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Inflation Uncertainty and Risk Premia: An Empirical Study of the Stock Market Behavior During the Post-1960 Period

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INFLATION UNCERTAINTY & RISK PREMIA: AN EMPIRICAL STUDY OF THE STOCK MARKET BEHAVIOR DURING THE POST-1960 PERIOD

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INFLATION UNCERTAINTY AND RISK PREMIA: AN EMPIRICAL STUDY
OF THE STOCK MARKET BEHAVIOR DURING THE POST-1960 PERIOD†

By

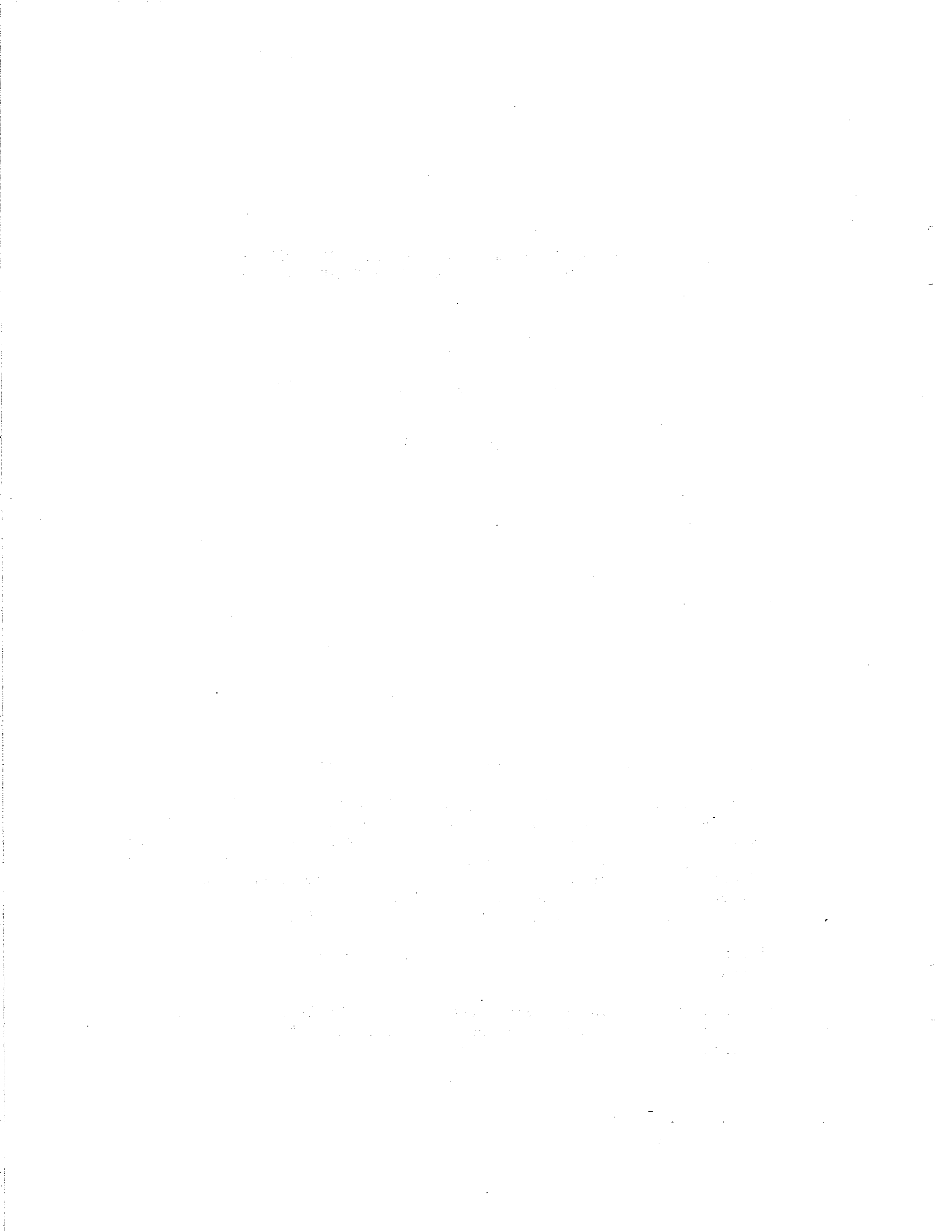
Yoon Dokko* and Robert H. Edelstein**

(April 1987)

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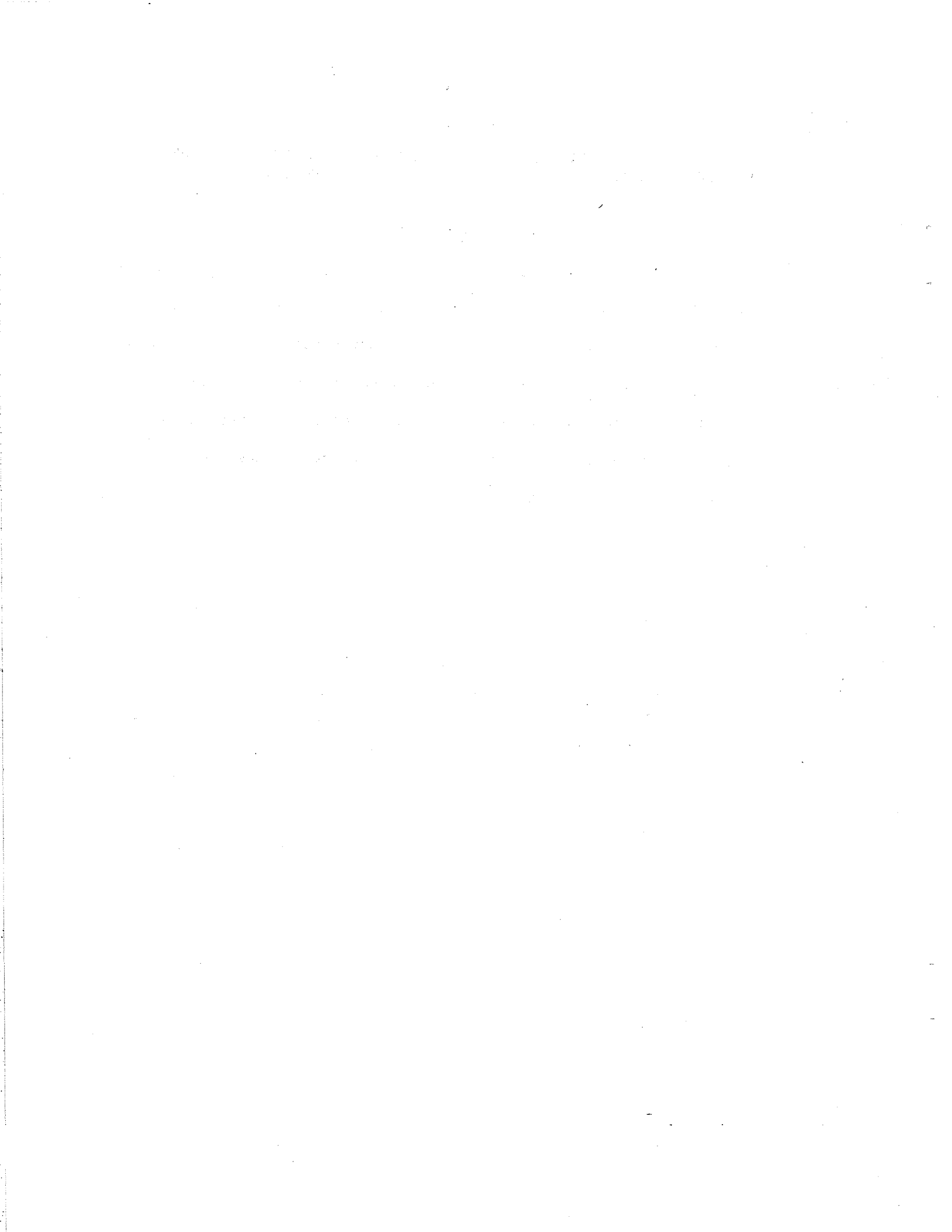
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INFLATION UNCERTAINTY AND RISK PREMIA: AN EMPIRICAL STUDY
OF THE STOCK MARKET BEHAVIOR DURING THE POST-1960 PERIOD†

