Stock Returns and Inflation: A Long-Horizon Perspective

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Two main empirical facts regarding the statistical relation between stock returns and inflation emerge from the current literature in finance. The first is that *ex post* nominal stock returns and inflation are negatively correlated. Financial economists consider this result surprising since stocks, as claims against real assets, should compensate for movements in inflation. The second, and related, empirical result documents a negative relation between *ex ante* nominal stock returns and *ex ante* inflation. Since the Fisher model implies that expected nominal rates should move one-for-one with expected inflation, this negative correlation strikes at the heart of one of the oldest and most respected financial models (see e.g., John Lintner, 1975; Zvie Bodie, 1976; Charles Nelson, 1976; Eugene Fama and G. William Schwert, 1977; Jeffrey Jaffe and Gershon Mandelker, 1977; N. Bulent Gultekin, 1983; Gautam Kaul, 1987).

Existing studies, however, have focused almost exclusively upon short-term asset returns with time horizons of one year and less.[1] Since the Fisher model (and its corresponding intuition) might be expected to hold at all horizon lengths, this void in the empirical literature is unfortunate for several reasons. First, from a practical perspective, many investors hold stocks over long holding periods. Therefore, it is important to know the manner in which stock returns move with inflation over longer horizons. Second, the relation between stock returns and inflation at long horizons is of particular interest given that the results at short horizons (both *ex ante* and *ex post*) appear to be anomalous. That is, evidence at these longer horizons may provide additional information regarding explanations for the negative correlation between nominal stock returns and both *ex ante* and *ex post* inflation.

In this paper, the relation between stock returns and inflation at long horizons is examined. In approaching this issue, several problems arise which must be addressed. The first difficulty is the necessity for a long data sample in order to capture long-term movements in the time series of returns. We have been able to accumulate two centuries of data on stocks, short-term and long-term bonds, and inflation in both the United States and the United Kingdom in order to fulfill this requirement. The second difficulty results from the inability to model *ex ante* long-term inflation accurately. We circumvent the absence of any long-horizon inflation model by using an instrumental-

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[1]As a representative sample of this literature, in their study of a variety of assets, Fama and Schwert (1977) document a negative relation between *ex ante* stock returns and expected inflation using monthly, quarterly, and semiannual data.

variables approach. We choose instruments (past inflation rates and short- and long-term interest rates) that have theoretical support as measures of *ex ante* inflation. Using *ex post* inflation as our proxy for *ex ante* inflation rates, along with these instruments, we provide consistent estimates of the *ex ante* relation between stocks and inflation.

In contrast to existing evidence at short horizons, we find evidence to suggest that long-horizon nominal stock returns are positively related to both *ex ante* and *ex post* long-term inflation. As additional sources of information, we find that these results are somewhat robust with respect to particular subperiods chosen over the past two centuries, as well as to both the U.S. and U.K. markets. To the extent that this evidence conforms to a priori intuition, these results should come as good news to financial economists.

I. Preliminaries

A. *The Fisher Hypothesis*

While there are several variations of the "Fisher" hypothesis, in this paper we consider the most common version, namely, that expected nominal rates of return on assets move one-to-one with expected inflation. This is often formulated as *ex ante* real rates being statistically uncorrelated with expected inflation. An additional assumption often made by researchers is that the *ex ante* real rate is constant (e.g., see Fama's [1975] work on interest rates as short-term predictors of inflation). In either case, as Fama and Schwert (1977) point out, the Fisher model might be expected to hold for all assets and over all time horizons, such that

$$(1)\quad \sum_{i=1}^{j} R_{t+i} = \alpha_j + \beta_j E\left[\sum_{i=1}^{j} \pi_{t+i} | \phi_t\right] + \varepsilon_t(j)$$

with $H_0: \beta_j = 1$, where R_t is the continuously compounded nominal return on an asset, π_t is the continuously compounded rate of inflation, ϕ_t is the agent's information set, and ε_t captures the prediction error of the nominal rate.

