0.79	0.78	0.75	0.73	0.67	0.63	0.64	0.63	0.57	0.57	0.57	0.0031	0.0015
Government bonds														
D_{1t}	0.25	0.09	0.13	0.12	0.12	0.04	−0.05	0.01	0.00	−0.01	0.06	0.06	0.0031	0.0044
D_{2t}	0.16	0.09	0.07	0.09	0.01	0.02	−0.11	−0.05	−0.03	−0.06	0.00	0.02	0.0031	0.0066
D_{3t}	0.18	0.11	0.05	0.10	−0.01	−0.02	−0.11	−0.10	−0.04	−0.05	−0.02	−0.03	0.0029	0.0080
D_{4t}	0.15	0.05	0.08	0.11	−0.07	−0.04	−0.11	−0.09	−0.01	−0.04	−0.06	0.00	0.0026	0.0096
Real estate														
r_t	0.39	0.21	0.06	0.13	0.13	0.21	0.21	0.18	0.18	0.25	0.29	0.25	0.0017	0.0036
Labor income														
h_t	0.09	0.11	−0.02	0.14	0.08	0.10	0.02	−0.03	−0.05	−0.07	0.00	−0.12	0.0032	0.0059
Common stocks														
s_{vt}	0.11	0.01	0.01	0.14	0.09	−0.03	−0.09	−0.11	0.07	−0.17	0.00	0.01	0.0089	0.0362
s_{et}	0.19	0.08	−0.01	0.11	0.06	0.04	−0.14	−0.21	0.01	−0.09	0.04	0.00	0.0102	0.0425
Inflation														
Δ_t	0.37	0.36	0.27	0.30	0.28	0.28	0.25	0.33	0.35	0.33	0.26	0.36	0.0019	0.0023

[a]Sample autocorrelations are estimated as regression coefficients. The asymptotic standard error of ρ_τ is 0.07 under the hypothesis that the true autocorrelations are all equal to zero.

Table 2

Means, standard deviations and autocorrelations of monthly real rates of return, January 1953 – July 1971.[a]

Asset	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Mean	Standard deviation
Treasury bills														
B_{1t}	0.11	0.12	−0.02	−0.01	−0.02	−0.02	−0.07	0.05	0.10	0.10	0.03	0.19	0.0007	0.0020
B_{6t}	0.13	0.14	−0.02	−0.03	−0.01	−0.06	−0.08	0.03	0.06	0.12	0.04	0.18	0.0010	0.0020
B_{3t}	0.15	0.14	−0.03	−0.06	−0.01	−0.08	−0.09	0.01	0.05	0.11	0.03	0.17	0.0012	0.0020
Government bonds														
D_{1t}	0.17	0.07	0.04	0.01	0.07	−0.03	−0.12	−0.05	−0.05	−0.03	0.03	0.05	0.0012	0.0047
D_{2t}	0.14	0.12	0.02	0.04	−0.01	0.00	−0.13	−0.07	−0.05	−0.05	0.00	0.04	0.0012	0.0068
D_{3t}	0.18	0.14	0.03	0.07	−0.02	−0.02	−0.12	−0.10	−0.03	−0.03	0.00	−0.01	0.0010	0.0083
D_{4t}	0.15	0.08	0.07	0.09	−0.07	−0.03	−0.11	−0.09	0.00	−0.03	−0.05	0.02	0.0007	0.0099
Real estate														
r_t	0.14	−0.03	−0.16	−0.16	−0.02	0.04	0.05	0.01	−0.02	0.05	0.09	0.13	−0.0002	0.0034
Labor income														
h_t	0.16	0.15	0.00	0.10	0.03	0.10	0.03	−0.02	−0.03	−0.06	0.03	−0.12	0.0013	0.0061
Common stocks														
s_{vt}	0.14	0.02	0.03	0.14	0.10	−0.03	−0.09	−0.10	0.08	−0.16	0.00	0.01	0.0070	0.0366
s_{et}	0.21	0.09	0.00	0.11	0.07	0.04	−0.13	−0.20	0.02	−0.09	0.04	0.00	0.0084	0.0430

[a]The asymptotic standard error of ρ_τ is 0.07 under the hypothesis that the true autocorrelations are all equal to zero.

