STOCKS ARE A GOOD HEDGE FOR INFLATION
(IN THE LONG RUN)

by

Jacob Boudoukh
Matthew Richardson

14-92

RODNEY L. WHITE CENTER FOR FINANCIAL RESEARCH
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367

STOCKS ARE A GOOD HEDGE FOR INFLATION (IN THE LONG RUN)

Jacob Boudoukh*
Stern School of Business, New York University

Matthew Richardson
Wharton School, University of Pennsylvania

First draft: August 1991
Revised: July 1992

Abstract

It is a common empirical finding that stocks are not a good hedge for either ex-ante or ex-post inflation at short horizons. In contrast, using two centuries of data, we demonstrate that there is a positive relation between stock returns and inflation at long horizons. This result is reconciled with the anomalous short run evidence by appealing to the proxy-effect in the context of a consumption based asset pricing model.

---

*We would like to thank Pierluigi Balduzzi, John Campbell, Bob Cumby, Silverio Foresi, Yasushi Hamao, Jeremy Siegel, two anonymous referees, and participants at the Western Finance Association meetings (San Francisco, 1992) for their helpful comments and suggestions. Special thanks to Tim Opler and Jeremy Siegel for use of the data. Research support from the Geewax-Terker Research Foundation is gratefully acknowledged.

1 Introduction

In apparent contradiction to the Fisher (1930) hypothesis, it is a common empirical finding that expected stock returns and expected inflation are negatively related.[1] This result carries through to the hedging relationship between ex-post stock returns and ex-post inflation (see, for example, Nelson (1976) and Fama and Schwert (1977)). These results are surprising because stocks, as claims against real assets, should provide a good hedge against movements in inflation. These empirical studies, however, have primarily focused on the relation between stock returns and inflation at short horizons (i.e. less than one year).

This paper attempts to answer the following simple question: Are stocks a good hedge against either ex-ante or ex-post inflation in the long run? This question is interesting for two reasons. First, from a practical perspective, it is important to know whether stock returns move with inflation. Second, the relation at long-horizons is of particular interest given the anomalous result at short horizons. Using data over the past two centuries, we find evidence to suggest that stocks are a good hedge for both ex-ante and ex-post long-term inflation. This evidence is based on various methodologies such as contemporaneous regressions, instrumental variables and the use of specific models for inflation. While the results can be fairly noisy, all the approaches suggest a positive relation at long horizons, while confirming the existing evidence in the short run.

This is interesting since there has been little success at documenting any type of positive relationship between expected stock returns and expected inflation. While at first glance this difference in results may be surprising, we try to reconcile these results in the context of existing asset pricing models. In particular, we use a variant of Fama's (1981) proxy hypothesis to show how stock returns and inflation may vary differently over short and long horizons.

The paper is organized as follows. In Section 2, we provide a discussion of the issues and a description of the data. Section 3 documents the statistical relation between stock returns and inflation (and expected inflation), illustrating the different results attained from short and long horizons. Section 4 reconciles these results via the proxy effect in the context of a consumption based asset pricing model. Section 5 extends the results beyond U.S. to U.K. data. Section 6 concludes the paper.

---

[1] See, for example, Lintner (1975), Bodie (1976), Jaffe and Mandelker (1977), Nelson (1976), Fama and Schwert (1977), Gultekin (1983) and Kaul (1987), among others.

2.2 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 to 1990. The data are obtained from 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 and interest rate data are collected by Siegel (1992a). The price level data is obtained to most closely match the consumer price index series compiled by the Bureau of Labor Statistics.[2] 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 twenty years. In the earlier part of the sample, Siegel (1992a) 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 his constructed series matches actual available rates during this period (for more details, see Siegel (1992a)). 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 pre 1870 data is not as comprehensive as later periods since they consist primarily of a portfolio of financial firms and railroads.

Of interest to our analysis, there are several studies documenting structural changes in the inflation series over the sample period. The usual cut-off points for these changes are either the switch from the gold standard in 1933 or the start of the Federal Reserve in 1914. (See, for example, Shiller and Siegel (1975) and Barsky (1987)). In the absence of more detailed data sets, however, empirically modeling these structural changes is difficult. Note that our primary concern in this paper are the comovements between stock returns and inflation (and expected inflation). Whether this relation changes with these types of structural changes remains an empirical question.[3]

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

---

[2] In this sample, the series is made up of three periods. Specifically, the following sources are used by Siegel (1992a): for the period 1800-1850, the Snyder-Tucker Series, L1, Historical Statistics (1949); for the period 1850-1925, the Bureau of Labor Statistics series, series E135, (modified by Wilson and Jones (1987)); and for the period 1926-1989, Ibbostson and Sinquefield series (1989).

