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Re-Examination of the Fisher Equation for
Stock Returns: Using Ex Ante Data

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Re-Examination of the Fisher Equation for Stock Returns:
Using Ex Ante Data

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RE-EXAMINATION OF THE FISHER EQUATION FOR STOCK RETURNS:

USING EX ANTE DATA

ABSTRACT

The main theme of this paper is consideration of the Darby hypothesis and the Mundell hypothesis in the Fisher equation for stock returns by examining the relationship between the expected return on common stocks and the expected inflation rate. This paper's results show that (i) when the Fisher equation is "adjusted" for the effect of inflation uncertainty on the required return for common stocks, the magnitude of the effect of expected inflation on the expected nominal (real) return for common stocks is less than one (zero); and (ii) when the Fisher equation is "misspecified" by ignoring the inflation uncertainty effect, the relationship between the expected real return for common stocks and the expected inflation rate appears spuriously to be positive. When the Fisher equation is correctly specified, our results are consistent with the Mundell hypothesis.

Introduction

One of the anomalous findings from the U.S. stock market is the negative correlation between the stock returns and inflation (see Lintner [14], Fama and Schwert [9], and Friend and Hasbrouck [10], among others). Since this negative relationship contradicts traditional thought that nonmonetary assets such as common stock are hedges against inflation, a large quantum of academic research energy has been directed to the examination about why and how inflation affects stock returns. Nevertheless, the ex ante relationship between expected (required) returns for common stocks and expected inflation has not been thoroughly examined. The objective of this paper is to examine the Fisher equation¹ adjusted for the risk aversion and inflation uncertainty, using the Livingston expectations data.² Our results show that (i) expected inflation is negatively related to the real required return for common stocks when the Fisher equation for stock returns is

adjusted for the effect of inflation uncertainty; and (ii) the real required return for common stocks has been substantially raised by inflation uncertainty.

I. THE "GENERALIZED" FISHER EQUATION

Clearly, the Fisher equation does not hold in the joint presence of the risk aversion and inflation uncertainty. When we examine the relationship between the required return for common stocks and the rate of expected inflation, the required return for common stocks needs to be adjusted for inflation uncertainty. The "generalized" Fisher equation for stock returns can be expressed as (see Appendix A for its derivation):

$$\begin{aligned} E[R_s] &= \frac{1}{1-\tau}E[\mu_0] + \frac{1}{1-\tau}E[\pi] + \frac{\lambda}{1-\tau}\sigma_s^2 + \frac{\lambda}{1-\tau}(b_s^2 + b_s)\sigma_\pi^2 \\ &= \beta_0 + \beta_1 E[\pi] + \beta_2 \sigma_s^2 + \beta_3 \sigma_\pi^2 \end{aligned} \tag{1}$$

where $E[R_s]$ is the nominal expected return on common stocks before personal taxes; τ is the overall effective personal income tax rate; $E[\mu_0]$ is the expected real interest rate after personal taxes; $E[\pi]$ is the expected inflation rate; λ is the market price of risk; σ_s^2 measures the risk of common stocks which is independent of inflation uncertainty; b_s measures the degree of responsiveness of the real stock return after personal taxes, μ_s , with respect to unexpected inflation, i.e., $b_s = \text{COV}(\mu_s, \pi^u)/\sigma_\pi^2$; π^u denotes unexpected inflation; and σ_π^2 is the measure of inflation uncertainty.³

When there is no uncertainty ($\sigma_s^2 = \sigma_\pi^2 = 0$), or when investors are risk neutral ($\lambda = 0$), (1) is reduced to the standard Fisher equation except for the Darby [5] effect⁴ ($\beta_1 = \frac{1}{1-\tau} > 1.0$).

Empirical evidence indicates that ex post real returns of common stocks have a strongly negative relationship with unexpected inflation, and b_s is much less than -1.0. This finding implies that inflation uncertainty increases the real required return for common stocks.

Moreover, it is intuitively plausible and empirically shown as well that there exists a structural relationship between the level of inflation and the degree of inflation uncertainty.⁵ Therefore, given the positive relationship between the level of expected inflation and the degree of inflation uncertainty, if we estimate β_1 without controlling for the positive effect of inflation uncertainty on the required return for common stocks, the estimate of β_1 will be biased.⁶

II. EMPIRICAL RESULTS

For each of the semi-annual Livingston surveys from June 1955 through June 1960, the expected stock market return and the expected inflation rate are estimated from the arithmetic averages of individual respondents' forecasts for the stock return and the inflation rate with six-month forecasting horizon.⁷ Since σ_π^2 is not directly observed, the observed forecast errors of previous inflation predictions⁸ and the cross-sectional variance of individual respondents' forecasted inflation rates⁹ are alternatively used as a surrogate for the measure of σ_π^2 . The variance of the monthly realized real stock return, after being orthogonalized to the estimated monthly unexpected inflation rate,¹⁰ from the six-month sample period prior to each of the Livingston surveys is

used as a surrogate for σ_s^2 . This sample variance would represent the measure of real activity uncertainty perceived by the stock market since stock prices are principally determined by expectations about future real activity.