Table 3

Average, annualized, percent, nominal returns on assets and average CPI inflation rates.[a]

Variable	Period 1/53–12/57	1/58–12/62	1/63–12/67	1/68–7/71	8/71–12/75
Inflation					
Δ_t	1.3	1.3	2.2	5.1	7.1
Treasury bills					
B_{1t}	1.9	2.2	3.7	5.5	5.7
B_{2t}	2.1	2.7	4.0	5.9	6.0
B_{3t}	2.3	3.0	4.1	6.1	6.4
Government bonds					
D_{1t}	2.3	3.5	3.6	6.1	N.A.
D_{2t}	2.7	3.6	3.2	5.7	N.A.
D_{3t}	2.6	3.7	2.9	5.1	N.A.
D_{4t}	2.4	3.3	2.6	4.5	N.A.
Real estate					
r_t	1.0	0.6	1.7	5.9	6.2
Labor income					
h_t	2.2	3.4	5.2	4.7	6.1
Common stocks					
s_{vt}	12.3	12.8	12.5	3.0	1.6
s_{et}	10.5	14.4	18.5	3.3	−0.6

[a]Average nominal returns and inflation rates are annualized from monthly average returns like those in table 1. For bills (B_{1t}, B_{2t}, B_{3t}) and bonds (D_{1t}, D_{2t}, D_{3t}, D_{4t}) this means that instruments of a given maturity are purchased and sold each month, and then the average monthly returns are annualized, that is, multiplied by 1,200. Data for the bond portfolios are not available (N.A.) for the latest subperiod.

A general picture of the qualities of different assets as inflation hedges is also provided by table 3, which shows average annualized percent inflation rates and nominal asset returns for subperiods. For the real estate variable (r_t) and for each of the three treasury bills (B_{1t}, B_{2t}, B_{3t}), the subperiod ordering of average nominal returns corresponds exactly to the ordering of average inflation rates. The correspondence between the ordering of average returns and average inflation rates is not so exact for the four government bond portfolios (D_{1t}, D_{2t}, D_{3t}, D_{4t}), but the tendency for average returns to follow the average inflation rate is still noticeable. The average rates of change of income per capita (h_t) generally move with average inflation rates, but $\bar{h}$ is relatively high during the 1963 to 1967 subperiod when the average inflation rate is relatively low. Finally, a phenomenon that perplexes us throughout this study is the apparent inverse relationship between stock returns (s_{vt}, s_{et}) and inflation rates since 1953.

Note, however, that in spite of their inverse relationship with inflation rates, average returns on stocks are higher for the overall period than average returns on other assets, a fact which is more evident in tables 1 and 2. Note also that, with the exception of the last subperiod in table 3, average returns on bills and bonds are greater than the average inflation rate, so that real returns on these instruments are generally positive. Moreover, average returns on bills increase with maturity, a pattern which is less evident in the bond returns. Finally, the fact that the average returns to private residential real estate shown in table 3 are generally less than the average inflation rates does not necessarily imply negative average real returns to real estate since our measure of the real estate return covers only capital gains.

Tables 1 to 3 provide a useful introduction to the properties of different assets as inflation hedges, but the picture that emerges is impressionistic. The tests that follow provide more precise measures of the relationships between asset returns and the two components of the inflation rate, expected and unexpected.

3. Tests of assets as hedges against expected inflation

3.1. A measure of expected inflation

To implement tests of assets as hedges against expected and unexpected inflation using the model in (4), an empirical measure of the expected inflation rate, $E(\tilde{\Delta}_t|\phi_{t-1})$, based on data available at time $t-1$, is needed. The nominal return or interest rate on a treasury bill which matures at time t, B_t, is known at $t-1$. Fama (1975) notes that if the expected real return on the bill is constant through time, and if the bill market is efficient, the nominal return on the bill is equal to the constant expected real return plus the expected inflation rate,

$$B_t = E(\tilde{\imath})+E(\tilde{\Delta}_t|\phi_{t-1}). \tag{6}$$

Thus, the expected inflation rate is

$$E(\tilde{\Delta}_t|\phi_{t-1}) = -E(\tilde{\imath})+B_t. \tag{7}$$

Tests of (7) can be obtained from estimates of

$$\tilde{\Delta}_t = \alpha+\beta\, B_t+\tilde{\varepsilon}_t, \tag{8}$$

where the proposition of (7) is that $\beta = 1.0$ and $E(\tilde{\varepsilon}_t|\phi_{t-1}) = 0$; that is, all variation in the nominal return B_t set at $t-1$ reflects variation in $E(\tilde{\Delta}_t|\phi_{t-1})$, the best possible assessment at $t-1$ of the expected value of the inflation rate to be observed at t. The unexpected component of the inflation rate is then just the disturbance $\tilde{\varepsilon}_t$ in (8).

The estimate of (8) using monthly data for the January 1953 – July 1971 period is shown in table 4. Consistent with the hypothesis of (7), the estimate of β is 0.98 with a standard error of 0.10, and the first three autocorrelations of the residuals, $\rho_1(\hat{\varepsilon})$, $\rho_2(\hat{\varepsilon})$, and $\rho_3(\hat{\varepsilon})$, are close to zero. Table 4 also shows the estimate of the regression of the quarterly inflation rate on the return to maturity or interest rate on a three month treasury bill, B_{3t}, set at the beginning of the quarter. The estimate of the slope coefficient $\hat{\beta}$ is close to one with a small standard error, $\bar{R}^2$ is 0.48, and the residuals seem to be serially uncorrelated. Finally, the regression of the semiannual inflation rate on B_{6t}, the return to maturity or interest rate on a six month treasury bill set at the beginning of the six month period, indicates that B_{6t} is a good proxy for the semiannual expected inflation rate. The estimate of β is 1.06 with a standard error of 0.10, $\bar{R}^2$ is 0.82, and the residuals do not seem to be autocorrelated.