ABSTRACT

Using ex ante data, we provide new empirical evidence, previously overlooked or de-emphasized, for explaining observed stock market behavior for the post-1960 period. Our principal finding is that the real required risk premium for common stocks has substantially increased as a response to increased inflation uncertainty, apparently caused by the "adverse" impacts of inflation uncertainty upon real earnings before corporate tax.



INTRODUCTION

A well-documented but anomalous finding about the U.S. and other stock markets is the negative relationship between aggregate stock market returns and inflation.^{1,2} Stock market behavior for the 1960's and 1970's, with steadily rising and volatile changes in the general price level, has been characterized by a steady decline in real stock prices accompanied by wide fluctuations. This finding is contrary to traditional thought that non-monetary assets, such as common stock (equity), are hedges against inflation. As a result, a large quantum of academic research energy has been directed to the examination of this issue. Despite this effort, however, little agreement has emerged about why and how inflation affects stock prices.

Our principal objective in this paper, in an attempt to provide an economic explanation for the observed stock market behavior during the post-1960 period, is to investigate the interrelationships between stock market prices and inflation, controlling for uncertainty variables. The adverse effects of inflation uncertainty on real economic activity are well-recognized. For example, Friedman [1977] in his Nobel Laureate Lecture argues that inflation uncertainty, by making it harder to extract the signal about relative prices from absolute prices, reduces the efficiency of the price system and thus lowers the growth rate of real output. Levi and Makin [1979, 1980] and Mullineaux [1980] provide empirical evidence which supports Friedman's position.

Vining and Elwertowski [1976] and Parks [1978] find empirically that increased, unstable inflation tends to be associated with increased

dispersions for mean relative price changes. Cukierman [1982] demonstrates that the variances of general inflation rates and relative price changes are closely related to each other. Also, while the underlying cause is a subject of continued debate, the positive statistical relationship between the level of actual/expected inflation and the volatility of inflation (both in the U.S. and other countries) has been verified independently by many studies.³

In summary, the results from these studies indicate that higher inflation levels are associated with higher inflation uncertainty. This is associated, in turn, with unpredictable relative price changes (i.e., a less efficient price system) and, consequently, depressed economic activity, a key determinant of real stock prices. Nevertheless, the effects of inflation uncertainty upon real asset prices have been down-played in previous studies about the stock market return-inflation relationship.

In brief, by recognizing the effects of inflation uncertainty on real activity, our study's principal finding is the following:

Increased inflation uncertainty is an important cause for the increase in the required risk premium for common stocks and, thus, the observed decline (and fluctuations) in stock prices for the post-1960 period. This result occurs apparently because inflation uncertainty adversely affects real earnings before corporate tax.

Based upon this principal finding, we further provide alternative views to existing literature about the stock market-inflation relationship.

The presentation is divided into four sections. Section I reviews previous literature. Section II presents the theoretical model for studying the interrelationship between the required risk premium for

common stocks and inflation uncertainty. Section III, the heart of our paper, presents the data base, estimation procedures, empirical findings, and their implications. The last section contains a summary and suggests additional avenues for future research.

I. PRIOR LITERATURE IN PERSPECTIVE

Feldstein [1980] and Summers [1981], among others, have attributed the decline in real stock prices during recent inflationary periods to the failure of the corporate income tax system to index nominal gains and depreciation bases. According to their view, firms, reporting inflation generated book profits, are penalized by an increased tax burden. The immediate limitation of the pure "tax effect" hypothesis is its implicit assumption that corporations have no debt. If one assumes, as is the case empirically, that nominal interest rates respond "at most" point-for-point to changes in the inflation rate, then, because tax deductions are calculated for nominal interest payments, increased inflation will decrease the burden of real interest and principal payments to corporations. Because of debt effects, the net real effect of tax-inflation is less clear. Abstracting from debt effects, during the time period for our analysis nominal capital gains taxation may be less important than expected a priori because the U.S. tax system permits the use of counter-inflation tax accounting methods,⁴ which implicitly may act as a substitute for indexation (see Gonedes [1981]).

Modigliani and Cohn [1979] allege that investors have systematic money illusion; investors do not recognize capital gains on debt, or mistakenly use the nominal required rate of return to discount real

cash flows, thereby explaining the observed decline in stock prices during inflationary periods. Although Modigliani and Cohn's argument might be supported by the inability of numerous studies⁵ to find empirical evidence for a wealth redistribution effect of unexpected inflation from bondholders to equity-owners, recent studies by Bernard [1986] and Dokko [1987] provide empirical evidence for the nominal contracting hypothesis.

Fama [1981] suggests that the observed negative relationships between stock returns and inflation are "spurious." Increased inflation alters real variables such that the real return on capital is reduced; and, therefore, the observed negative relationships are generated by the real income "proxy effect" of inflation because stock prices are principally determined by expectations about future real activity. Fama's empirical result shows a statistically insignificant relationship between expected inflation and subsequently realized stock returns, controlling for real activity. Critics of this approach argue that, within the context of a standard IS-LM analysis, one would expect a positive relationship between real activity and expected inflation.^{6,7}

Geske and Roll [1983] present an alternative view that the negative relationship between expected inflation (at the beginning of the period) and ex post stock returns (at the end of the period) is not created by a "causal" effect from inflation to stock prices. Instead, they claim that a decrease in stock prices, in an efficient stock market, signals an increase in the government's monetized debt and its consequence, inflation; and, therefore, there is a "reverse causality"

from stock returns to inflation. While we readily would grant the argument that stock returns and inflation are simultaneously and endogenously determined,⁸ we find it difficult to reject on theoretical grounds that inflation, working through the economic system, does not affect stock prices.