Since we are mainly concerned with how the real required return for common stocks is affected by expected inflation and inflation uncertainty, $E[\pi]$ is subtracted from both sides of (1). Then, our testing equations are represented by:

$$LE_t[r_s] = \gamma_0 + \gamma_1 LE_t[\pi] + \gamma_2 V_t[r_s^*] + \gamma_3 FECPI_{t-2} + \gamma_4 FECPI_{t-3} \quad (2a)$$

$$LE_t[r_s] = \psi_0 + \psi_1 LE_t[\pi] + \psi_2 V_t[r_s^*] + \psi_3 V_t(LE_t[\pi]) \quad (2b)$$

where the subscript t stands for the time of the Livingston survey; LE is the Livingston expectation operator; V is the variance operator; $FECPI_t$ is the forecast error of the inflation prediction from the survey conducted at time t ; ¹¹ and r_s^* denotes the "orthogonalized" part of the monthly realized real stock return.

Since there is compelling evidence for a structural break in the Livingston data around 1960, ¹² the results for (2) are examined separately for two sub-periods: (i) June 1960 to June 1980; and (ii) June 1955 to June 1980. There is no qualitative difference in the results for these two sub-periods; and the results for the post-55 period are relegated to Appendix B.

 INSERT TABLE 1

The results for each of the two testing equations, reported in Table 1, show that the magnitude of the effect of expected inflation on the real

TABLE 1

REGRESSION RESULTS FOR THE RELATIONSHIP BETWEEN THE REAL REQUIRED RETURN FOR COMMON STOCKS AND EXPECTED INFLATION: SURVEYS FROM JUNE 1960 THROUGH JUNE 1980

Panel A: $LE_t[r_s] = \gamma_0 + \gamma_1 LE_t[\pi] + \gamma_2 V_t[r_s^*] + \gamma_3 FECPI_{t-2} + \gamma_4 FECPI_{t-3}$

Eq. No.	γ_1	γ_2	γ_3	γ_4	Adj R ²	F	DW
1*	0.646 (0.374) ⁺	-	-	-	0.049	2.99	1.64
2	0.302 (0.266)	8.167 (2.348)	-	-	0.306	9.83	1.66
3	-0.365 (0.303)	-	1.485 (0.365)	0.978 (0.354)	0.438	11.40	1.89
4	-0.384 (0.291)	4.529 (2.246)	1.190 (0.380)	0.834 (0.348)	0.481	10.27	1.82

Panel B: $LE_t[r_s] = \psi_0 + \psi_1 LE_t[\pi] + \psi_2 V_t[r_s^*] + \psi_3 V_t(LE_t[\pi])$

Eq. No.	ψ_1	ψ_2	ψ_3	Adj R ²	F	DW
3	-1.603 (0.545)	-	8.168 (1.783)	0.411	14.94	1.70
4	-1.320 (0.548)	4.487 (2.376)	6.423 (1.958)	0.448	11.82	1.74

Footnotes *: Eq. no. followed by '*' indicates that the regression is adjusted for the first-order autocorrelation of the residual, using the Cochrane-Orcutt Method.

+: Standard errors of the coefficient estimates are in parenthesis.

required return for common stocks becomes negative when we introduce a measure of inflation uncertainty into the Fisher equation. Our results also indicate that the real required return for common stocks has been substantially increased by inflation uncertainty, which could account for relatively depressed stock prices during the inflationary period.