A more detailed discussion of the interest rate–inflation model of eqs. (6) to (8) is in Fama (1975) and Fama and Schwert (1977b). For our purposes, the important empirical finding is that estimates of eq. (8) are consistent with the proposition that changes in the interest rate, B_t, correspond to changes in the expected inflation rate, $E(\tilde{\Delta}_t|\phi_{t-1})$. Thus, we use the nominal return or interest rate on a treasury bill which matures at the end of period t as a proxy for the expected inflation rate for period t, and the unexpected inflation rate is measured as $\Delta_t - B_t$, the difference between the inflation rate realized *ex post* and the *ex ante* interest rate. The empirical analog of eq. (4) is then[2]

$$\tilde{R}_{jt} = \alpha_j + \beta_j B_t + \gamma_j(\Delta_t - B_t) + \tilde{\eta}_{jt}. \tag{9}$$

Finally, the proxies for the expected and unexpected monthly inflation rates have very different time series properties. The autocorrelations of B_{1t} in table 1 are close to 1.0 at lower-order lags and only decay slowly at higher-order lags, which is suggestive of a non-stationary process such as a random walk. Thus, the proxy for the expected inflation rate wanders slowly over time with little affinity for any particular value. In contrast, since the estimated regression of Δ_t on B_{1t} in table 4 produces a slope coefficient $\hat{\beta} = 0.98$, the residuals from the regression have time series properties almost identical to those of $\Delta_t - B_{1t}$. Thus from the monthly results in table 4 we can conclude that $\Delta_t - B_{1t}$ has the properties required of a proxy for the unexpected inflation rate; that is, $\Delta_t - B_{1t}$ is serially uncorrelated and uncorrelated with the proxy for the expected inflation rate. The inflation rate, which is just the sum of its expected and unexpected components, is therefore approximately a random walk plus serially uncor-

[2]There is some evidence that inflation can be predicted slightly better by using additional information available at time $t-1$, such as lags of the inflation rate [see, for example, Hess and Bicksler (1975) or Nelson and Schwert (1977)]. Taking account of such complications does not materially affect the results.

Table 4

Interest rates as measures of expected inflation, $\Delta_t = \hat{a} + \hat{\beta} B_t + \hat{\varepsilon}_t$ (standard errors in parentheses).[a]

Interest rate[b] B_t	Period	Sample size T	$\hat{a}$	$\hat{\beta}$	$\bar{R}^2$	$S(\hat{\varepsilon})$	$\rho_1(\hat{\varepsilon})$	$\rho_2(\hat{\varepsilon})$	$\rho_3(\hat{\varepsilon})$
Monthly, B_{1t}	1/53 – 7/71	223	−0.0007 (0.0003)	0.98 (0.10)	0.29	0.0020	0.10	0.12	−0.02
Quarterly, B_{3t}	1/53 – 6/71	74	−0.0023 (0.0011)	0.93 (0.11)	0.48	0.0038	0.00	0.04	0.10
Semi-annual, B_{6t}[c]	7/59 – 6/71	24	−0.0097 (0.0024)	1.06 (0.10)	0.82	0.0038	0.00	−0.04	0.16

[a]The coefficients of determination, $\bar{R}^2$, are adjusted for degrees of freedom. $S(\hat{\varepsilon})$ is the standard error of the regression residuals, and $\rho_\tau(\hat{\varepsilon})$ is the residual autocorrelation at lag τ.

[b]B_t is the return or interest rate on a treasury bill which matures at the end of period t. It is known at the beginning of the period.

[c]Returns on six-month bills are only available since March 1959.

related noise. This is consistent with the autocorrelations of the inflation rate in table 1 which are much less than one but do not decay as the lag is increased.[3]

3.2. Tests based on monthly data

Estimates of eq. (9) for monthly data from January 1953 to July 1971 are shown in table 5. The estimates of β_j, the coefficient for the expected inflation proxy in (9), are close to one for treasury bills (B_{2t}, B_{3t}), the government bond portfolios (D_{1t}, D_{2t}, D_{3t}, D_{4t}), and real estate (r_t). Although the estimates of β_j for the returns to two and three month bills are more than two standard errors above one, the standard errors of the coefficients are underestimated in this case because the residuals and the expected inflation proxy are both positively autocorrelated [cf. Theil (1971, pp. 254–257)]. The estimate of β_j for the income variable, h_t, is 0.51 with a standard error of 0.31, so we cannot comfortably reject the hypothesis that $\beta_j = 1$. However, since there is a wide range of alternative hypotheses that also can't be rejected, table 5 does not provide much evidence that labor income is a hedge against the monthly expected inflation rate.