Malkiel [1979] and Friend [1982] infer independently that the risk premium for common stocks has increased as a response to increased economic uncertainty, presumably created by more inflation uncertainty.⁹ While Dokko and Edelstein [1987a] provide supporting empirical evidence for the conjectures of Malkiel and Friend, Pindyck [1984] and Poterba and Summers [1986] contend different views. Pindyck suggests that even though increased stock return volatility accounts for the decline in stock prices during the recent inflationary period, the impact of inflation uncertainty on real stock prices is likely to be negligible. Poterba and Summers, in a critique of Malkiel and Pindyck, find that one cannot explain observed reductions in stock prices by increased stock return volatility. This finding hinges on two inter-related elements: (i) stock return volatility autocorrelation is sufficiently low, and (ii) over time stock return volatility has not substantially increased. However, neither Pindyck's nor Poterba and Summers' arguments are convincing. Pindyck's conclusion is based crucially on the erroneous assumption that real activity uncertainty is independent of inflation uncertainty.¹⁰ Poterba and Summers do not consider the impacts of inflation uncertainty, which has secularly and substantially increased during the post-1960 period, upon stock prices.

II. THE MODEL: RISK PREMIA AND UNCERTAINTY

Utilizing the capital asset pricing theory (CAPM), we generate an empirically testable relationship between inflation uncertainty and the required risk premium for common stocks. If risk averse investors hold nominally risk-free bonds and market portfolios of common stocks, the CAPM market equilibrium condition is¹¹

$$E[r_s - r_o] = \lambda \{ \text{COV}(r_o, r_s - r_o) + \alpha_s \text{VAR}(r_s - r_o) \} \quad (1)$$

where r_s and r_o are real after tax returns on common stocks and bonds, respectively; λ is the market price of risk; and α_s is the fraction of total wealth invested in common stocks.

In order to distinguish between inflation uncertainty and real uncertainty in equation (1), the unexpected real stock market return, $r_s - E[r_s]$, is assumed to be generated by a linear factor model, equation (2-a):

$$r_s - E[r_s] = b_s \pi^u + \epsilon_s; \text{COV}(\epsilon_s, \pi^u) \equiv 0 \quad (2-a)$$

where π^u is the unexpected inflation rate with mean zero and variance σ_π^2 ; $b_s = \text{COV}(r_s, \pi^u) / \sigma_\pi^2$; and ϵ_s has mean zero and variance σ_ϵ^2 . Earlier empirical works show that b_s is negative. Real uncertainty and inflation uncertainty are represented, respectively, by σ_ϵ^2 and σ_π^2 .

For a nominally fixed interest rate, the unexpected ex post component of the real interest rate, $r_o - E[r_o]$, is defined by equation (2-b):

$$r_o - E[r_o] \equiv -\pi^u. \quad (2-b)$$

Using equations (2),

$$\text{COV}(r_o, r_s - r_o) = -(1+b_s) \sigma_\pi^2 \quad (3-a)$$

$$\text{VAR}(r_s - r_o) = \sigma_\epsilon^2 + (1+b_s)^2 \sigma_\pi^2 \quad (3-b)$$

Hence, equation (1) can be rearranged to be equation (4):

$$E[r_s - r_o] = \lambda \alpha_s \sigma_\epsilon^2 + \lambda \{ (1+b_s)^2 \alpha_s - (1+b_s) \} \sigma_\pi^2 \quad (4)$$

Our analysis will determine the impact of inflation uncertainty on the required (ex ante) risk premium for common stocks (hereafter, referred to as the risk premium).¹² Equation (4) can be rewritten for convenience as equation (5):

$$E[r_s - r_o] = \beta_1 \sigma_\epsilon^2 + \beta_2 \sigma_\pi^2 \quad (5)$$

III. EMPIRICAL ANALYSIS

III.1. Data Base

Our raw data base for ex ante variables is the Livingston expectations surveys from June 1960 through June 1980.¹³ For each semi-annual survey, individual respondents generated six-month forward forecasts for the Consumer Price Index, the Industrial Production Index and the S&P Composite Index. From individual "level" predictions, forecasted "rates" can be computed;¹⁴ and for each survey, average forecasts for inflation, stock market, and industrial production (real output) are computed. The risk premium, PREM, is obtained by subtracting the six-month Treasury bill rate (at the beginning of the month in which the corresponding survey was conducted) from the expected stock market return.

The key estimated empirical relationships in our study depend upon the use of an appropriate measure for inflation uncertainty, σ_{π}^2 . We employ two alternative widely-used surrogates for inflation uncertainty: the cross-sectional variance of individual inflation forecasts (v_{π});¹⁵ and the forecast error of the previous inflation prediction ($|\hat{\pi}^u|$, i.e., the absolute value of the Livingston unexpected inflation rate). Finally, our surrogate measure for real output uncertainty, σ_{ϵ}^2 , is the cross-sectional variance of individual production forecasts (v_{ϵ}).

III.2. Inflation Uncertainty and the Risk Premium: Empirical Findings

Given our data base for the risk premium and the measures for inflation and real uncertainty, the empirical model analog for equation (5), the principal empirical-theoretical testing equation, will be equations (6):

$$\text{PREM}_t = c_0 + c_1 \log v_{\pi,t} + c_2 \log v_{\epsilon,t} \quad (6-a)$$

$$\text{PREM}_t = c_0 + c_1 |\hat{\pi}_{t-1}^u| D1_{t-1} + c_2 |\hat{\pi}_{t-1}^u| D2_{t-1} + c_3 \log v_{\epsilon,t} \quad (6-b)$$

where c's are parameters to be estimated; subscript t represents the time of the Livingston survey; the dependent variable represents the risk premium (in percentage); v_{π} is the cross-sectional variance of the Livingston inflation forecasts; v_{ϵ} is the cross-sectional variance of the Livingston production forecasts; $\hat{\pi}_{t-1}^u$ is the observed¹⁶ Livingston unexpected inflation rate (in percentage); D1(D2) is the dummy variable such that D1(D2) = 1 if $\hat{\pi}_{t-1}^u$ is positive (negative), or

zero otherwise.¹⁷ v_{π} and v_{ϵ} are transformed into logarithm to control for variable scale differences.

Figures I-a and I-b show graphically the relationships of the risk premium with measures of inflation uncertainty ($\log v_{\pi}$) and real uncertainty ($\log v_{\epsilon}$), respectively. In both charts, the risk premium tracks uncertainty measures relatively well in both the 1960's and the 1970's. These observations reinforce the hypothesis that uncertainty variables may be important explanations for observed changes in the risk premium over time. Figure I-c shows the relationship between the expected inflation level and inflation uncertainty. Since 1965 the expected inflation level has risen secularly; and similarly our inflation uncertainty measure also has risen secularly, but with more volatility. Collectively, Figures I-a and I-c suggest that it is crucial to sort independently the effects of expected inflation and inflation uncertainty on stock prices.