As mentioned above, there is little evidence in the empirical finance literature which supports a positive relation between *ex ante* nominal returns and expected inflation, let alone the stronger condition $\beta_j = 1$. Since these studies all focus on short horizons (i.e., small j), however, there are no empirical facts describing this relation at long horizons.

B. *Data Sources*

The empirical analysis is conducted using annual data on inflation, stock returns, and short-term and long-term interest rates over the sample period 1802–1990. The data are obtained from Jeremy Siegel (1992a) and Schwert (1990). Since there is a detailed discussion of the data in these papers, we provide only a brief description:

The price level data are derived from various sources chosen to most closely match the consumer price series compiled by the Bureau of Labor Statistics (see Siegel, 1992a, appendix A).

With respect to the yield data, there was an active market for long-term U.S. government bonds over most of the sample period. Although the maturities differ, Siegel (1992a) chooses the bonds closest to 20 years. In the earlier part of the sample, he constructs the one-year rate using U.S. commercial paper rates, U.K. short-term rates (under the gold standard) and available U.S. government rates. He finds that his constructed series matches actual available rates during this period (Siegel, 1992a appendix B).

The stock-return data are collected by Schwert (1990) to match a market index. As Siegel (1992a) and Schwert (1990) point out, however, the stock index constructed from the data collected prior to 1870 is not as comprehensive as later periods, since the series consist primarily of a portfolio of financial firms and railroads.

Of interest to our analysis, several studies document structural changes in the inflation series over the sample period. The usual cutoff points for these changes are either the switch from the gold standard in 1933 or the start of the Federal Reserve in 1914 (see e.g., Robert Shiller and Siegel, 1975; Robert Barsky, 1987). In the absence of more detailed data sets, however, empirically modeling these structural changes is difficult. Note that the primary focus of this paper is on the comovements between stock returns and inflation (and expected inflation). Whether this relation changes with these types of structural changes remains an empirical question.[2]

Due to possible differences in the data, therefore, we perform our analysis on both the overall sample period (1802–1990) and the subperiods 1870–1990 (reflecting the more comprehensive sample) and 1914–1990 (reflecting the creation of the Federal Reserve). The focus of our analysis is on the different empirical implications over short and long horizons. Although there is no guide to what exactly constitutes a "long" horizon, we arbitrarily choose five years. This provides us with almost 40 independent observations in the overall sample, yet covers a much longer horizon than has been previously studied.

C. *A First Look*

Although there are no studies documenting the relation between *ex ante* returns and expected inflation for long horizons, there have been a few papers that examine how stock returns compare to inflation over various time periods. Phillip Cagan (1974) studies *ex post* real returns on stocks for various countries over the time period 1871–1970. His general conclusion, based on anecdotal evidence, is that stocks have performed well relative to inflation except in times of severe distress. Siegel (1992b) studies the time period 1802–1990 and finds that, *ex post*, U.S. equities have for the most part dominated inflation, bonds, and gold for most time periods. Moreover, over longer horizons, this domination is more pronounced.

As an illustration, Figure 1 graphs rolling five-year real returns and one-year real returns over the 1802–1990 period. In contrast to the one-year real return, the five-year real returns rarely fall below zero. For example, during this period, *ex post* one-year real returns are negative in 31.2 percent of the sample, in comparison to only 18.9 percent for the five-year holding period. The two substantive periods in which five-year real returns are negative include the Civil War and the Great Depression. Outside of these rare occurrences, over long investment horizons, stocks have for the most part maintained their real value during the past two centuries.