Since the regressions for treasury bill and bond returns yield coefficient estimates for B_{1t} that are close to 1.0 and coefficients for $\Delta_t - B_{1t}$ that are generally within one standard error of zero, the time series properties of the residuals from these regressions correspond to the properties of the premiums on bills and bonds, that is, the differences between their one month returns and the return on a one month bill. The non-trivial autocorrelations of these premiums, evident in the residual autocorrelations in table 5, are documented and discussed in Fama (1976a).

However, these residual autocorrelations gain additional interest in our work. Since B_{1t} in (9) is the proxy for the expected inflation rate in eqs. (1) to (4), the residual autocorrelations in the regressions for bills and bonds in table 5 can be interpreted as variation in expected real returns which is independent of variation in the expected inflation rate. Thus, the residual autocorrelations are evidence of the type of independent variation of expected real returns and the expected inflation rate which allows (2) and (4) to provide meaningful measures of variation in expected nominal returns in response to variation in the expected inflation rate. On the other hand, the large first-order residual autocorrelation for the real estate return r_t in table 5 is less interesting since it is probably a consequence of the fact that the Home Purchase Price index on which r_t is based is a three month moving average.

Given an asset whose expected return varies directly with B_{1t}, we can expect the large autocorrelations of B_{1t} to have a more noticeable effect on the time series behavior of the asset's return when the proxy for the expected inflation rate

[3]Box and Jenkins (1976, pp. 123–124 and 200–201) describe such a process and the behavior of its sample autocorrelations.

Table 5

Hedges against monthly expected and unexpected inflation, $R_{jt} = \hat{a}_j + \hat{\beta}_j B_{1t} + \hat{\gamma}_j(\Delta_t - B_{1t}) + \hat{\eta}_{jt}$ (standard errors in parentheses); 1/53 – 7/71, $T = 223$.

Asset R_{jt}	$\hat{a}_j$	$\hat{\beta}_j$	$\hat{\gamma}_j$	R^2	$S(\hat{\eta}_j)$	$\rho_1(\hat{\eta}_j)$	$\rho_2(\hat{\eta}_j)$	$\rho_3(\hat{\eta}_j)$
B_{2t}	0.0002 (0.0001)	1.04 (0.02)	0.01 (0.01)	0.94	0.0003	0.34	0.20	0.18
B_{3t}	0.0002 (0.0001)	1.08 (0.03)	0.02 (0.02)	0.85	0.0006	0.28	0.13	0.20
D_{1t}	0.0001 (0.0006)	1.11 (0.22)	−0.11 (0.14)	0.10	0.0042	0.20	0.02	0.07
D_{2t}	0.0002 (0.0010)	1.03 (0.34)	−0.15 (0.22)	0.03	0.0065	0.14	0.07	0.06
D_{3t}	0.0002 (0.0012)	0.94 (0.41)	−0.26 (0.27)	0.02	0.0079	0.18	0.09	0.06
D_{4t}	−0.0001 (0.0015)	0.90 (0.50)	−0.36 (0.33)	0.01	0.0096	0.15	0.04	0.08
r_t	−0.0012 (0.0005)	1.19 (0.16)	0.31 (0.11)	0.21	0.0032	0.22	−0.01	−0.17
h_t	0.0020 (0.0009)	0.51 (0.31)	0.16 (0.20)	0.01	0.0059	0.09	0.11	−0.03
s_{vt}	0.0228 (0.0055)	−5.52 (1.85)	−0.77 (1.22)	0.03	0.0356	0.06	−0.02	−0.03
s_{et}	0.0235 (0.0064)	−5.70 (2.17)	−2.35 (1.44)	0.03	0.0418	0.13	0.07	−0.05

is a large component of the variance of the asset's return. This is observed in the results for real estate, bills, and bonds in tables 1 and 5. In the regressions of table 5, the coefficients of determination, $\bar{R}^2$, are large for the monthly returns on two and three month bills while the $\bar{R}^2$ statistics are relatively small for real estate and the government bond portfolios. In table 1, the autocorrelations of the bill returns are likewise larger than those for real estate and bonds.

Having discussed the results for assets whose expected returns seem to vary directly with our proxy for the expected inflation rate, we turn now to the prime counterexample. In table 5, the estimates of β_j for s_{et} and s_{vt}, the returns to the NYSE common stock portfolios, are both approximately -5.5, with standard errors of about 2.0. We can reject the hypothesis that common stocks are a hedge against the expected monthly inflation rate. The negative relationship between common stock returns and expected inflation rates has also been noted by Lintner (1975), Body (1976), Nelson (1976), and Jaffe and Mandelker (1976), among others. The anomalous behavior of common stock returns is analyzed in more detail in section 4.