The regression results for equations (6), reported in Table I,¹⁸ confirm that the risk premium increases when uncertainty increases.¹⁹ In equations (6-b), we differentiate between inflation uncertainty (unexpected inflation) and deflation uncertainty (unexpected deflation). Inflation uncertainty has a statistically significant positive effect upon the risk premium; and deflation uncertainty does not (see, also, footnote 17). Also, our findings imply that common stocks are not, even relative to bonds, hedges against uncertain inflation; and contrast with a common claim that bond investment is riskier with respect to uncertain inflation than equity investment.²⁰

FIGURE I

TIME-SERIES OF THE RISK PREMIUM, INFLATION UNCERTAINTY,
 REAL UNCERTAINTY AND EXPECTED INFLATION
 JUNE 1960 THROUGH JUNE 1980

Figure I-a

Solid line: $E[R_s - R_0]$
 Dotted line: $\text{Log } V_\pi$
 Corr = 0.598

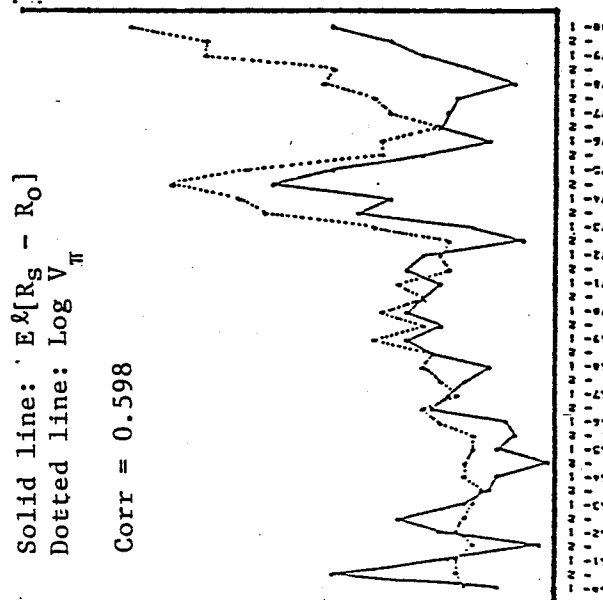


Figure I-b

Solid line: $E[R_s - R_0]$
 Dotted line: $\text{Log } V_\epsilon$
 Corr = 0.657

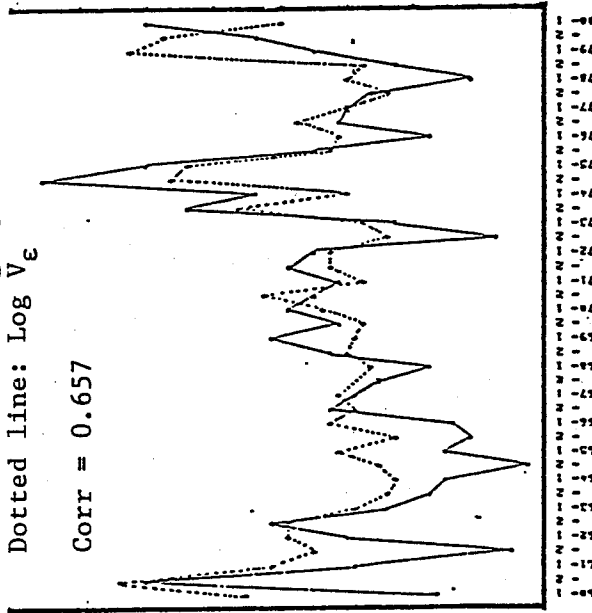
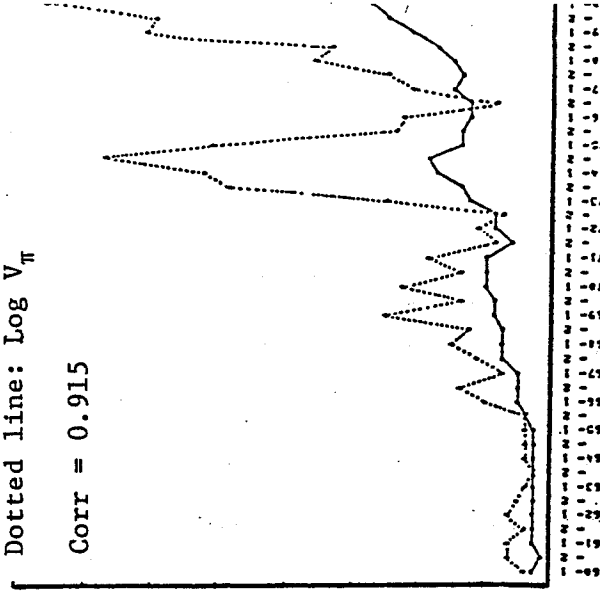


Figure I-c

Solid line: $E[V_\pi]$
 Dotted line: $\text{Log } V_\pi$
 Corr = 0.915



In order to test for the possibility of "reserve causality" from the risk premium to uncertainty variables, we employ statistical techniques similar to those suggested by Sims [1972].²¹ First, the results reported in Table II indicate that future values of PREM variables are significant in explaining the $\log v_{\pi}$ dependent variable, but future values of $\log v_{\pi}$ variables are not positively related to the PREM dependent variable. This finding is consistent with a uni-directional causality relationship from increased inflation uncertainty to increased risk premia.

Second, future values of PREM variables are not significant in explaining the $\log v_{\epsilon}$ dependent variable; and, also, the future values of $\log v_{\epsilon}$ are not significant in explaining the PREM dependent variable. This finding may indicate that even though the current $\log v_{\epsilon}$ variable is significantly related to the current PREM variable (the results reported in Table I), the impacts of real output uncertainty upon stock prices may not be "persistent." We now turn our analysis to the persistence of the impacts of changing uncertainty upon the risk premium and, thus, the stock price.

III.3. The Impact of Inflation Uncertainty Autocorrelation Upon Stock Prices

Ceteris paribus, increasing uncertainty over time tends to depress stock prices ex post, and thereby leads to lower ex post realized

TABLE I†

EMPIRICAL RELATIONSHIPS BETWEEN THE RISK PREMIUM
AND UNCERTAINTY
JUNE 1960 THROUGH JUNE 1980

Equation 6-a: $PREM_t = c_0 + c_1 \log v_{\pi,t} + c_2 \log v_{\epsilon,t} + c_3 TIME_t$

Eq.No.	c_1	c_2	c_3	\bar{R}^2	DW
6-a-1*	1.723 (4.045)	—	—	0.400	1.88
6-a-2*	—	2.474 (4.790)	—	0.451	1.80
6-a-3*	1.146 (3.337)	1.964 (4.041)	—	0.560	1.89
6-a-4	1.998 (3.349)	1.706 (3.443)	-0.081 (-1.780)	0.573	1.77

Equation 6-b: $PREM_t = c_0 + c_1 |\hat{\pi}_{t-1}^u| D1_{t-1} + c_2 |\hat{\pi}_{t-1}^u| D2_{t-1} + c_3 \log v_{\epsilon,t} + c_4 TIME_t$

Eq.No.	c_1	c_2	c_3	c_4	\bar{R}^2	DW
6-b-1	1.814 (4.653)	-1.324 (-0.651)	—	—	0.339	1.70
6-b-2	1.258 (3.732)	-0.132 (-0.079)	2.095 (4.614)	—	0.569	1.76
6-c-3	1.158 (2.596)	0.239 (0.120)	2.117 (4.563)	0.011 (0.346)	0.558	1.75

†t-statistics are in parentheses below estimated coefficients. Equations followed by * indicate that the regression is adjusted for first-order autocorrelation (using the Cochrane-Orcutt method). PREM and $\hat{\pi}^u$ are scaled by multiplying by 100 (i.e., in percentage).