II. Stock Returns and Inflation

A. *Ex Post Relation*

To look at the contemporaneous relation between stock returns and inflation, we regress one-year stock returns on one-year inflation and five-year stock returns on five-year inflation:

$$R_{t+1} = \alpha_1^* + \beta_1^* \pi_{t+1} + \varepsilon_t^*(1)$$

$$\sum_{i=1}^{5} R_{t+i} = \alpha_5^* + \beta_5^* \sum_{i=1}^{5} \pi_{t+i} + \varepsilon_t^*(5).$$

The equations are estimated jointly in order to estimate the parameter estimators' covariance matrix. Specifically, note that in testing the hypothesis $\beta_5^* = \beta_1^*$ versus the alternative $\beta_5^* > \beta_1^*$, the statistic

$$z = \sqrt{T}\left(\hat{\beta}_5^* - \hat{\beta}_1^*\right)/\hat{\sigma}_{\beta_5^* - \hat{\beta}_1^*}$$

[2] As an example of a study using similar data, Schwert (1989) looks at time series of volatilities in stock returns and inflation, among other variables, in the post-Civil War period. To counter some of the possible shifts over such a long sample, he investigates the overall period as well as appropriately chosen subperiods. We follow this approach here.

requires a consistent estimate of the correlation between the estimators, $\hat{\beta}_5^*$ and $\hat{\beta}_1^*$. This is tantamount to estimating each equation separately via ordinary least squares and then using the variance-covariance matrix for the normal equations to calculate the correlation between the estimators. Since the five-year estimator is calculated using overlapping annual data, the covariance matrix is adjusted for the induced serial correlation in the regression errors via Lars Hansen's (1982) work.

Table 1 presents the results of these regressions. The regression coefficient of five-year stock returns on the contemporaneous five-year inflation rate is significantly positive, $\hat{\beta}_5^* = 0.52$, with a standard error $\hat{\sigma}_{\hat{\beta}_5^*} = 0.17$. Therefore, nominal stock returns and inflation tend to move together over the sample, thus supporting the view that stocks provide some compensation for movements in inflation. On the other hand, the estimate of $\hat{\beta}_1^*$ (0.07) is close to zero. The latter result is in accordance with previous research which documents significantly negative estimates at the monthly and quarterly frequencies, but estimates close to zero at the annual frequency. In testing the hypothesis $\beta_5^* = \beta_1^*$ versus the alternative $\beta_5^* > \beta_1^*$, the z statistic equals 4.20, which is significant at the 1-percent level.

With respect to both the post-Civil War (1870–1990) and the Federal Reserve (1914–1990) subperiods, the point estimates of the coefficients are similar to the estimates for the overall sample. For example, the short-run coefficient $\hat{\beta}_1^*$ equals 0.13 and 0.09, respectively, over these samples. In stark contrast, over long holding periods, stocks appear to have a more positive relation with inflation; the long-run coefficient $\hat{\beta}_5^*$ equals 0.46 and 0.43, respectively. The standard errors of the estimates, however, tend to be larger for the 1870–1990 subperiod (although not for the 1914–1990 period). We attribute this loss of accuracy, at least in part, to the loss of 13 nonoverlapping five-year periods. This imprecision aside, our overall conclusion is that, in contrast to the short-horizon results, stocks seem to compensate for inflation in the long run.

Note that the coefficients on both short-term and long-term *ex post* inflation are significantly different than 1. Though the Fisher model is *ex ante*, Table 1 can nevertheless be interpreted in the context of the Fisher model given in equation (1). In particular, by recognizing that inflation equals its *ex ante* rate plus a prediction error, the OLS estimates in Table 1 could have come from a regression of stock returns on *ex ante* inflation in the presence of measurement error. This leads to the well-known errors-in-variables formulation, yielding asymptotically biased estimates for β_j. The bias in these estimates, however, is most probably downward.[3] Therefore, in the context of measurement error, the positive coefficients in Table 1 are understating the true values of β_j. One difficulty here is that there is no way to determine precisely how large the magnitude of this bias is. As a consequence, it seems natural to consider also regressions in which the inconsistency of the estimates can be corrected.

B. *Ex Ante Relation: Instrumental-Variables Estimation*

One approach to the errors-in-variables problem which will lead to consistent estimates for β_j is to use instrumental variables (IV).[4] The main advantage of the IV ap-

[3]In particular, the magnitude of this bias depends on (i) how much variation in inflation the market can explain and (ii) whether stock returns respond to unanticipated inflation. For short-horizon analyses, the conclusions have been that the downward bias can be quite large and that stock returns respond negatively to inflation shocks (see e.g., Nelson, 1976; Gultekin, 1983). These conclusions, however, are primarily based on the econometrician's forecasts of inflation. With respect to long-term inflation, little is known about the magnitude of the potential bias.