3.3. Tests based on quarterly and semiannual data

The Fisher hypothesis that expected nominal returns should vary directly with the expected inflation rate can be applied to any time interval over which the variables might be measured. Table 6 shows estimates of eq. (9) based on quarterly and semiannual returns and inflation rates. The nominal return or interest rate on a three month bill observed at the beginning of each quarter, B_{3t}, is the proxy for the expected quarterly inflation rate. The *ex ante* six month bill rate, B_{6t}, is likewise taken as the proxy for the semiannual expected inflation rate. Since data for six month bills are not available prior to March 1959, the semiannual tests only cover the second half of 1959 through the first half of 1971.

The quarterly and semiannual results in table 6 are similar to the monthly results in table 5. Government bonds and real estate are complete hedges against the expected inflation rate since the estimates of β_j, the coefficient of the expected inflation proxy in (9), are close to one for these assets. Quarterly labor income is positively related to the quarterly expected inflation proxy while semiannual labor income is negatively related to the semiannual expected inflation proxy, but both coefficient estimates have large standard errors. Although the standard errors of the coefficients get progressively larger, common stock returns show negative relationships with the quarterly and semiannual expected inflation proxies similar in magnitude to those observed in the monthly data.

4. Tests of assets as hedges against unexpected inflation

4.1. Tests based on monthly data

In the monthly tests of table 5, the estimates of γ_j, the regression coefficient in

(9) that measures the quality of an asset as a hedge against the unexpected component of the inflation rate, are mostly less than one standard error from zero. The only estimate of γ_j which is more than two standard errors from zero is obtained when the return to real estate, r_t, is the dependent variable in the regression. Thus, there is some evidence that real estate is a partial hedge against unexpected monthly inflation. Apparently it is not a complete hedge since the estimate of γ_j for real estate is reliably less than unity.

There is a suggestive pattern in the relationships between the unexpected inflation proxy and the returns to the government bond portfolios. The estimates of γ_j for D_{1t}, D_{2t}, D_{3t} and D_{4t} are all negative and they increase in absolute value with term to maturity. An explanation for this result, having to do with the information that current unexpected inflation contains about future expected inflation, is explored later. Current unexpected inflation seems to have a negative effect on the nominal returns to NYSE common stocks, but the standard errors of the estimates of γ_j are large relative to the values of the coefficients.

Table 6

Hedges against quarterly and semiannual expected and unexpected inflation, $R_{jt} = \hat{a}_j + \hat{\beta}_j B_t + \hat{\gamma}_j(\Delta_t - B_t) + \hat{\eta}_{jt}$ (standard errors in parentheses).

Asset R_{jt}	$\hat{a}_j$	$\hat{\beta}_j$	$\hat{\gamma}_j$	R^2	$S(\hat{\eta}_j)$	$\rho_1(\hat{\eta}_j)$	$\rho_2(\hat{\eta}_j)$	$\rho_3(\hat{\eta}_j)$
			(A) Quarterly data: 1/53–6/71, $T = 74$					
B_{1t}	−0.0002	0.95	0.05	0.97	0.0007	0.17	0.06	0.29
	(0.0002)	(0.02)	(0.02)					
D_{1t}	−0.0026	1.21	−0.50	0.29	0.0080	0.11	0.06	−0.07
	(0.0023)	(0.23)	(0.25)					
D_{2t}	−0.0041	1.23	−0.93	0.17	0.0130	0.11	0.03	−0.09
	(0.0037)	(0.38)	(0.40)					
D_{3t}	−0.0054	1.18	−1.33	0.15	0.0158	0.18	0.00	−0.07
	(0.0045)	(0.46)	(0.49)					
D_{4t}	−0.0069	1.19	−1.47	0.12	0.0187	0.16	−0.05	−0.05
	(0.0054)	(0.55)	(0.58)					
r_t	−0.0032	1.15	0.56	0.35	0.0065	−0.20	0.03	−0.02
	(0.0019)	(0.19)	(0.20)					
h_t	0.0049	0.45	−0.32	0.02	0.0108	0.19	0.18	−0.15
	(0.0031)	(0.32)	(0.33)					
s_{vt}	0.0572	−4.88	−4.11	0.09	0.0693	0.01	−0.08	−0.10
	(0.0199)	(2.04)	(2.14)					
s_{et}	0.0549	−4.95	−6.50	0.09	0.0861	0.04	−0.02	−0.13
	(0.0247)	(2.54)	(2.66)					

Table 6 (continued)