TABLE II†

TESTS OF THE DIRECTION OF CAUSALITY BETWEEN THE RISK
PREMIUM AND UNCERTAINTY
JUNE 1961 THROUGH JUNE 1980

Panel A

Dep Var	Indep Future Var	No of Future Indep Vars	Sum of Coef Estimates (t-statistics)	F for Indep Vars
PREM	log v_{π}	3	-0.026 (-1.811)	2.088
		4	-0.015 (-1.750)	1.399
PREM	log v_{ϵ}	3	-0.003 (-0.219)	0.716
		4	0.005 (0.336)	0.494

Panel B

Dep Var	Indep Future Var	No of Future Indep Vars	Sum of Coef Estimates (t-statistics)	F for Indep Vars
log v_{π}	PREM	3	16.120 (2.500)	2.902
		4	13.281 (1.718)	2.006
log v_{ϵ}	PREM	3	3.048 (0.402)	0.637
		4	-4.763 (-0.542)	1.162

†All variables are prefiltered (see footnote 21).

returns for common stocks. Hence, the positive ex ante relationship between the risk premium and real output uncertainty and inflation uncertainty (see Table I) would imply a negative ex post relationship between stock prices and uncertainty. However, Poterba and Summers [1986] claim that because stock return volatility is not highly auto-correlated, the impacts of increased (e.g., 100 percent) stock return volatility upon stock prices would be neither substantial nor persistent.

In contrast with the analysis of Poterba and Summers, when we decompose stock return volatility into inflation uncertainty and production uncertainty (see equations 3), our analysis shows that an increase in inflation uncertainty will change stock prices. In order to understand the relationships among stock prices, inflation uncertainty and real output uncertainty, we examine the following GLS (Cochrane-Orcutt) regression for the June 1960 - June 1980 time period:²²

$$\begin{aligned} \log SP_t = \text{const} & - 0.063 \log v_{\pi,t} - 0.039 \log v_{\epsilon,t} + 0.830 \log DIV_t \\ & (-1.827) \quad (-1.588) \quad (4.062) \\ & - 0.725 \text{ TIME}_t \quad (\bar{R}^2 = 0.86) \\ & (-1.499) \quad (\text{DW} = 1.88) \end{aligned} \quad (7)$$

where SP is the S&P Composite Index (price level adjusted) at the end of June or December in each year, DIV is the real dividend paid (semi-annual), and TIME is the time trend variable.²³ In equation (7), the coefficient estimate for inflation uncertainty is statistically significant; while that for real output uncertainty is not.

The small (but statistically significant) coefficient estimate for inflation uncertainty (i.e., 0.063)²⁴ should not be ignored. Using

equation (7), the expected change in stock prices, caused by a change in inflation uncertainty, can be estimated. The average level of inflation uncertainty during the late 1970's (1975.12-1980.06) is approximately 8.2 times higher than that during the early 1960's (1960.06-1964.12).²⁵ This implies that the decline in real stock prices from the early 1960's through the late 1970's attributed to increased inflation uncertainty would be about 45 percent. Indeed, the S&P Composite Index (price level adjusted) declined by 49 percent from December 1964 to June 1980. In addition, the average change in inflation uncertainty ($\Delta v_{\pi}/v_{\pi}$) over a six-month period for the surveys from June 1960 through June 1980 is 20 percent. This implies that the average decline in stock prices due to increased inflation uncertainty over a six-month period is 1.26 percent; and, consequently, stock prices would be expected to decline by 40 percent from 1960 through June 1980. In fact, the S&P Composite Index (price-level adjusted) declined by 30 percent from December 1960 to June 1980.

Finally, around the "oil shock" period, inflation uncertainty for December 1974 is 8.6 times higher than that for December 1972. The expected decline in stock prices during the two year span attributed to increased inflation uncertainty would be 48 percent. During this period, the actual decline in the (price-level adjusted) S&P Composite Index was 52 percent. In brief, the observed declines in real stock market prices from the early 1960's to the early 1980's appear to be influenced strongly by secularly and substantially increased inflation uncertainty.

III.4. Real Output Changes, Inflation Uncertainty, and Stock Market Fluctuations

We explain the observed stock market fluctuations during the post-1960 period as a function of changes in real output and inflation uncertainty. To do this, we use a simple stock valuation model, equation (8):

$$SP_t = E_t PX_{t+1} / E_t r_{s,t+1} \quad (8)$$

where PX is the real output level represented by the Industrial Production Index; and Er_s is the real required rate of return for common stocks.

By the logarithmic differentiation of equation (8) with respect to time, equation (9) is derived:²⁶

$$\begin{aligned} \Delta \log SP_t &= c_0 + c_1 \log(E_t^l PX_{t+1} / PX_t) \\ &+ c_2 \{ \Delta \log PX_t - \log(E_{t-1}^l PX_t / PX_{t-1}) \} \\ &+ c_3 \Delta \log E_t^l r_{s,t+1} \end{aligned} \quad (9)$$

where E^l is the Livingston expectations operator; and the change in the real required return for common stocks ($\Delta \log Er_s$) is proxied by the unanticipated changes in inflation uncertainty ($\Delta^u \log v_\pi$) and/or real output uncertainty ($\Delta^u \log v_e$).²⁷

The regression results for equation (9) in various specifications, reported in Table III, confirm the ex post consequences of the ex ante findings in Table I for equations (6) as well as the claimed consistency between the Livingston ex ante data and the market ex post data.

First, as would be theoretically expected, stock prices are determined principally by expectations about future real activity; and this real output effect is statistically significant irrespective of the presence of the uncertainty variables.

Second, an unanticipated change in production uncertainty does not have a statistically significant effect on ex post stock price changes (equations 9-c, 9-d, 9-f, and 9-g). This is consistent with the statistically insignificant coefficient estimate for real production uncertainty in equation (7) (see, also, footnote 23).

Third, an unanticipated increase in inflation uncertainty has a statistically significant, depressant effect on ex post stock price changes even when controlling for real output (equations 9-e and 9-g). This finding explains how Fama [1981] observes a "non-spurious" negative relationship between ex post stock market returns and unexpected inflation, controlling for real activity; a contradiction to his "proxy effect" hypothesis.²⁸ We contend that this relationship can be explained by taking into account inflation uncertainty.