The negative relationship between the real required return for common stocks and the expected inflation rate, when adjusted for inflation uncertainty, is consistent with the wealth effect hypothesis suggested by Mundell [16].¹³ However, when the Fisher equation is misspecified by ignoring the effect of inflation uncertainty on the required return for common stocks, our results show that expected inflation appears spuriously to be positively related to the real required return for common stocks.¹⁴ Because the wealth effect hypothesis implies a stimulating effect of expected inflation on real activity, our results contradict Fama's [8] claim that real activity is negatively related to expected inflation.¹⁵

Even though real activity is not negatively related to inflation, our results may explain why negative relationships between expected inflation and subsequently realized stock returns have been observed. This negative relationship, which is perhaps the most puzzling finding among observed stock return-inflation relationships, can be viewed as an ex post counterpart of the spuriously positive relationship between the required return for common stocks and expected inflation in the absence of inflation uncertainty (Equations No. 1 and 2 in Table 1). In other words, our results suggest that the observed negative relationship between expected inflation and subsequently realized stock

returns could be an empirical illusion created by a structural relationship between the level of (expected) inflation and the degree of inflation uncertainty.¹⁵

III. CONCLUDING REMARKS

This paper has presented empirical results that expected nominal stock returns before personal taxes, when adjusted for inflation uncertainty, respond less than point-for-point to changes in the rate of expected inflation. Ever since Irving Fisher, empirical studies using short-term interest rate data have confirmed the same findings as those presented by this paper. In addition, it has been essentially shown that the misspecified relationship between expected stock returns and expected inflation, by ignoring the effect of inflation uncertainty on the required return, results in a spuriously positive relationship between expected real stock returns and expected inflation. It should be further noted that our results do NOT necessarily indicate a "fiscal illusion" in the sense of Tanzi [19] even though our results are not consistent with the Darby hypothesis. As pointed out by Levi and Makin [13], the Fisher equation should be viewed as a reduced-form equation, derived from a set of structural equations for a comprehensive macroeconomic model. This paper opens an opportunity for the further study of the generalized Fisher equation for stock returns in a general equilibrium framework.

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FOOTNOTES

¹The standard Fisher equation states that the nominal rate of interest (return) on asset can be decomposed into the real rate of interest (return) lenders (investors) expect plus an adjustment for the rate of expected inflation over the asset's term to maturity:

$$\begin{array}{rcccl} \text{Nominal} & & \text{Expected} & & \text{Expected} \\ \text{Rate of} & & \text{Real Rate} & + & \text{Future Rate} \\ \text{Interest} & \approx & \text{of Interest} & & \text{of Inflation.} \end{array}$$

²Since 1946, an economic columnist of the Philadelphia Inquirer, Joseph A. Livingston, has conducted surveys of about sixty leading economists twice a year (June and December) for the forecasts of a variety of economic variables, such as the consumer price index, the stock market price index, the industrial production index, and gross national income. Ready availability of more than three decades of consistently uninterrupted observations makes the Livingston survey data perhaps the richest source of ex ante information for major economic variables.

³Uncertainty about inflation can be viewed as a dispersion measure of the distribution from which a point forecast (expected inflation) is drawn.

⁴Because nominal income is taxed, investors are concerned about the expected net real rate of return after taxes. The importance of the distinction between expected real rates of interest before taxes and after taxes was first emphasized by Darby [5]. The Fisher equation is modified to:

$$\begin{array}{l} \text{Nominal} \\ \text{Rate of} \\ \text{Interest} \\ \text{before tax} \end{array} = \begin{array}{l} \text{Expected} \\ \text{Real Rate} \\ \text{of Interest} \\ \text{before tax} \end{array} + \frac{1}{1 - \text{Tax Rate}} \begin{array}{l} \text{Expected} \\ \text{Future Rate} \\ \text{of Inflation.} \end{array}$$

⁵Historically, high levels of inflation tend to be associated with high inflation uncertainty. See Logue and Willet [15] and Holland [12], among others. Vining and Elwertowski [21] found that higher inflation tends to be associated with a greater dispersion of price changes. Put differently, the nature of uncertainty associated with high inflation could emanate from unpredictable relative price changes.

⁶Let $Y = \phi_1 X_1 + \phi_2 X_2$ (true model) and $Y = \gamma_1 X_1$ (misspecified model) where Y , X_1 , and X_2 , respectively, denote the nominal expected return on common stocks, the expected inflation rate, and the measure of inflation uncertainty. Then, the OLS estimate of ϕ_1 will be:

$$\hat{\phi}_1 = \frac{\hat{\gamma}_1 - \frac{\sigma_{12}}{\sigma_{11}} \frac{\sigma_{2y}}{\sigma_{22}}}{1 - \rho_{12}^2}$$

From the Livingston data, σ_{12}/σ_{11} is between 2 and 4; σ_{2y}/σ_{22} is about 1; and ρ_{12} is between 0.5 and 0.8. Then, $\frac{\sigma_{12}}{\sigma_{11}} \frac{\sigma_{2y}}{\sigma_{22}} > \rho_{12}^2$. Given that $\hat{\gamma}_1$ is between 1.5 and 2.5 (see Gultekin [11]), the misspecified model yields $\hat{\gamma}_1 > \hat{\phi}_1$ for our analysis.