Asset R_{jt}	$\hat{a}_j$	$\hat{\beta}_j$	$\hat{\gamma}_j$	R^2	$S(\hat{\eta}_j)$	$\rho_1(\hat{\eta}_j)$	$\rho_2(\hat{\eta}_j)$	$\rho_3(\hat{\eta}_j)$
(B) Semiannual data: 7/59–6/71, $T = 24$								
B_{1t}	0.0025 (0.0017)	0.84 (0.06)	0.23 (0.11)	0.92	0.0020	0.44	0.46	0.09
B_{2t}	0.0018 (0.0013)	0.89 (0.04)	0.15 (0.09)	0.95	0.0016	0.35	0.37	0.00
B_{3t}	0.0027 (0.0013)	0.88 (0.04)	0.16 (0.08)	0.95	0.0015	0.07	0.35	−0.09
D_{1t}	−0.0110 (0.0089)	1.08 (0.29)	−1.15 (0.59)	0.38	0.0106	0.03	−0.27	0.12
D_{2t}	−0.0158 (0.0143)	1.03 (0.47)	−1.75 (0.95)	0.19	0.0170	0.01	−0.38	0.11
D_{3t}	−0.0183 (0.0185)	0.88 (0.61)	−2.37 (1.24)	0.12	0.0220	0.01	−0.44	0.05
D_{4t}	−0.0212 (0.0223)	0.79 (0.73)	−2.75 (1.49)	0.09	0.0266	−0.03	−0.47	0.03
r_t	−0.0054 (0.0073)	1.27 (0.24)	1.14 (0.49)	0.60	0.0087	−0.21	0.39	−0.15
h_t	0.0367 (0.0125)	−0.13 (0.41)	1.40 (0.84)	0.04	0.0149	0.08	−0.10	0.01
s_{vt}	0.1169 (0.0990)	−4.26 (3.25)	−2.09 (6.62)	0.00	0.1178	−0.20	−0.18	−0.04
s_{et}	0.1222 (0.1266	−4.87 (4.15)	−4.38 (8.46)	−0.01	0.1506	−0.03	−0.19	−0.05

4.2. Tests based on quarterly and semiannual data

The quarterly and semiannual results in table 6 suggest more pronounced relationships between unexpected inflation rates and asset returns. The negative relationship between the common stock returns, s_{et} and s_{vt}, and the unexpected inflation proxy shows up more reliably, at least in the results for quarterly data. For the returns on the government bond portfolios (D_{1t}, D_{2t}, D_{3t} and D_{4t}), the estimates of γ_j get progressively more negative as one goes from the monthly regressions in table 5 to the quarterly and semiannual regressions in table 6, and in all cases, the absolute magnitude of $\hat{\gamma}_j$ increases with term to maturity.

On the other hand, for quarterly and semiannual labor income, the estimates of γ_j, the coefficient of the unexpected inflation proxy in (9), are very different from each other, although both estimates have large standard errors. Indeed, a coherent explanation for the monthly, quarterly, and semiannual estimates of eq. (9) for the labor income variable, h_t, is not evident. Perhaps a more detailed analysis of the relationship between inflation and labor income, emphasizing the 'wage lag' hypothesis of Kessel and Alchian (1960) or 'Phillips Curve' phenomena, would yield more consistent results. Or perhaps there are unidentified problems in the way the labor income variable is measured. In any case, our results show little relationship between nominal labor income and the expected and unexpected components of inflation measured over periods of up to six months.

There is a more interesting story in the measured relationships between the return to real estate, r_t, and unexpected inflation rates. In tables 5 and 6, the estimates of γ_j for the return to real estate are largest for semiannual data (1.14), next largest for quarterly data (0.56), and smallest for monthly data (0.31). All of these estimates are more than two standard errors above zero. One interpretation of these results is that real estate provides a better hedge against longer-term unexpected inflation. However, an alternative explanation, based on measurement problems in the real estate data, seems more plausible. Moreover, it suggests that real estate is a complete hedge against expected and unexpected inflation, even on a monthly basis.

The Home Purchase Price index from which r_t is calculated is computed as a three month moving average, and since the actual transaction dates typically occur from one to three months prior to the time they are reflected in the index, the correlation between r_t and unexpected inflation rates is spuriously spread over six months. However, looking at longer holding periods has the effect of overcoming most of the non-synchronous measurement of r_t and unexpected inflation.

The lags built into the measurement of r_t do not have a similar attenuating effect on the estimates of β_j, the coefficient for the interest rate in (9), which are all relatively close to unity for the real estate variable, even in the monthly data of table 5. This result is probably due to the fact that the interest rate, our proxy for the expected inflation rate, is a slowly wandering series whose level shows much persistence through time (see table 1). Thus, even though it is a little out of date, the 'expected' inflation rate portion of the measured real estate return is probably highly correlated with the expected inflation rate which is built into the current interest rate.