Fourth, equation (9-e), controlling for both real output and inflation uncertainty, shows the best fit among the regressions in Table III; almost 50 percent of the variability in ex post stock price changes are explained by changes in inflation uncertainty and real output. In brief, our findings in Table III confirm that stock price changes, in spite of wide fluctuations during the post-1960 period, are "economic."

TABLE III†

REGRESSION RESULTS OF EQUATION (9)
JUNE 1960 THROUGH JUNE 1980

$$\Delta \log SP_t = c_0 + c_1 \log(E_t^L PX_{t+1}/PX_t) + c_2 \{\Delta \log PX_t - \log(E_{t-1}^L PX_t/PX_{t-1})\} + c_3 \Delta^u \log v_{\pi,t} + c_4 \Delta^u \log v_{\epsilon,t}$$

Eq.No.	c ₁	c ₂	c ₃	c ₄	R ²	DW
9-a	2.589 (5.126)	3.529 (4.999)	--	--	0.432	1.99
9-b	--	--	-13.798 (-4.161)	--	0.282	2.05
9-c	--	--	--	-3.840 (-1.176)	0.025	2.01
9-d	--	--	-13.378 (-3.929)	-1.930 (-0.690)	0.272	2.07
9-e	1.986 (3.554)	3.020 (3.839)	-7.048 (-2.141)	--	0.481	2.01
9-f	2.537 (4.634)	3.532 (4.448)	--	-0.742 (-0.269)	0.418	1.99
9-g	1.945 (3.274)	3.019 (3.784)	-7.037 (-2.106)	-0.570 (-0.216)	0.467	2.01

†: All regressions are adjusted for first-order autocorrelation of residuals (using the Cochrane-Orcutt method). t-statistics are in parenthesis below the estimated coefficients. $\Delta \log SP_t$, $\log(E_t^L PX_{t+1}/PX_t)$, and $\{\Delta \log PX_t - \log(E_{t-1}^L PX_t/PX_{t-1})\}$ are scaled by multiplying by 100.

III.5. Expected Inflation and the Risk Premium: Empirical Findings

If, as is assumed in some quarters, expected inflation is neutral, the risk premium (and, thus, the real stock price) should not be affected by expected inflation. However, a "simple" positive correlation between the risk premium and expected inflation might occur because of the high correlation between expected inflation and inflation uncertainty. This is shown by the following GLS (Cochrane-Orcutt) regression:

$$\text{PREM}_t = \text{const} + 0.645 E_t^L \pi_{t+1} + 2.212 \log v_{\epsilon,t} \quad (\bar{R}^2 = 0.50) \quad (10)$$

(2.306) (4.392) (DW = 1.89)

where $E_t^L \pi$ is the Livingston forecast for inflation.

In order to obtain a "true" statistical relationship, OLS regression (11) controls for inflation uncertainty:

$$\text{PREM}_t = \text{const} - 0.693 E_t^L \pi + 1.945 \log v_{\pi,t} + 1.975 \log v_{\epsilon,t} \quad (11)$$

(-1.329) (2.703) (4.216)

$$(\bar{R}^2 = 0.56, \text{DW} = 1.70)$$

Therefore, the observed positive relationship between the risk premium and expected inflation in equation (10) appears to be spurious. Equation (11) suggests that expected inflation by itself does not depress real stock prices.²⁹

III.6. Uncertain Inflation and Earnings Before Corporate Tax: Tax Effects and Money Illusion Hypotheses

We believe that increased uncertain inflation reduces real earnings before corporate tax. To the extent this is true, of course, stock prices are affected by uncertain inflation.

To explain the interrelationships among stock prices, uncertain inflation and before tax earnings, we introduce a reduced form generating process for the real return on the firm's assets, r_a , equation (12), similar to that developed by Lucas [1973]:³⁰

$$r_a = E[r_a] + b_a \pi^u + \mu; \text{COV}(\pi^u, \mu) \equiv 0 \quad (12)$$

where $b_a = \text{COV}(\pi^u, r_a) / \sigma_\pi^2$, and μ has mean zero and finite variance.

In this model, the empirical value of b_a is the key determinant for the relationship between uncertain inflation and real stock returns.

Assuming that the firm does not pay nominal capital gains taxes, the firm's after tax income will be $(1-t_c)r_a V - [(1-t_c)R_o - \pi]D$, where V , D , and S are the values of the firm's total assets, debt, and equity, respectively; and t_c is the corporate income tax rate. If firms pay capital gains taxes ($g_c \pi V$; where g_c is the "effective" corporate capital gain tax rate), corporate income available to shareholders is $(1-t_c)r_a V - [(1-t_c)R_o - \pi]D - g_c \pi V$.

Shareholder after (personal) tax income will be $(1-t_p)\{(1-t_c)r_a V - [(1-t_c)R_o - \pi]D - g_c \pi V\} - g_p \pi S$;³¹ where t_p is the personal income tax rate, g_p is the effective personal capital gains tax rate, and πS is the nominal capital gain on equity investment. Therefore, b_s can be expressed as:

$$b_s = \theta_p \{\theta_c b_a V/S + D/S - g_c V/S\} - g_p \quad (13)$$

where $\theta_p = 1-t_p$, and $\theta_c = 1-t_c$.

The positive relationship between the risk premium and inflation uncertainty implies that assuming $\alpha_s = 2/3$, b_s is less than -1 or

greater than 0.5 (see equation 4). The negative b_s is consistent with empirical observations; and, then, b_a in equation (12) will be less than $(-2 + 3\theta_p g_c + 2g_p - \theta_p)/3\theta_p c$. If pseudo nominal capital gains are taxed as ordinary income ($g_p = t_p$ and $g_c = t_c$), b_a will be less than -1. If nominal capital gains escape taxation ($g_c = g_p = 0$), b_a will be less than about -2.4 (assuming $t_p = .25$ and $t_c = .5$). Therefore, b_a must be less than -1, irrespective of effective tax rates on nominal capital gains.

This result contrasts with the positions of Feldstein [1980] and Summers [1981] that inflation depresses real stock prices because nominal capital gains taxation with "historic cost" methods of depreciation causes a decline in expected real earnings after tax. Summers, regressing real stock returns on changes in expected inflation, allegedly proves his position by finding that the coefficient for the change in expected inflation is statistically significantly negative. However, because expected inflation is highly correlated with inflation uncertainty, the tax effect hypothesis may not be tested using Summers' statistical model.

Our position is statistically confirmed by the following GLS (Cochrane-Orcutt) regressions:

$$r_{s,t} = \text{const} - 12.707 \Delta E_t^L \pi \quad (\bar{R}^2 = 0.14) \quad (14-a)$$

(-2.564) (DW = 2.00)

$$r_{s,t} = \text{const} - 4.128 \Delta E_t^L \pi$$

(-0.748)

$$- 10.702 \Delta^u \log v_\pi \quad (\bar{R}^2 = 0.24) \quad (14-b)$$

(-2.610) (DW = 2.00)

where r_s is the semi-annual real rate of return on the S&P Composite Index.