⁷Individual respondents' forecasted expected stock returns are estimated following Gultekin's [11] suggestion and individual respondents' forecasted inflation rates are estimated following Carlson's [3] suggestion. In a strict sense, the expected dividend

yield is not included in the expected stock return because the Livingston survey participants have predicted the level of the stock price index. The exclusion of dividend yield should be inconsequential to the coefficient estimates of the generalized Fisher equation because the dividend yield (contemporaneous) is statistically uncorrelated to measures of $E[\pi]$ and σ_{π}^2 . For the details of the data base and estimation procedure, see Dokko [6].

⁸It seems intuitively plausible that more uncertainty about the future is to be perceived when forecast errors from the previous predictions are realized.

⁹Cukierman and Wachtel [14] presented a formal proof that the cross-sectional variance measure is closely related with the measure of inflation uncertainty within a rational expectations model; and Bomberger and Frazer [2] presented empirical evidence that the Livingston cross-sectional variance is an internally consistent measure of inflation uncertainty.

¹⁰Since realized real stock returns are negatively related with unexpected inflation, we need to separate out uncertainty of stock returns which is independent of unexpected inflation. Refer to equation (A.2) in Appendix A.

¹¹Let the subscript $t-1$, as an example, represent the December 1980 survey. $FECPI_{t-1}$ is defined as the difference between the realized inflation rate from the beginning of January 1981 to the end of June 1981 and the expected inflation rate for the corresponding period from the December 1980 survey. The survey participants could not observe this forecast error when the June 1981 survey (represented

by the subscript t) was conducted in early June or late May of that year; and this unobserved forecast error is inadequate as a surrogate for inflation uncertainty. This unobserved forecast error problem was pointed out by Brown and Maital [1].

¹²See Turnovsky [20] and Brown and Maital [1], among others.

Brown and Maital found the absence of bias in the Livingston forecasts of stock market returns and inflation rates from the post-60 surveys. They further showed that forecast errors of stock price predictions from the post-60 surveys are uncorrelated with lagged economic variables, which indicate that Livingston stock price predictions are informationally efficient.

¹³The wealth effect hypothesis states that an increase in expected inflation causes portfolio substitutions from money to financial assets such as common stock. Therefore, an increase in expected inflation causes a decrease (increase) in the expected return (current price) of common stocks, which stimulates economic activity.

¹⁴The ex ante relationship between expected inflation and expected stock returns, using the Livingston expectations data, was originally examined by Gultekin [11]. But Gultekin did not consider the effect of inflation uncertainty on the real required return for common stocks, and his findings and interpretations resulted from this misspecified relationship.

¹⁵Fama [8] asserts that real economic activity is negatively related to inflation. Therefore, according to Fama, given that stock returns are principally determined by expectations about real activity, the observed negative relationship between expected inflation and

subsequently realized stock returns is spurious as a result of the real income proxy effect of inflation.

¹⁶See Edelstein and Dokko [7] for empirical evidence.

APPENDIX A

THE GENERALIZED FISHER EQUATION FOR STOCK RETURNS

The economy is described as:

1. Individuals (denoted by superscript k) are the standard Sharpe-Lintner CAPM investors.
2. There are only two assets; nominally risk-free bond (denoted by subscript o) and common stock (denoted by subscript s). Supply of these assets is fixed.

The uncertain inflation rate, $\tilde{\pi}$, is decomposed into the expected and unexpected inflation rate:

$$\tilde{\pi} \equiv E[\tilde{\pi}] + \tilde{\pi}^u \quad (\text{A.1})$$

where $\tilde{\pi}^u$ is the unexpected inflation rate; and $\tilde{\pi}^u \sim N(0, \sigma_{\pi}^2)$.

The real rate of return on common stock after personal taxes, $\tilde{\mu}_s$, is assumed to be generated by a two-factor return generating process:

$$\tilde{\mu}_s = E[\tilde{\mu}_s] + \tilde{y}_s + b_s \tilde{\pi}^u \quad (\text{A.2})$$

where $\tilde{y}_s \sim N(0, \sigma_s^2)$; $\text{COV}(\tilde{y}_s, \tilde{\pi}^u) = 0$ by construction; and $b_s = \text{COV}(\tilde{\pi}^u, \tilde{\mu}_s) / \sigma_{\pi}^2$.