An alternative approach to estimating the effects of nonsynchronous measurement of r_t and the monthly unexpected inflation rate is provided by the model

$$\tilde{r}_t = \alpha + \beta B_{1t} + \sum_{i=0}^{6} \gamma_i (\Delta_{t-i} - B_{1t-i}) + \tilde{\varepsilon}_t. \tag{10}$$

As noted earlier, our proxy for the unexpected monthly inflation rate, $(\Delta_t - B_{1t})$, is serially uncorrelated, so the seven unexpected inflation rates in eq. (10) are uncorrelated. Since there is reason to believe that the current measured return to real estate, r_t, is composed of price changes which have occurred over the last three to six months, we expect some of the coefficients of lagged unexpected inflation rates in (10) to be positive. The estimate of eq. (10) using monthly data from July 1953 to July 1971 is

$$\begin{aligned} r_t = & \underset{(0.0005)}{-0.0009} + \underset{(0.16)}{1.22B_{1t}} + \underset{(0.11)}{0.27}(\Delta_t - B_{1t}) + \underset{(0.11)}{0.31}(\Delta_{t-1} - B_{1t-1}) \\ & + \underset{(0.11)}{0.22}(\Delta_{t-2} - B_{1t-2}) - \underset{(0.11)}{0.06}(\Delta_{t-3} - B_{1t-3}) + \underset{(0.11)}{0.23}(\Delta_{t-4} - B_{1t-4}) \\ & - \underset{(0.11)}{0.10}(\Delta_{t-5} - B_{1t-5}) + \underset{(0.11)}{0.01}(\Delta_{t-6} - B_{1t-6}) + \hat{\varepsilon}_t, \end{aligned}$$

where standard errors are in parentheses. The F-statistic for the hypothesis that $\gamma_1 = \gamma_2 = \ldots = \gamma_6 = 0$ is 3.01, which is greater than the 0.01 fractile of the F-distribution with 6 and 208 degrees of freedom.

Moreover, applying the analysis of Scholes and Williams (1977) indicates that the sum of the estimators of the coefficients of current and lagged unexpected inflation rates in (10) is a consistent estimator of the contemporaneous relationship between the true return to real estate and the unexpected monthly inflation rate when there are no dating errors in $\Delta_t - B_{1t}$, but there are lagged dating errors in r_t. The sum of the estimated coefficients of unexpected inflation rates

$$\sum_{i=0}^{6} \hat{\gamma}_i = 0.88,$$

is close to one, with a standard error (calculated as the square root of the sum of the variances of the individual coefficients) equal to 0.29.

In short, once we take account of the measurement errors in the real estate return, either in the manner of (10) or by working with semi-annual data, estimates of β_j and γ_j in (9) are both close to unity. These results are consistent with the hypothesis that real estate is a complete hedge against inflation, expected and unexpected. That is, the nominal return to real estate varies directly with both the expected and unexpected components of the inflation rate, so that the real return to real estate (the nominal return minus the inflation rate) is unrelated to the inflation rate.

Note, however, that being a complete hedge against inflation does not imply that the inflation adjusted return to real estate is certain. For example, the coefficient of determination in the semiannual regression in table 6 suggests that about 40 percent of the variance of the semiannual real estate return is left unexplained by the combined effects of the expected and unexpected components of the semiannual inflation rate.

5. Short-term bills as hedges against longer-term inflation

Table 6 also shows estimates of (9) for quarterly and semiannual data where the dependent variables are the returns from strategies of rolling over a sequence of shorter-term bills. For example, the quarterly return to one month treasury bills, labeled B_{1t} in part A of table 6, is the sum of the three monthly returns on one month bills during the quarter. The semiannual returns on one, two, and three month bills, B_{1t}, B_{2t} and B_{3t}, used in part B of table 6, are likewise obtained by rolling over the relevant shorter-term bills during the six month period. Thus, the six-month version of B_{2t} involves three consecutive two month bills, while B_{3t} is obtained by purchasing two consecutive three month bills.

Since short-term bill returns contain assessments of expected inflation rates which are updated within longer holding periods, the strategy of rolling over short-term bills provides a hedge against changes in expected inflation rates during longer holding periods. For example, the return to maturity on a three month bill cannot adjust to intraquarter changes in expectations about inflation, whereas month to month reassessments of the expected inflation rate are built into the quarterly return on a sequence of one month bills.

In statistical terms, the *ex ante* interest rate or return on a three month bill contains measurement error as an estimate of the sequence of one month expected inflation rates impounded in the quarterly return on three successive one month bills. Likewise, the *ex ante* interest rate or return on a six month bill contains measurement error as a measure of the expected inflation rates impounded in strategies of rolling over one, two, or three month bills during the six month period. This measurement error perhaps explains why for the short-term bills the estimates of β_j, the coefficient of the longer-term interest rate, are several standard errors less than unity in both the quarterly and semiannual regressions in table 6.

The returns to strategies of rolling over shorter-term bills produce estimates of γ_j, the coefficient of the unexpected inflation proxy in (9), which are all positive and more than two standard errors from zero. Although we now seem to be dealing with unexpected quarterly and semiannual inflation rates, this result is again traceable to the fact that rolling over shorter-term bills provides a moving hedge against changes in expected inflation rates which is not obtained when a longer-term bill is purchased and held to maturity.