[3] 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, Schwert (1989) investigates the overall period as well as appropriately chosen subperiods. We follow this approach here.

year stock returns on five-year inflation.[4] Table 1 presents the results of these regressions. The regression coefficient of five-year stock returns on the contemporaneous five year inflation is significantly positive, $\hat{\beta}_5 = .524$, with a standard error $\hat{\sigma}_{\hat{\beta}_5} = .174$. Therefore, stock returns and inflation tend to move together over the sample — thus, supporting the hedging relation at long horizons. On the other hand, the estimate of $\hat{\beta}_1$ (.070) is close to zero. The latter result is in accordance with estimates documented elsewhere in the literature which are significantly negative at the monthly and quarterly frequencies, but close to zero at the annual frequency. In terms of the hypothesis $\beta_5 = \beta_1$ versus the alternative $\beta_5 > \beta_1$, the statistic $z = \sqrt{T}\frac{\hat{\beta}_5 - \hat{\beta}_1}{\hat{\sigma}_{\hat{\beta}_5 - \hat{\beta}_1}} = 4.20$, is significant at the 1% 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 coefficients $\hat{\beta}_1$ equal .131 and .087 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 .462 and .432 depending on the period. The standard errors of the estimates, however, tend to be larger for the 1870-1990 sub-period (although not for the 1914-1990 period). We attribute this loss of accuracy, at least in part, to the loss of thirteen non-overlapping five-year periods. This imprecision aside, our overall conclusion is that, in contrast to the short horizon results, stocks seem to provide a better hedge against inflation in the long run.

3.1 Implications for the Fisher Model from Contemporaneous Regressions

The major difficulty in studying long-term implications for the Fisher model, i.e. the relation between stock returns and *expected* inflation, is choosing a model for expected inflation. This is especially true for earlier time periods since the information available to the econometrician is much less than the information available to economic agents. It is possible, however, to interpret the regressions in Table 1 in terms of the Fisher model.

Specifically, following Nelson (1976), consider the market's best forecast of future inflation

---

[4] Note that the equations are estimated jointly in order to estimate the parameter estimators' covariance matrix. This is paramount 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 Hansen (1982).

3.2 Implications for the Fisher Model from Approaches Correcting for Measurement Error

3.2.1 Instrumental Variables Approach

One approach to the errors-in-variables problem which will lead to consistent estimates of β_j is to use instrumental variables (IV). While the IV approach is a popular method for errors-in-variables, its use has been limited in the stock return/inflation literature. It is important, therefore, to mention the potential drawbacks of the IV methodology. First, in order to maintain some reasonable level of efficiency, we need to choose instruments which are hopefully correlated with the true expected inflation. These instrumental variables, however, must have the required IV property that they are uncorrelated with unexpected inflation (i.e. $\eta_t(j)$ in equation (3)), such as predetermined variables. Second, we need to assume that the instruments are uncorrelated with the regression error (i.e. $\epsilon_t(j)$ in equation (2)). This is tantamount to assuming that the instruments are uncorrelated with changes in the expected real rate. This assumption can be tested using overidentifying restrictions.

Consider rewriting the regression models in (2) as:

$$\begin{aligned} R_{t+1} &= \alpha_1 + \beta_1 \pi_{t+1} + \nu_t(1) && (4) \\ \sum_{i=1}^{5} R_{t+i} &= \alpha_5 + \beta_5 \sum_{i=1}^{5} \pi_{t+i} + \nu_t(5) && (5) \\ \text{where } \nu_t(j) &= \epsilon_t(j) - \beta_j \eta(j)_{t+j}. \end{aligned}$$

In order to correct for the errors in variables, we estimate system (4) and (5) using instrumental variables instead of the contemporaneous variables. We choose the following set of instruments: the one-year interest rate R_{st} and the long-rate of interest R_{lt}. These variables are especially good choices for the instruments since the interest rates should contain information about expected inflation rates and are known at time t.[6] Two systems of equations are estimated. The first system uses the short-rate and long-rate of interest as instruments in regression (4) and (5), respectively. The second system recognizes that the short-rate may have information for the long-horizon regression (5) and therefore includes both R_{st} and R_{lt} as instruments. 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)).