The results in equations (14-a) and (14-b) represent ex post consequences of our ex ante findings in equations (10) and (11), respectively. In equation (14-b), the coefficient estimate for the change in expected inflation is statistically insignificant (though negative), and cannot be used to support the tax effect hypothesis. In brief, prior claims about the importance of the tax system for determining real stock values may be overstated.³²

Another implication of the effects of inflation uncertainty on real earnings before corporate taxes relates to the empirical test of the nominal contracting hypothesis: unexpected inflation, through changes in subsequent expectations, will redistribute wealth from bondholders to shareholders. Our analysis indicates that unexpected inflation, a concomitant of increased inflation uncertainty, may affect the firm's value (equity plus debt) through two interrelated channels: (i) real earnings before corporate taxes decline, and (ii) the real required rate of return for equity increases. Although inflation will cause the real value of corporate debt to decline, the decrease in real earnings before corporate tax and/or the increase in the real required rate of return for common stocks may offset the net wealth redistribution effect.

Earlier studies (see footnote 5) do not provide supporting evidence for the nominal contracting hypothesis. Modigliani and Cohn [1979] attribute this to irrational investor behavior. Our analysis suggests that earlier studies, by neglecting the effects of uncertain inflation

on the firm's operating income, do not test adequately the nominal contracting hypothesis.³³

IV. SUMMARY

The key finding of this paper is that the required risk premium for common stocks has increased because of increased inflation uncertainty during the post-1960 period, resulting in relatively depressed real stock prices. The increase in the risk premium occurred because increased inflation uncertainty has apparently increased the riskiness of real earnings before corporate tax.

Based upon this principal finding, we further suggest that (i) observed stock market fluctuations are "economic," i.e., can be explained by changes in real output and inflation uncertainty; (ii) the expected inflation level itself, controlling for inflation uncertainty, does not depress real stock prices; and (iii) prior claims about the importance of nominal capital gains taxation for determining stock values may be overstated.

Our research leaves open several important questions. First, our analysis does not identify the "sources" of changes in perceived uncertainty about future inflation. Second, there is a clear area for future research: the study of the relationship among economic policy variables, real economic variables and their uncertainty, inflation uncertainty, and stock prices.

FOOTNOTES

1. This finding has been well documented by a number of studies since Lintner [1975]. See, for example, Fama [1981] and Friend and Hasbrouck [1982] and the references therein.
2. Geske and Roll [1983], among others, describe the negative relationship in three different ways: realized stock market returns are negatively related to (i) expected inflation (at the beginning of the time period), (ii) changes in the expected inflation rate (during the time period), and (iii) lagged and contemporaneous unexpected inflation rates.
3. See, for example, Okun [1971], Logue and Willet [1976], Cukierman and Wachtel [1979], Fischer [1981], Taylor [1981], Hafer and Heyne-Hafer [1981], and Pegan, Hall and Trivedi [1983], among others.
4. In addition, fewer firms than might have been expected have actively changed from FIFO to LIFO. This suggests that the tax cost associated with the FIFO method is probably insignificant: recent accounting literature suggests that signaling benefits from FIFO may exceed tax benefits from LIFO (see Jung [1986] and Hughes and Schwartz [1987]). Also, note that the U.S. tax laws do not allow the use of different inventory valuation methods for financial and tax purposes.
5. See, for example, French, Ruback and Schwert [1983] and the references therein.
6. Ram and Spencer [1983], in response to Fama, show positive relationships between real activity measures and expected inflation. Even though Fama [1981] suggests a negative relationship between real economic activity and expected inflation, as shall be seen later, one needs to distinguish between the level of actual/expected inflation and the degree of inflation uncertainty. Though beyond the scope of this paper, it would seem worthwhile to examine the relationship between real economic activity and expected inflation controlling for inflation uncertainty. For example, Makin [1982] shows strongly positive relationships between real activity and anticipated money growth (a proxy for expected inflation) controlling for inflation uncertainty.
7. Fama observes non-spurious negative relationships between unexpected inflation and stock returns in spite of controlling for real activity variables. This finding might contradict his proxy effect hypothesis. See, also, footnote 28.
8. For example, Rogalski and Vinso [1977] show a "bi-directional" causality between stock returns and money supply.

9. Klemkosky and Jun [1982] find weak evidence that variability of stock market returns increases with the variance of money growth rates.
10. See Dokko and Edelstein's [1987b] clarifying evidence using Pindyck's data.
11. See, for example, Friend and Blume [1975].
12. Equation (4) can be used to derive the "generalized" Fisher equation which has the expected pre-tax nominal return on common stocks as the dependent variable. Empirically, it is difficult to estimate the generalized Fisher equation because real interest rates may not be constant over time (for example, see Mishkin [1981]) or may be correlated with inflation (for example, see Mundell [1963], Tobin [1965] and Startz [1981]). See, also, Dokko and Edelstein [1987a].
13. Brown and Maital [1981] and Caskey [1985], among others, examine the characteristics of the Livingston forecasts. Recognizing the details of the survey procedure, Brown and Maital provide supporting evidence for the informational efficiency of the Livingston stock market forecasts; and Caskey demonstrates optimal forecasting behavior (a Bayesian learning model) from the Livingston inflation forecasts.

Our OLS regression analysis strongly supports the unbiasedness of the Livingston stock market forecasts (from the June 1960 survey through the June 1980 survey):

$$R_t = -0.007 + 1.051 E_{t-1}^L R_t \quad (\bar{R}^2 = 0.07) \quad (F13)$$

(0.024) (0.567) ($\rho = -0.13$)

where standard errors are in parentheses below coefficient estimates, the explanatory variable is the Livingston stock market forecast, the dependent variable is the corresponding ex post stock market return, and ρ is the first-order autocorrelation of the residual.

The Livingston surveys seem to be appropriate to represent the overall market; according to Ahlers [1977], the institutions with which the respondents were affiliated have accounted for more than sixty percent of all stock market exchange trading during the late 1960's and through the early 1970's. Details about the Livingston data base and survey procedure can be obtained by contacting the authors.