[4]An alternative method is to choose a model for *ex ante* inflation and jointly estimate this *ex ante* model with equation (1). While this method may provide more efficient estimation, the estimators may not be consistent if the inflation model is misspecified. In an earlier version of the paper, we applied this method using *ex ante* inflation models suggested by Fama and Schwert (1977). The conclusions are similar to those reached by the IV estimation and will be provided by the authors upon request.

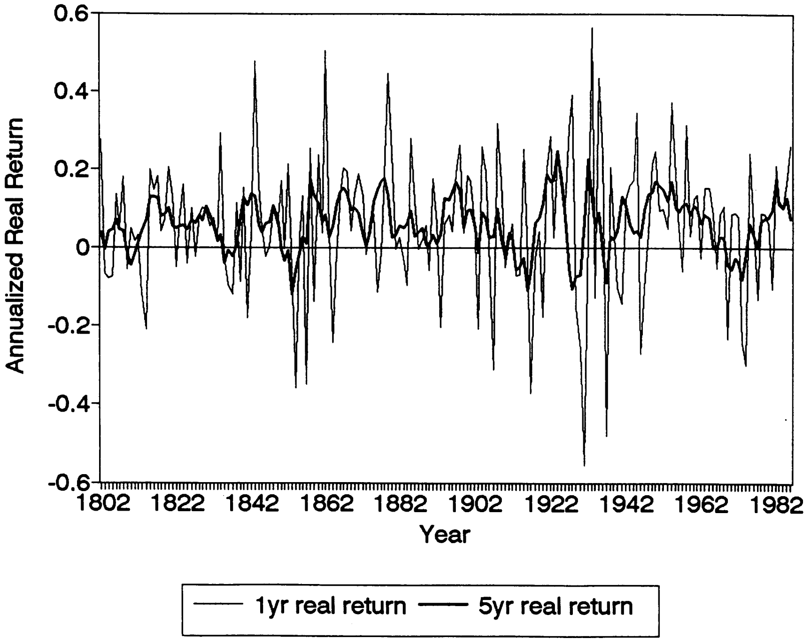

FIGURE 1. ROLLING FIVE-YEAR REAL RETURNS AND ONE-YEAR REAL RETURNS, 1802–1990

Note: The data are continuously compounded annualized returns.

TABLE 1—STOCK RETURNS AND CONTEMPORANEOUS INFLATION

Period	α_1^* (SE)	β_1^* (SE)	α_5^* (SE)	β_5^* (SE)	$z_{\beta_5^* > \beta_1^*}$ (P value)	MSE_1 R-square	MSE_5 R-square
1802–1990	0.072	0.070[a]	0.333	0.524[a]	4.198	0.027	0.108
	(0.013)	(0.235)	(0.026)	(0.174)	(1.000)	0.001	0.083
1870–1990	0.080	0.131[a]	0.366	0.462[a]	1.045	0.032	0.125
	(0.021)	(0.048)	(0.055)	(0.257)	(0.852)	0.001	0.054
1914–1990	0.094	0.087[a]	0.408	0.432[a]	6.642	0.039	0.154
	(0.014)	(0.221)	(0.035)	(0.050)	(1.000)	0.001	0.041

Notes: The table provides estimates of the regressions of one- and five-year stock returns on one- and five-year inflation rates, respectively. The estimation is conducted using annual continuously compounded data over the sample period 1802–1990 and the subperiods 1870–1990 and 1914–1990. The regressions are from the following systems:

$$R_{t+1} = \alpha_1^* + \beta_1^* \pi_{t+1} + \varepsilon_t^*(1)$$

$$\sum_{i=1}^{5} R_{t+i} = \alpha_5^* + \beta_5^* \sum_{i=1}^{5} \pi_{t+i} + \varepsilon_t^*(5)$$

where R_t denotes the stock return, π_t denotes the inflation rate, and ε_t is the disturbance term. MSE_i is the mean squared error for the i-period inflation equation; $z_{\beta_5^* > \beta_1^*}$ is the test statistic for the hypothesis $\beta_5^* = \beta_1^*$ versus $\beta_5^* > \beta_1^*$.