For example, a sequence of six one month bills takes advantage of the market's monthly reassessments of expected inflation rates, whereas the return on a six month bill held to maturity does not benefit from such updates of inflation expectations, However, our proxy for the unexpected semiannual inflation rate is just $\Delta_t - B_{6t}$, the *ex post* six month inflation rate minus the interest rate on a six month bill set at the beginning of the semiannual period. Even if B_{6t} fully reflects all of the information about the inflation rate for the coming six months which is available at the beginning of the period, $\Delta_t - B_{6t}$ is nevertheless at least partially attributable to changes in expectations about inflation that take place within the semiannual period. Since these intraperiod changes in expected inflation rates are built into the returns to strategies of rolling over shorter-term bills, they account for the positive estimates of γ_j for the returns to these strategies. The estimates of γ_j are far from unity because only a small part of the variation in the longer-term unexpected inflation rate is due to the shorter-term reassessments of expected inflation rates that are captured by the rollover strategies.

6. Common stocks and inflation

6.1. Theoretical considerations

Various arguments can be given for why common stocks might be helped or hurt by unanticipated inflation. For example, Kessel (1956) argues that unanticipated inflation is to the benefit of the stockholders of firms that are net debtors. In more general terms, unanticipated inflation should benefit the common stock of firms that have made more long-term commitments to pay fixed nominal amounts than to receive them. The net debtor–creditor hypothesis is difficult to implement empirically since a firm might have long-term contracts to purchase labor, raw materials, and capital, to sell its own products, and to borrow money to finance its operations. Nevertheless, this hypothesis and others [see, for example, Lintner's (1975) discussion of the tax effects of inflation] provide some theoretical possibilities for explaining the effects of unanticipated inflation on the returns to common stocks.

On the other hand, like others who have investigated the topic, for example, Lintner (1975), Nelson (1976), and Jaffe and Mandelker (1976), we have no explanation for the negative relationship between common stock returns and the *expected* component of the inflation rate. There are two possibilities. Some as yet unidentified phenomenon might cause equilibrium expected real returns to stocks to be negatively related to expected inflation rates, Or the market might be inefficient in impounding available information about future inflation into stock prices.

We now examine the relationship between stock returns and the expected inflation rate from a different perspective and in somewhat more detail. The additional results improve our understanding of the statistical nature of the phenomenon, but we remain unable to identify its economic origins.

6.2. Some additional tests

Using data for the January 1953 to July 1971 period, the estimated regression of the monthly return to the value-weighted portfolio of NYSE common stocks on the one month treasury bill rate is

$$\underset{}{s_{vt}} = \underset{(0.0054)}{0.0234} - \underset{(1.85)}{5.50}B_{1t} + \hat{\varepsilon}_t, \qquad \bar{R}^2 = 0.03, \quad S(\hat{\varepsilon}) = 0.0356. \tag{11}$$

Thus, the estimated relationship between the expected nominal return on stocks for month t and our proxy for the expected inflation rate for month t (the one month bill rate set at the end on month $t-1$) is

$$E(\tilde{s}_{vt} \mid B_{1t}) = 0.0234 - 5.5B_{1t}. \tag{12}$$

If the return on a one month bill exceeds 0.0042, that is, 0.42 percent per month, eq. (12) assesses a negative expected nominal return on the portfolio of NYSE common stocks. During the twenty-three month period from January 1969 through November 1970, B_{1t} was always greater than 0.0042, implying that expected nominal returns on NYSE stocks were negative during this period. For example, in Febuary 1970, B_{1t} was 0.0063, which implies an expected nominal return on stocks of approximately -1.17 percent for this month.

While market efficiency does not rule out a negative relationship between expected returns on common stocks and expected inflation rates, it does rule out situations where risky assets (common stocks) have lower expected returns than less risky assets such as treasury bills or even cash. It is of some interest, then, to test more systematically the extent to which the negative relationship between interest rates and expected returns to common stocks can be used for profit. We examine the following trading strategy:

(a) Using thirty-six months of data starting in January 1953, estimate the regression of the return to the value-weighted portfolio of common stocks, s_{vt}, on the one month treasury bill rate, B_{1t}.

(b) Use the estimates of the regression parameters along with the interest rate on one month treasury bills observed at the end of the thirty-sixth month to assess $\hat{s}_{vt}$, the expected return on the common stock portfolio for the thirty-seventh month.

(c) If this prediction of the return on stocks is less than the treasury bill return, $\hat{s}_{vt} < B_{1t}$, buy the treasury bill in that month, so that the return on the strategy is $R_{pt} = B_{1t}$. Otherwise, buy the stock portfolio, so that $R_{pt} = s_{vt}$.

(d) Update the estimates of the stock return–interest rate relationship in step (a) by dropping the oldest month and adding the most recent month (always using the most recent three years' worth of data for estimation), and repeat steps (b) and (c).

The strategy is in operation for each month from January 1956 through December 1975. Note that since the treasury bill rate which is being used to predict stock returns for month t is available at the beginning of the month, the strategy is of interest irrespective of one's attitude toward our proposition that the bill rate is a good proxy for the expected inflation rate.