---

[6] The notion that interest rates capture movements in expected inflation in all periods, however, has come under recent fire (see, for example, Barsky (1987)).

Nevertheless, as illustrations of this approach, we choose two methods for modeling expected inflation. The first model follows Fama and Schwert (1977) and uses short-term (i.e one year) and long-term interest rate data to capture movements in one-year and five-year expected inflation, respectively.[8] While the data we have does not include 5-year interest rates per se, it does contain a long-term interest rate. If the term structure is relatively flat at long maturities, then this longer rate should be a reasonable proxy for five-year expected inflation. Specifically, in this case, regression model (2) becomes

$$\sum_{i=1}^{j} R_{t+i} = \alpha_j + \beta_j R_{int(j),t} + \epsilon_t(j),$$

where $R_{int(j),t}$ is the one-period rate if $j = 1$, and the long-term rate if $j = 5$. To avoid this approximation, we also model five-year expected inflation as a linear combination of the short- and long-term interest rates. The linear weights are determined via OLS, jointly estimated with the one-year and five-year stock return regressions. Hence, in regression (2), $E\left[\sum_{i=1}^{5} \pi_{t+i} | \phi_t\right]$ is substituted for $\gamma_1 + \gamma_2 R_{st} + \gamma_3 R_{lt}$.

The results for the Fama and Schwert (1977) method are given in Table 3A. Similar to Section 3.2.1, the short-horizon coefficients are negative (although not significantly) in the overall period as well as the subperiods. In contrast, both measures of five-year expected inflation are positively related to expected stock returns in all the sample periods. For example, in the 1802-1990 period, $\hat{\beta}_5 = .511$ using the long rate of interest, while $\hat{\beta}_5 = 2.00$ using the linear combination of the short and long rates. We attribute differences in the magnitude of these coefficients to non-flat term structures beyond five years. Since the second measure captures this possibility (although only as a linear approximation), it maybe the preferred estimate. With this in mind, Table 3A shows that the five-year estimates using the second expected inflation measure are all significantly positive and are of magnitude consistent with the Fisher model.

The second method for generating expected inflation models is to estimate a univariate model for inflation. We choose an AR(1) in inflation: $\pi_{t+1} = \mu + \rho\pi_t + \omega_{t+1}$, and estimate the coefficient on expected inflation, β_j, as if this were the true model.[9] Rewriting regression

---

[8] Fama and Schwert (1977) use the nominal return on a default-free bond over a given period as their measure of expected inflation over that same period. The analysis is based on 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. There is some evidence, not entirely uncontroversial, to suggest that this model for expected inflation does not work that well in pre World War II data or even in some periods in the 1980's. These analyses, however, tend to use shorter term data such as monthly and quarterly. (See, for example, Barsky (1987) and Mishkin (1991) for a discussion of these issues). Putting this work aside, we nevertheless use the Fama and Schwert (1977) method to produce the expected inflation measure in this particular example.

[9] As an aside, we estimated various autoregressive and moving average models and found that a first order

a company's growth prospects) and inflation are negatively correlated, then inflation will proxy for future real ouptut. This can lead to a negative relation between stock returns and expected inflation in a regression model. Fama (1981) and others find that, when you include as explanatory variables both inflation and a measure of future real output, this negative relation disappears.

In the context of the empirical results above, a natural question to ask is whether the differences between the short and long-horizon results can be explained in terms of the "proxy" effect. In order to investigate this question, we consider a variant of the "proxy" hypothesis. Specifically, consider the first order equation from a *nominal* Lucas-type (1978) economy:[13]

$$E_t\left[\frac{U'(c_{t+1})p_t}{U'(c_t)p_{t+1}}(1+r_{t+1})\right] = 1$$

where $U(\cdot) =$ the representative agent's utility function

$c_t =$ aggregate real consumption at time t

$p_t =$ the price level at time t

$r_t =$ return from time t to t + 1.

As an example, assume that the representative agent has constant relative risk aversion (CRRA) preferences and that the joint conditional distribution of consumption, inflation and stock returns is lognormal. (For more details regarding this economic environment, see Hansen and Singleton (1983)). Under these assumptions, it is possible to show that expected j-period log returns can be written as

$$E_t\left[\sum_{i=1}^{j} R_{t+i}\right] = k_j + \gamma E_t\left[\sum_{i=1}^{j} gc_{t+i}\right] + E_t\left[\sum_{i=1}^{j} \pi_{t+i}\right] \qquad (6)$$

where $R_{t+1} =$ the continuously compounded return from t to t + 1

$k_j =$ a constant parameter given by the model

$\gamma =$ the CRRA parameter

$gc_{t+1} =$ log consumption growth from time t to t + 1

$\pi_{t+1} =$ log inflation from time t to t + 1.