[a]Statistically significant at the 10-percent level for a test of $\beta_j = 1$.

proach is that a model for expected inflation need not be specified. Given the lack of available time-series data, this feature is especially attractive for the long-horizon analysis.

Consider rewriting the normal equations derived from the regression model (1) in the following IV setting:

$$(2)\quad E\left[\left(\sum_{i=1}^{j} R_{t+i} - \alpha_j - \beta_j \sum_{i=1}^{j} \pi_{t+i}\right) \otimes \mathbf{Z}_{jt}\right] = 0 \qquad \forall j$$

where $\mathbf{Z}_{jt}$ is a set of instruments associated with a particular horizon j (e.g., 1, past inflation, interest rates at time t, etc.). Under standard IV assumptions, $\hat{\beta}_j^{\mathrm{IV}}$ will provide consistent estimates of β_j in equation (1). In order to maintain some reasonable level of efficiency, however, we need to choose instruments which are believed to be correlated with the true expected inflation. These instrumental variables must have the required IV property that they are uncorrelated with unexpected inflation. Predetermined variables such as $\mathbf{Z}_{jt}$ satisfy this requirement. An additional assumption is that the instruments are uncorrelated with the regression error in equation (1). This is tantamount to assuming that the instruments are uncorrelated with the expected real rate. Although this is a common assumption in the literature (see Fama and Schwert, 1977), we can test this restriction using overidentifying restrictions.

We estimate equation (2) using a variety of instruments.[5] The first set of instruments includes the one-year interest rate R_{st} and the long-rate of interest $R_{\ell t}$ to capture movements in one-year and five-year expected inflation, respectively. The motivation underlying this choice has foundations in earlier finance work, such as Fama and Schwert (1977), who use the nominal return on a default-free bond over a given period as their measure of expected inflation over that same period. Their analysis is based on a paper by Fama (1975), who argues that, if expected real returns on these bonds are constant and the market is efficient, then expected inflation equals a constant plus the nominal return on the default-free bond.[6] The second set of instruments includes the past one-year and five-year inflation rates. There is a long history in the empirical literature for using past inflation rates as predictors of future inflation. For example, Fama and Michael Gibbons (1984) provide a discussion of various forecasting methods, including univariate models for inflation (albeit over much shorter horizons). In terms of the relation between stock returns and *ex ante* inflation, Nelson (1976) provides an application using past inflation rates.[7]

Four systems of equations are estimated in the IV framework. Two of the systems are exactly identified:

$$\text{(i)}\quad \mathbf{Z}_{1t} = (1, R_{st}) \qquad \mathbf{Z}_{5t} = (1, R_{\ell t})$$

$$\text{(ii)}\quad \mathbf{Z}_{1t} = (1, \pi_t) \qquad \mathbf{Z}_{5t} = \left(1, \sum_{i=1}^{5} \pi_{t-5+i}\right).$$

In contrast, the third and fourth systems recognize that the short-term rate or the current inflation rate may have information for the long-horizon IV regression. Therefore, systems (iii) and (iv) choose $\mathbf{Z}_{5t} =$

[5]A recent paper by Nelson and Richard Startz (1990) shows that IV estimators can be severely biased in small samples if the instrument is barely correlated with the regressor (e.g., $\Sigma_{i=1}^{j}\pi_{t+i}$ for each j). For the instruments studied here (past multiperiod inflation and short- and long-term interest rates), this does not seem to be the case. In most of the sample periods, the *ex post* correlations between the regressors and instruments are of higher magnitude than those considered troublesome by Nelson and Startz (1990).

