THE HECKMAN BINDERY, INC.
North Manchester, Indiana

KRL

H or V	JUST	FONT	SLOT	TITLE
H	CC	1W	22	BEBR
			21	FACULTY
			20	WORKING
			19	PAPER
H	CC	1W	8	1989
			7	NO.1540-1554
H	CC	1W		330
				B385<'CV">
				no.1540-1554
				cop.2
H	CC	7W		<IMPRINT>
				U. of ILL.
				LIBRARY
				URBANA

BINDING COPY

PERIODICAL ☐ CUSTOM ☐ STANDARD ☐ ECONOMY ☐ THESIS
BOOK ☐ CUSTOM ☐ MUSIC ☐ ECONOMY AUTH. 1ST ☐
NO VOLS. THIS TITLE | LEAD ATTACH.

ACCOUNT	LIBRARY	NEW	RUB OR SAMPLE	TITLE I.D.	FOIL	COLOR MATERIAL
56672	001			5632	WHT	488

ACCOUNT NAME
UNIV OF ILLINOIS

ACCOUNT INTERNAL I.D. | ISSN.
B01912400

I.D. #2 | NOTES | BINDING FREQUENCY | WHEEL | SYS. I.D.
STX3 | | | 1 | 3 | 39256

COLLATING
35

ADDITIONAL INSTRUCTIONS
Dept=STX3 Lot=#20 Item=142 HNM=1BY
1CR2ST3CR MARK BY # B4 91

SEP SHEETS	PTS. BD PAPER	TAPE STUBS	CLOTH EXT.	FILLER GUM	STUB

LEAF ATTACH

POCKETS: PAPER | BUCK | CLOTH — SPECIAL PREP

INSERT MAT | ACCOUNT LOT NO #20 | JOB NO HY363

PRODUCT TYPE 11 | ACCOUNT PIECE NO 142 | PIECE NO 91

HEIGHT 11 | GROUP CARD 1 | VOL THIS TITLE

COVER SIZE X

0012475

BEBR
FACULTY WORKING
PAPER NO. 89-1553

Asset Prices, Market Fundamentals, and Long Term Expectations: Some New Tests of Present Value Models

Louis O. Scott

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois Urbana-Champaign

BEBR

FACULTY WORKING PAPER NO. 89-1553

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

April 1989

Asset Prices, Market Fundamentals, and Long Term Expectations:
Some New Tests of Present Value Models

Louis O. Scott, Assistant Professor
Department of Finance

ASSET PRICES, MARKET FUNDAMENTALS, AND LONG TERM EXPECTATIONS: SOME NEW TESTS OF PRESENT VALUE MODELS

We present some new tests of present value models which allow for variability in interest rates and risk premia. Our approach is to use several different models to incorporate discount rate variation into our calculation of ex post market fundamentals. We apply a regression test to determine whether asset prices are unbiased predictors of ex post market fundamentals. The tests are applied to stock prices and bond prices and we find that bond prices pass the tests for unbiased prediction, but stock prices do not. The tests for bond prices provide us with additional evidence on the state of long term expectations.

ASSET PRICES, MARKET FUNDAMENTALS, AND LONG TERM EXPECTATIONS: SOME NEW TESTS OF PRESENT VALUE MODELS

A number of empirical studies, beginning with the work of Shiller (1981) and LeRoy and Porter (1981), have produced evidence that stock prices exhibit excess volatility. The econometric techniques of the original studies have been criticized, but subsequent research, in reaction to the criticism, has continued to produce evidence of excess volatility. The interpretations of these results are numerous and varied. Some of the interpretations maintain the validity of rational expectations while others emphasize irrational behavior in the stock market. Most of the empirical tests are based on a constant discount factor model, and it has been observed that risk aversion and variation in discount rates could be responsible for the apparent excess volatility.[1] By contrast, Shiller (1984) and Summers (1986) have interpreted the results as evidence of fads or irrational departures of stock prices from the underlying market fundamentals. Another related interpretation which has received considerable attention is the possibility of "rational" speculative bubbles. These last two interpretations can be traced back to the analysis of Keynes in Chapter 12, "Long Term Expectation," of The General Theory. Keynes described the behavior of the stock market as irrational and compared it to a "game of Snap, of Old Maid, of Musical Chairs."

Early in Chapter 12, Keynes made a distinction between short-term and long-term expectations, but he placed his emphasis on the state of long-term expectations. Another possible interpretation of the empirical results on stock market volatility is that the market does not form long-term expectations rationally. The present value model incorporates expectations over a very long time horizon and the rational behavior of long-term expectations is part of the null hypothesis being tested. Many researchers have found that stock price changes and rates of return over short time intervals are difficult to predict, and the evidence of serial correlation in short-period returns has not been sufficient to warrant rejection of the efficient markets hypothesis or the rationality of short-term expectations.[2] Recently, Fama and French (1988a) have found that serial correlation in returns becomes greater in magnitude as we extend out to several years the time horizon over which returns are calculated. Their results cast some doubt on the behavior of medium-term expectations, but they point out that this correlation can be explained by variation in expected returns.