14. The procedures for computing forecasted rates are described in Carlson [1977] and Gultekin [1983].

15. Cukierman and Wachtel [1979] demonstrate that the inflation uncertainty measure can be proxied by the cross-sectional variance of inflation forecasts. Bomberger and Frazier [1981] present empirical evidence that the Livingston cross-sectional variance is an internally consistent measure of inflation uncertainty.
16. Let the subscript $t-1$, for example, represent the December 1980 survey. $\hat{\pi}_t^u$ is defined as the unexpected inflation rate from the beginning of January 1981 to the end of June 1981 (i.e., the forecast error of the inflation prediction of the December 1980 survey). Note that this forecast error was not observed when the June 1981 survey (represented by the subscript t) was conducted late May or early June of that year.
17. Fischer [1981] shows that the effects of unexpected inflation on the increase in the variance of relative price changes are greater than those of unexpected deflation. Hence, it is useful to differentiate between the unexpected inflation forecast error (inflation uncertainty) and the unexpected deflation forecast error (deflation uncertainty).
18. In order to control for the possibility of temporal trends in equations (6), a time trend variable (TIME: 1960.06 = 0.01, etc.) has been introduced into the regressions. The regression results, after controlling for the possible time effect, are virtually unchanged.
19. Shiller [1981] argues that the observed stock market volatilities, larger than those jointly implied by rational valuation and a constant discount rate, are attributed to investor irrational behavior. LeRoy and LaCivita [1981] and Michener [1982] show that Shiller's variance bound may not exist when the discount rate is not a constant. Also, Kleidon [1986] suggests that even though investors know the parameters which determine the distribution of future dividends, there is sufficient uncertainty which causes a large divergence between the stock market price and the ex post perfect foresight price. Our findings suggest that the risk premium and, thus, the stock price are sensitive to uncertainty about the future, which would support the results of these studies.
20. For example, an earlier work by Gordon and Halpern [1976] claims that "an increase in the uncertainty of the inflation will result in a reduction of the expected risk premium (p. 563)." However, they assume that real returns on non-monetary assets are independent of inflation, and consider the effect of inflation uncertainty only on the required rate of return for bonds. Pindyck [1984] also claims that volatility of inflation "makes bonds relatively riskier, and should therefore increase share values

(p. 336)." But Pindyck's suggestion is also derived from the assumption that the real productivity risk is independent of the inflation risk.

21. Because the assumption of serially uncorrelated residuals is important in the Sims test of the direction of causality, all variables are prefiltered assuming an AR(1) process which appears to be an appropriate description of the data series. The OLS regression results are:

$$\text{PREM}_t = 0.007 + 0.421 \text{PREM}_{t-1} \quad (\bar{R}^2 = 0.15) \quad (\text{F22-a})$$

(1.793) (2.901) (\rho = 0.07)

$$\log v_{\pi,t} = -1.100 + 0.892 \log v_{\pi,t-1} \quad (\bar{R}^2 = 0.72) \quad (\text{F22-b})$$

(-1.208) (10.415) (\rho = -0.11)

$$\log v_{\epsilon,t} = -4.950 + 0.412 \log v_{\epsilon,t-1} \quad (\bar{R}^2 = 0.15) \quad (\text{F22-c})$$

(-4.040) (2.847) (\rho = 0.01)

where t-statistics are in parentheses below coefficient estimates, and ρ is the first-order autocorrelation of the residual. For the use of separate prefilters, see Pierce and Haugh [1977].

22. Hereafter, all regressions are run for the June 1960 - June 1980 time period; and t-statistics are in parentheses below coefficient estimates.
23. DIV and TIME are included to control for the long-run growth trend. Exclusion of the DIV and TIME variables does not alter the regression result:

$$\log \text{SP}_t = \text{const} - 0.112 \log v_{\pi,t} - 0.026 \log v_{\epsilon,t} \quad (\bar{R}^2 = 0.81) \quad (\text{F23})$$

(-3.229) (-0.940) (DW = 2.26)

24. This magnitude can be found in a similar context of the analysis of Poterba and Summers. It can be shown that

$$\frac{\partial \log \text{SP}_t}{\partial \log \sigma_{\pi,t}^2} = \frac{-\alpha_{\pi,t} - \gamma(\partial \sigma_{\epsilon,t}^2 / \partial \log \sigma_{\pi,t}^2)}{1 + E_t[r] - \rho_1^{\pi}(1+g)} \quad (\text{F24})$$

where α_{π} is the risk premium attributed to inflation uncertainty, γ is the risk aversion parameter, $E[r]$ is the real required return

for common stocks, ρ_1^{π} is the first-order autocorrelation of inflation uncertainty, and g is the growth rate of the real dividend. Our data yields the average values (semi-annual) of α_{π} and $E[r]$ are, respectively, 0.012 and 0.032; and $\partial \sigma_{\epsilon,t}^2 / \partial \log \sigma_{\pi,t}^2$ is 0.708×10^{-4} (regression result with t-statistic of 2.088). Assuming $\gamma = 3.5$ and $g = 0.005$ (following Poterba and Summers), $\partial \log \text{SP} / \partial \log \sigma_{\pi}^2$ is -0.059.

25. The average levels of v_{π} for the first 10 surveys (1960.06-1964.12) and the last 10 surveys (1975.12-1980.06) are, respectively, 8.98×10^{-6} and 7.36×10^{-5} .

$$26. \quad SP_t / SP_{t-1} = \frac{E_t PX_{t+1}}{E_{t-1} PX_t} \div \frac{E_t r_{s,t+1}}{E_{t-1} r_{s,t}}$$

$$= \frac{E_t PX_{t+1}}{PX_t} \times \left[\frac{PX_t}{PX_{t-1}} \div \frac{E_{t-1} PX_t}{PX_{t-1}} \right] \div \frac{E_t r_{s,t+1}}{E_{t-1} r_{s,t}} \quad (F26)$$

27. See footnote 21 for the estimation procedures for $\Delta^u \log v_{\pi}$ and $\Delta^u \log v_{\epsilon}$.
28. Fama attributes this finding to possible measurement errors in real activity variables; and suggests using ex ante survey activity variables. Because our real activity variables (observed from the Livingston surveys) explain more than forty percent of the variability of ex post stock price changes (equation 9-a in Table III), measurement error problems with real activity variables in our study do not appear to be serious, and the negative coefficient estimate for the change in inflation uncertainty, controlling for real activity, is not spurious.
29. The negative coefficient for expected inflation in equation (11) (though statistically not significant) is consistent with the Mundell-Tobin wealth effect hypothesis. That is, when expected inflation increases, the opportunity cost of holding near-money financial assets (bonds) increases relative to that of more distant-money financial assets (common stocks). This leads to an increase in the demand for common stocks relative to that for bonds. For more empirical evidence, see Dokko and Edelstein [1987a].
30. Changes in price uncertainty may cause a change in the firm's production function, or a shift in demand for its output. Uncertainty about the future, induced by uncertainty about price changes, is likely to change the firm's investment decision. Similarly, consumers may alter consumption-saving decisions because of perceived changes in price uncertainty. We view the asset return generating function as a reduced form of the production and demand functions, represented by a linear factor model such as equation (12).
31. For analytic convenience, a 100% dividend payout ratio is implicitly assumed. Consideration of retained earnings (and, thus, "real" capital gains due to growth opportunity) is eliminated in order to focus on the effect of "psuedo" profit taxes ($g_c \pi V$ and $g_p \pi S$) on the stock price.

32. See Friend and Hasbrouck [1982b] for another critique of the tax effect hypothesis. Note that we do not reject the effects of nominal capital gains taxation on stock prices at the micro-firm level (see Dokko [1987]).
33. See Dokko [1987] for the discussion of recent empirical tests of the nominal contracting hypothesis.

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