[6]The notion that interest rates capture movements in expected inflation in all periods, however, has come under recent criticism (see e.g., Barsky, 1987; Frederick Mishkin, 1991). These analyses, however, tend to use shorter-term data (such as monthly or quarterly).

[7]Note that there is some evidence to suggest that the stochastic process for inflation may have been different in the pre-1914 period (see Barsky, 1987). The effect on the relation between stock returns and inflation, however, is less clear.

TABLE 2—STOCK RETURNS AND EXPECTED INFLATION: THE INSTRUMENTAL-VARIABLES APPROACH

Period	Instruments	α_1 (SE)	β_1 (SE)	α_5 (SE)	β_5 (SE)	$z_{\beta_5>\beta_1}$ (P value)	$X^2_{[1]}$ (P value)
1802–1990	(i)	0.106	−2.781	0.277	1.394	1.218	
		(0.043)	(3.252)	(0.098)	(1.365)	(0.888)	
	(ii)	0.074	−0.048[a]	0.252	1.820	1.581	
		(0.015)	(0.422)	(0.075)	(1.091)	(0.943)	
	(iii)	0.099	−2.531	0.236	2.072	1.346	0.309
		(0.041)	(3.221)	(0.068)	(0.685)	(0.911)	(0.422)
	(iv)	0.070	0.061[a]	0.301	0.380	0.523	2.858
		(0.014)	(0.417)	(0.062)	(0.549)	(0.700)	(0.909)
1870–1990	(i)	0.093	−0.541	0.304	1.097	1.504	
		(0.034)	(1.290)	(0.106)	(0.880)	(0.943)	
	(ii)	0.083	0.051	0.267	1.434	1.510	
		(0.025)	(0.613)	(0.091)	(0.776)	(0.935)	
	(iii)	0.099	−0.919[a]	0.264	1.568	1.750	2.895
		(0.021)	(1.136)	(0.043)	(0.775)	(0.960)	(0.911)
	(iv)	0.072	0.286	0.314	0.655	0.705	1.936
		(0.024)	(0.590)	(0.081)	(0.512)	(0.760)	(0.836)
1914–1990	(i)	0.102	−0.171	0.300	1.111	1.395	
		(0.054)	(1.203)	(0.190)	(1.051)	(0.919)	
	(ii)	0.100	−0.118	0.187	2.120	1.408	
		(0.048)	(1.186)	(0.137)	(1.190)	(0.920)	
	(iii)	0.109	−0.670[a]	0.180	1.884[a]	2.487	3.326
		(0.043)	(1.034)	(0.074)	(0.385)	(0.944)	(0.932)
	(iv)	0.089	0.109	0.280	0.779	0.661	1.607
		(0.043)	(0.818)	(0.202)	(0.962)	(0.746)	(0.795)

Notes: The table provides instrumental variable (IV) estimates for the relation between stock returns and expected inflation. The estimation is conducted using annual continuously compounded data over the sample period 1802–1990 and the subperiods 1870–1990 and 1914–1990. The IV estimation is generated from the following system of equations:

$$E\left[\left(\sum_{i=1}^{j} R_{t+i} - \alpha_j - \beta_j \sum_{i=1}^{5} \pi_{t+i}\right) \otimes \mathbf{Z}_{jt}\right] = 0 \qquad \forall j$$

where R_t denotes the stock return, π_t denotes the inflation rate, and $\mathbf{Z}_{jt}$ is a set of instruments associated with a particular horizon j. Several sets of instruments are considered:

$$\text{(i)}\quad \mathbf{Z}_{1t} = (1, R_{st}), \mathbf{Z}_{5t} = (1, R_{\ell t})$$

$$\text{(ii)}\quad \mathbf{Z}_{1t} = (1, \pi_t), \mathbf{Z}_{5t} = \left(1, \sum_{i=1}^{5} \pi_{t-5+i}\right)$$

$$\text{(iii)}\quad \mathbf{Z}_{1t} = (1, R_{st}), \mathbf{Z}_{5t} = (1, R_{\ell t}, R_{st})$$