In this paper we address two issues. First, we develop alternative versions of the present value model for asset prices to incorporate variation in discount rates. We do this by incorporating variation in short-term interest rates and risk premia, and our alternative models do not require linear approximations. Second, we provide indirect evidence on the behavior of long-term expectations by applying the tests to bond prices as well as stock prices. The present value models for both long-term bonds and stocks incorporate expectations about the distant future. Long-term bonds, however, are different because they have a natural terminal condition, maturity, which can be used to rule out the possibility of a rational speculative bubble. Testing the present value model for bond prices provides additional evidence on the behavior of long-term expectations. If the present value model is rejected for both stocks and long-term bonds, then we interpret the results as evidence against the rationality of long-term expectations. If the present value model is rejected for stocks, but not for long-term bonds, we can conclude that the cause is not so much the state of long-term expectations, but rather something unique to the stock market. To foreshadow our results, we note that Keynes, toward the end of Chapter 12, altered his view of long-term expectations:

> We should not conclude from this that everything depends on waves of irrational psychology. On the contrary, the state of long-term expectation is often steady, and, even when it is not, the other factors exert their compensating effects.

I. Alternative Tests of Present Value Models

Our first objective is to incorporate variation in interest rates and risk premia into tests of asset prices and market fundamentals. We use two different approaches. The first one is to use a model based on single period discount rates and the second one is to use an intertemporal capital asset pricing model (CAPM) with estimates of the marginal rate of substitution (MRS). We present the model with single period discount rates first because it is easier to present and interpret. We start from the definition of the single period discount rate:

$$(1+k_t) \equiv E_t(1+R_{t+1}) = E_t\left(\frac{P_{t+1} + D_{t+1}}{P_t}\right),$$

where k_t is the one period rate for the asset, P_t is the price at the end of period t, and D_{t+1} is the dividend or cash flow received on the asset during period (t+1). We assume that dividends are received at the end of the period. E_t indicates the expectation conditional on information available at time t, $E_t(\cdot) = E(\cdot|I_t)$. We place a time subscript on the discount rate to allow for variation over time. We rearrange the equation so that it is a stochastic difference equation for price:

$$P_t = \left(\frac{1}{1 + k_t}\right)[E_t(P_{t+1})+E_t(D_{t+1})]. \tag{1}$$

A solution for prices in equation (1) is

$$P_t = E_t\left[\sum_{j=1}^{\infty} \frac{D_{t+j}}{\prod_{i=0}^{j-1} (1+k_{t+i})}\right]. \tag{2}$$

We emphasize that this is not the only solution to equation (1) because there is an arbitrary term or bubble that can be added to the solution in (2) if we are applying the model to stocks. Without an additional boundary or terminal condition, we do not have a unique solution to equation (1). The solution in equation (2) is the one that we generally associate with efficient capital markets and stock market rationality. The solution in (2) states that asset prices reflect the conditional expectation of discounted future cash flows and we shall refer to the right side of (2) as the market fundamental. We also note that equations (1) and (2) apply to either nominal prices and dividends or real prices and dividends, depending on how we define the discount rates. For convenience, we use nominal prices and dividends with nominal discount rates.

When the model in (2) is applied to bonds which are known to mature at a future date, we have

$$P_t = E_t\left[\sum_{j=1}^{N} \frac{D_{t+j}}{\prod_{i=0}^{j-1}(1+k_{t+i})}\right] = E_t\left[\sum_{j=1}^{N} \frac{C}{\prod_{i=0}^{j-1}(1+k_{t+i})} + \frac{\$100}{\prod_{i=0}^{N-1}(1+k_{t+i})}\right],$$

where C is the regular coupon payment, N is the number of periods to maturity, and par value is set at \$100. Maturity serves as a natural terminal condition which can be used to rule out the possibility of a rational bubble in bond prices.