---

[13] This is a model in which the price level serves simply as a unit of account. However, although money is neutral and therefore has no real effects, inflation and consumption growth can be correlated via the money supply process. (See, for example, Cox, Ingersoll and Ross (1985) for a discussion).

how returns and expected inflation can move together differently over short and long horizons. We conjecture, however, that more elaborate models and distributional assumptions will produce qualitatively similar results.[14]

5 Empirical Analysis for U.K. Market

In this section, we extend the empirical analysis of Section 3 to annual data on U.K. stock returns, interest rates and inflation over the period 1820 to 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 Harris and Opler (1991). A detailed description of the data are given in these papers.

The results in the previous sections strongly support the theory that 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 extending our analysis to international markets. Fortunately, a long time-series exists for U.K. data on stocks, bonds and inflation. 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%. Thus, the U.K. data will contain information about the Fisher relation in addition to the U.S. empirical results given in Tables 1 — 3.

Table 4 provides results for essentially the same regressions given in Section 3 (i.e. contemporaneous, instrumental variables and expected inflation models). 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, $\hat{\beta}_5 = .434$ versus $\hat{\beta}_1 = .232$, with a corresponding z-statistic (for the test $\beta_5 = \beta_1$ versus $\beta_5 > \beta_1$) equal to 7.13. The implications for the Fisher model from these regressions is that there is indeed a positive relation between returns and expected inflation at long horizons (see Section 3.1).

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 signficantly greater than the short-horizon coefficients at the 10% level. The regressions using the ex-ante model of

---

[14] As examples of possible extensions, see Marshall (1992) for a more elaborate equilibrium model with money included, and Tauchen and Hussey (1991) for techniques extending beyond the log-linear framework looked at here.

does not hold empirically. Here, using two centuries of data, we are able to explore this relation at longer horizons. What we find is that the positive relation that *should* exist does in fact hold up empirically at long horizons, which should come as good news to financial economists.

Table 2
Stock Returns and Expected Inflation: The Instrumental Variables Approach

Tables 2A and 2B provide 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:

$$\begin{aligned} R_{t+1} &= \alpha_1 + \beta_1 \pi_{t+1} + \nu_t(1) \\ \sum_{i=1}^{5} R_{t+i} &= \alpha_5 + \beta_5 \sum_{i=1}^{5} \pi_{t+i} + \nu_t(5), \end{aligned}$$

where R_t denotes the stock return, π_t denotes the inflation rate, and v_t is the combined disturbance term and measurement error. Table 2A provides estimates from an exactly identified system, using the short- and long-rate of interest as instruments in the two equations, respectively. Table 2B uses both the short- and long-rate of interest in the long-horizon regression. With five equations and only four parameters to estimate, this leaves one overidentifying restriction, which is tested using the generalized method of moments resulting in a χ_1^2 asymptotic distribution. Note that $z_{\beta_5 > \beta_1}$ is the test statistic for the hypothesis $\beta_5 = \beta_1$ versus $\beta_5 > \beta_1$.

2A. Identified System

Period	α_1 (std.err.)	β_1 (std.err.)	α_5 (std.err.)	β_5 (std.err.)	$z_{\beta_5>\beta_1}$ (P-value)
1802-1990	.106	-2.781	.277	1.394	1.218
	(.0432)	(3.252)	(.0983)	(1.365)	(.888)
1870-1990	.0927	-.541	.304	1.097	1.504
	(.0339)	(1.290)	(.106)	(.880)	(.934)
1914-1990	.102	-.171	.300	1.111	1.395
	(.0544)	(1.203)	(.190)	(1.051)	(.919)

2B. Overidentified System

Period	α_1 (std.err.)	β_1 (std.err.)	α_5 (std.err.)	β_5 (std.err.)	$z_{\beta_5>\beta_1}$ (P-value)	$\chi^2(1)$ (P-value)
1802-1990	.099	-2.531	.236	2.072	1.346	.309
	(.0413)	(3.221)	(.0678)	(.685)	(.911)	(.422)
1870-1990	.099	-.919	.264	1.568	1.750	2.895
	(.0214)	(1.136)	(.0428)	(.775)	(.960)	(.911)
1914-1990	.109	-.670	.180	1.884	2.487	3.326
	(.0433)	(1.034)	(.0741)	(.385)	(.994)	(.932)

Table 4
Returns and Inflation:
The U.K. Stock Market

Table 4 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 — 3. Specifically, contemporaneous regressions of stock returns on inflation, instrumental variable regressions of this relation , and regressions of stock returns on expected inflation are performed. The exact procedures are decribed in Tables 1 — 3 respectively for each of these methods.