$$\text{(iv)}\quad \mathbf{Z}_{1t} = (1, \pi_t), \mathbf{Z}_{5t} = \left(1, \sum_{i=1}^{5} \pi_{t-5+i}, \pi_t\right)$$

where R_{st} is the short-term interest rate and $R_{\ell t}$ is the long-term interest rate. The latter two sets of instruments imply five equations and only four parameters to estimate, leaving one overidentifying restriction. This restriction is tested using the generalized method of moments resulting in a $\chi^2_{[1]}$ asymptotic distribution; $z_{\beta_5>\beta_1}$ is the test statistic for the hypothesis $\beta_5 = \beta_1$ versus $\beta_5 > \beta_1$.

[a]Statistically significant at the 10-percent level for a test of $\beta_j = 1$.

TABLE 3—RETURNS AND INFLATION: THE U.K. STOCK MARKET

Estimation method	α_1 (SE)	β_1 (SE)	α_5 (SE)	β_5 (SE)	$z_{\beta_5>\beta_1}$ (P value)	$X^2_{[1]}$ (P value)
Ex Post Inflation:						
Contemporaneous regression	0.024	0.232[a]	0.108	0.434[a]	7.13	
	(0.008)	(0.103)	(0.022)	(0.121)	(1.00)	
Ex Ante Inflation:						
(i)	0.093	−0.897[a]	0.348	0.338[a]	1.710	
	(0.019)	(0.708)	(0.060)	(0.335)	(0.956)	
(ii)	0.790	−0.217[a]	0.274	1.098	1.528	
	(0.017)	(0.408)	(0.079)	(0.662)	(0.937)	
(iii)	0.077	−0.352[a]	0.330	0.509[a]	1.450	1.480
	(0.016)	(0.548)	(0.057)	(0.271)	(0.927)	(0.224)
(iv)	0.077	0.0123[a]	0.315	0.359[a]	0.685	2.323
	(0.017)	(0.380)	(0.070)	(0.382)	(0.753)	(0.873)

Notes: This table provides estimates of the relation between stock returns and inflation (expected and actual) at one-year and five-year horizons using continuously compounded annual data on U.K. stock returns, inflation, and interest rates over the period 1820–1988. Several estimation procedures are employed to coincide with Tables 1–2. Specifically, contemporaneous regressions of stock returns on inflation and instrumental-variable regressions of this relation using four different sets of instruments are employed. The exact procedures are described in Tables 1 and 2, respectively, for each of these methods.

[a]Statistically significant at the 10-percent level for a test of $\beta_j = 1$.

$(1, R_{\ell t}, R_{st})$ and $\mathbf{Z}_{5t} = (1, \Sigma_{i=1}^{5}\pi_{t-5+i}, \pi_t)$, respectively. For both of these systems, this provides us with five equations and only four parameters to estimate, leading to one overidentifying restriction. This restriction can then be tested using the generalized method of moments (see Hansen, 1982), representing a test of the IV assumption mentioned above.

Table 2 presents results for the IV estimation of the systems (i)–(iv). The results for the exactly identified systems generally support a positive relation between stock returns and *ex ante* inflation. For example, using IV system (ii), the estimate of the five-year coefficient, β_5, is 1.82 and is significantly positive (though not statistically different from the Fisher model's hypothesized value of 1). On the other hand, the estimate of the coefficient β_1 is -0.05. Although its standard error is relatively large (i.e., 0.42), the coefficient is nevertheless inconsistent with model (1) at short horizons. The subperiod results provide further evidence along these lines; in particular, $\hat{\beta}_5^{\mathrm{IV}}$ equals 1.43 and 2.12 in the post-Civil War and Federal Reserve subperiods, respectively, in contrast to estimates for $\hat{\beta}_1^{\mathrm{IV}}$ of 0.05 and -0.12. In each subperiod, the z statistic provides evidence against the hypothesis that $\beta_1 = \beta_5$ in favor of $\beta_5 > \beta_1$.