It is further assumed that the nominal interest rate before taxes, R_o , is known at the beginning of the period. Then, the net real interest rate after personal taxes, $\tilde{\mu}_o$, is:

$$\tilde{\mu}_o = (1 - \tau)R_o - \tilde{\pi} \quad (\text{A.3})$$

where τ is the overall effective personal income tax rate.

An investor with initial wealth, W_0^k , is to maximize his (her) expected utility of end-of-the-period real wealth, \tilde{W}_1^k :

$$\text{MAX}_{\alpha_s^k} E[U(W_0^k + W_0^k\{\tilde{\mu}_0 + \alpha_s^k(\tilde{\mu}_s - \tilde{\mu}_0)\})] \quad (\text{A.4})$$

where α_s^k is the fraction of initial wealth invested in common stock.

After obtaining the first-order condition of (A.4), and by expanding the marginal utility of end-of-the-period wealth about its expected value in a Taylor series expansion, the individual optimality conditions is:

$$E[\tilde{\mu}_s - \tilde{\mu}_0] = c^k [- (1 + b_s)\sigma_\pi^2 + \alpha_s^k\{\sigma_s^2 + (1 + b_s)^2\sigma_\pi^2\}] \quad (\text{A.5})$$

where c^k is the Pratt-Arrow measure of relative risk aversion. By multiplying both sides of (A.5) with $\lambda\gamma^k/c^k$; where $\gamma^k = W_0^k/\sum_k W_0^k$ and $\lambda = (\sum_k \frac{\gamma^k}{c^k})^{-1}$; and aggregating over k (assuming that the net supply of debt is zero, i.e., $\sum_k \gamma^k \alpha_s^k = 1$), the market equilibrium condition is derived as:

$$E[\tilde{\mu}_s - \tilde{\mu}_0] = \lambda[\sigma_s^2 + (b_s^2 + b_s)\sigma_\pi^2] \quad (\text{A.6})$$

where λ becomes the market price of risk.

Since $\tilde{\mu}_s$ and $\tilde{\mu}_0$ are after personal taxes, (A.6) is converted into the pre-tax nominal terms:

$$E[\tilde{R}_s - R_0] = \frac{\lambda}{1-\tau} [\sigma_s^2 + (b_s^2 + b_s)\sigma_\pi^2] \quad (\text{A.7})$$

where \tilde{R}_s and R_0 are before personal taxes such that $E[\tilde{\mu}_s] = E[(1-\tau)\tilde{R}_s - \tilde{\pi}]$ and $E[\tilde{\mu}_0] = E[(1-\tau)R_0 - \tilde{\pi}]$. Therefore, the "generalized" Fisher equation for stock returns is derived to be equation (1).

APPENDIX B

REGRESSION RESULTS FOR THE RELATIONSHIP BETWEEN THE REAL REQUIRED RETURN FOR COMMON STOCKS AND EXPECTED INFLATION: SURVEYS FROM JUNE 1955 THROUGH JUNE 1980

Panel A: $LE_t[r_s] = \gamma_0 + \gamma_1 LE_t[\pi] + \gamma_2 V_t[r_s^*] + \gamma_3 FECPI_{t-2} + \gamma_4 FECPI_{t-3}$

Eq. No.	γ_1	γ_2	γ_3	γ_4	Adj R ²	F	DW
1*	0.585 (0.355) ⁺	-	-	-	0.034	2.71	1.76
2*	0.312 (0.340)	6.176 (2.323)	-	-	0.147	5.11	1.75
3*	-0.189 (0.322)	-	1.297 (0.368)	1.078 (0.359)	0.308	8.08	1.86
4*	-0.318 (0.331)	4.634 (2.208)	1.083 (0.371)	1.026 (0.349)	0.337	7.06	1.79

Panel B: $LE_t[r_s] = \psi_0 + \psi_1 LE_t[\pi] + \psi_2 V_t[r_s^*] + \psi_3 V_t(LE_t[\pi])$

Eq. No.	ψ_1	ψ_2	ψ_3	Adj R ²	F	DW
3*	-0.585 (0.521)	-	4.890 (1.716)	0.168	5.81	1.86
4*	-0.540 (0.507)	4.662 (1.752)	3.826 (2.364)	0.215	5.35	1.81

Footnotes *: Eq. no. followed by '*' indicates that the regression is adjusted for the first-order autocorrelation of the residual, using the Cochrane-Orcutt Method.

+: Standard errors of the coefficient estimates are in parenthesis.

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