Estimation Method	α_1	β_1	α_5	β_5	$z_{\beta_5>\beta_1}$	$\chi^2(1)$
	(std.err.)	(std.err.)	(std.err.)	(std.err.)	(P-value)	(P-value)
Ex-post Inflation						
Contemporaneous	.024	.232	.108	.434	7.13	
Regression	(.008)	(.103)	(.022)	(.121)	(1.00)	
Ex-ante Inflation						
IV. Identified	.093	-.897	.348	.338	1.71	
	(.019)	(.708)	(.060)	(.335)	(.956)	
IV. Overidentified	.077	-.352	.330	.509	1.45	1.48
	(.016)	(.548)	(.057)	(.271)	(.927)	(.224)
Int. Rate Model (I)	.104	-.759	.303	.358	4.89	
	(.027)	(.572)	(.056)	(.227)	(1.00)	
Int. Rate Model (II)	.104	-.759	.332	.511	5.48	
	(.027)	(.572)	(.030)	(.220)	(1.00)	
AR(1) Model	.078	-.200	.354	.277	1.432	$\rho = .406$
	(.018)	(.416)	(.064)	(.573)	(.924)	(.118)

[16] Thomas Harris and Tim Opler, "Stock Market Returns and Real Activity: International Evidence", working paper (University of New South Wales and Southern Methodist Iniversity), 1991.

[17] Joel Hasbrouck, "The Impact of Inflation Upon Corporate Taxation", *National Tax Journal*, 36:65-81, 1983.

[18] *Historical Statistics of the U.S., 1789-1945*, U.S. Department of Commerce and the Bureau of Census with Cooperation of the Social Science Research Council, U.S. Government Printing Office, 1949.

[19] Roger Ibbotson and Rex Sinquefield, *Stocks, Bonds, Bills and Inflation*, 1989 Yearbook, Ibbotson Associates, Chicago, Illinois.

[20] Jeffery F. Jaffe and Gershon Mandelker, "The 'Fisher Effect' for Risky Assets: An Empirical Investigation," *Journal of Finance*, 31:447-458, 1977.

[21] Gautam Kaul, "Stock Returns and Inflation: The Role of the Monetary Sector," *Journal of Financial Economics*, 18:253-276, 1987.

[22] John Lintner, "Inflation and Security Return," *The Journal of Finance*, 30:259-280, 1975.

[23] Robert E. Lucas, "Asset Prices in an Exchange Economy," *Econometrica*, 46:1426-1446, 1978.

[24] David Marshall, "Inflation and Asset Returns in a Monetary Economy," forthcoming *Journal of Finance*, 1992.

[25] Frederick Mishkin, "Is the Fisher Effect Real? A Reexamination of the Relationship Between Inflation and Interest Rates", NBER working paper No. 3632, 1991.

[26] Charles R. Nelson, "Inflation and Rates of Return on Common Stocks," *Journal of Finance*, 31:471-483, 1976.

[27] G. William Schwert, "Why Does Stock Market Volatility Change over Time," *Journal of Finance*, 44:1115-1153, 1989.

[28] ———, "Indexes of the United States Stock Prices from 1802 to 1987," *Journal of Business*, 63:399-426, 1990.

[29] Robert Shiller and Jeremy Siegel, "The Gibson Paradox and Historical Movements in Real Interest Rates," *Journal of Political Economy*, 85:891-907, 1977.

[30] Jeremy Siegel, "The Real Rate of Interest from 1800-1990: A Study of the U.S. and U.K.," *forthcoming Journal of Monetary economics*, 1992a.

[31] ———, "Stock and Bond Returns Since 1802: Will Equity Continue to Dominate?" *Financial Analysts Journal*, 48:23-38, 1992b.

FIGURE 1

Figure 1 graphs rolling five-year real returns and one-year real returns over the sample period 1802-1990. The data are continuously compounded annualized returns.