Table 2 also provides results for the overidentified system. In general, although the results are similar to those in systems (i) and (ii), they tend to be more precise. For example, with respect to (iii), the coefficients on long-term expected inflation, $\hat{\beta}_5^{\mathrm{IV}}$, are significantly positive in all three periods that were examined. Further, all the tests reject (some strongly) the hypothesis that $\beta_1 = \beta_5$ in favor of $\beta_5 > \beta_1$.[8] Recall though that the IV approach requires that the expected real rate does not vary with the instrumental variables. Table 2 reports tests

[8]Note that these tests are performed in the joint system by taking into account the correlation between $\hat{\beta}_5^{\mathrm{IV}}$ and $\hat{\beta}_1^{\mathrm{IV}}$.

of this condition using Hansen's (1982) overidentifying-restrictions test. The results are mixed. For example, although most of the overidentifying-restrictions statistics are not significant at usual levels, the statistic's values are consistently in the right-tail area of the $\chi^2_{[1]}$ null distribution. This point aside, the estimates (albeit noisier) imply similar conclusions to those reported in Subsection II-A, namely, that there is a positive relation between nominal returns and *ex ante* inflation at long horizons.

III. Empirical Analysis for the U.K. Market

The results in the previous sections support the theory that nominal stock returns are positively related to both actual and expected inflation at long horizons. To garner additional evidence of Fisher-type effects at long horizons, it seems worthwhile to extend our analysis to international markets. Fortunately, a time series exists for U.K. data on stocks, bonds, and inflation over the period 1820–1988. The data on interest rates (e.g., one-year and long-term) and inflation are obtained from Siegel (1992a), while the data on stock returns come from Thomas Harris and Tim Opler (1991). Detailed descriptions of the data are given in these papers. While the U.K. stock returns are correlated with U.S. returns, the magnitude of the correlation over the 1820–1988 period is surprisingly small (i.e., only 44 percent). Thus, the U.K. data will contain information about the Fisher relation in addition to the U.S. empirical results given in Tables 1 and 2.

Table 3 provides results for essentially the same regressions given in Section II (i.e., contemporaneous and instrumental variables). With respect to the contemporaneous regressions, the long-horizon coefficient is significantly positive and is greater in magnitude than the short-horizon coefficient. In particular, $\hat{\beta}_5^* = 0.43$ versus $\hat{\beta}_1^* = 0.23$, with a corresponding z statistic (for the test $\beta_5^* = \beta_1^*$ vs. $\beta_5^* > \beta_1^*$) equal to 7.13. The implications for the Fisher model from these regressions is that there is indeed a positive relation between nominal returns and expected inflation at long horizons (see Subsection II-A).

With respect to a more direct relation between stock returns and expected inflation, the instrumental-variables approach further illustrates differences at short and long horizons. The point estimates using one-year data are negative for both the identified and overidentified systems. In contrast, the five-year coefficients are positive, and significantly greater than the short-horizon coefficients at the 10-percent level in most cases.[9] For example, using interest rates as instruments in the overidentified system (iv), $\hat{\beta}_1^{\mathrm{IV}} = -0.35$ versus $\hat{\beta}_5^{\mathrm{IV}} = 0.51$, with a corresponding z statistic equal to 1.45. For this system, the IV assumptions are satisfied with the overidentifying-restrictions statistic equal to 1.48 (i.e., the 87-percent level).

IV. Conclusion

Given the relatively low correlation between U.S. and U.K. stock markets, the empirical results describing the relation between nominal returns and inflation are remarkably similar. In conjunction with (i) the evidence across subperiods, (ii) the consistency in results using both *ex ante* and *ex post* inflation, and (iii) the similarities using different sets of instruments, this paper provides strong support for a positive relation between nominal stock returns and inflation at long horizons. To the extent that researchers develop theories to explain the negative correlation at short horizons, these models should also be consistent with the evidence presented here.

[9]One point of contrast between the United States and the United Kingdom in the stock-return/inflation relation is that the five-year coefficients on expected inflation are smaller for the U.K. data. Moreover, in contrast to the United States, the majority of the estimators are significantly different from their hypothesized value of 1.

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