Our tests are based on methods which have been applied in the literature.[3] We define the ex post market fundamental as follows:

$$P_t^* = \sum_{j=1}^{\infty} \frac{D_{t+j}}{\prod_{i=0}^{j-1}(1+k_{t+i})} .$$

If asset prices reflect market fundamentals only, then we have $P_t^* = P_t + \varepsilon_t$, where ε_t is a forecast error uncorrelated with P_t. The initial tests of this model by Shiller and LeRoy and Porter focused on the variances of P_t^* and P_t. More recent tests by Scott (1985), Campbell and Shiller (1987), and Shiller (1988) have focused on the implied regression relationship.[4] According to the efficient markets model, the asset price should be an unbiased predictor of the ex post market fundamental. In a regression of P_t^* (or P_t^* appropriately transformed) on P_t (or P_t with the same transformation), the slope coefficient on P_t should equal one and the intercept should equal zero. If asset markets experience excess volatility and tend toward overvaluation, then the slope coefficient will be less than one and the intercept will be greater than zero. If the asset price contains the addition of a significant noise term, as in the model of Summers (1986), then the regression has a classical measurement error interpretation and the slope coefficient will be less than one.

Our tests are based on the following simple regression:

$$P_t^* = a + bP_t + e_t. \tag{3}$$

We formally test whether asset prices are unbiased predictors of ex post market fundamentals by testing the null hypothesis that a = 0 and b = 1. To construct a valid statistical test for this model, we must address several important econometric issues. The first and most obvious is the measurement of P_t^*. The measurement of k_t, the one-period discount rate contained in P_t^*, is discussed below. Given measurements or estimates of the one-period discount rates, one must calculate P_t^* from a finite sample. If we apply the model to bonds we simply start at maturity and work backwards. For stocks and bonds that mature after the end of the sample period, we compute P_t^* as follows:

$$\hat{P}_T^* = \frac{P_{T+1} + D_{T+1}}{(1+k_T)}$$

$$\hat{P}_t^* = \frac{\hat{P}_{t+1}^* + D_{t+1}}{(1+k_t)}, \text{ for } t=1, \ldots, T-1.$$

Because $P_t = E_t(\hat{P}_t^*)$, the regression relation holds whether we use P_t^* or our measurement $\hat{P}_t^*$. The second concern is the serial correlation of the forecast error in (3) and we must account for this correlation in the computation of standard errors for the parameter estimates.[5] The problem is similar to one encountered by Hansen and Hodrick (1980). With long-term bonds and stocks the autocorrelation in the error term extends over many periods and we use the spectral method described in Scott (1985) to compute the appropriate asymptotic standard errors. The last issue concerns the time series behavior of P_t^* and P_t. Kleidon (1986) and Marsh and Merton (1986) have noted that the variance bounds tests are not valid if the time series are not stationary. Most of the asymptotic results for least squares regression also require that the time series be stationary. The tradition in the finance literature has been to model stock prices and dividends as time series that grow over time and to treat percentage changes as stationary time series. As long as firms continue to pay dividends the model implies that price-dividend ratios are also stationary.[6] We use the annual dividend $\overline{D}_t$, which is dividends accumulated over the year ending with period t, to deflate our time series. With stock price data we run the following regression:

$$\hat{P}_t^*/\overline{D}_t = a + b\, P_t/\overline{D}_t + e_t \tag{4}$$

where $P_t/\overline{D}_t$ is the price-dividend ratio which we treat as a stationary time series.

In our analysis of Treasury bonds, we compare $\hat{P}_t^*$ with P_t for different maturities over time. For example, we define one maturity group as ten-year bonds. To construct the price series, we start with an 11 or 12 year bond and follow it for several years until the time-to-maturity is down to nine years. At that point we switch to another 11 or 12 year bond and continue. We have four different maturity groups, and over the period 1932 to 1985, we observe no long-term trends up or down in either the price or the corresponding P_t^* series. As interest rates move up and down, the coupons on new bonds are adjusted to reflect current market rates. We also note that P_t is bounded between zero and the sum of the remaining cash flows. The lower bound of zero is obvious (extremely large interest rates), and the upper bound results from a restriction that nominal interest rates cannot drop below zero. For these reasons, we treat prices and ex post market fundamentals for bonds as stationary series and apply the regression in (3) directly.

One-period discount rates are needed in the calculation of $\hat{P}_t^*$, and these rates are generally not observable. We use several different estimates based on models from the finance literature. Much attention has been devoted to estimating expected returns and risk premia for common stocks. One common method for estimating the risk premium in the stock market is to assume that it is constant and compute the sample mean for the excess return on a stock market aggregate.[7] We refer to this method as our constant risk premium model and $k_t = R_{F,t+1} + \overline{RP}$ where $R_{F,t+1}$ is the return on a one-period Treasury bill for period (t+1) known at time t and $\overline{RP}$ is the estimated risk premium for the stock market. A more recent approach has been to allow variation over time in the risk premium and conditional variances of stock market returns. The risk premium is linked to the variability of stock returns via models described in Merton (1980). The current state of the art is best described in French, Schwert, and Stambaugh (1987) who use a generalized ARCH process to model the variance of stock returns. We use their G-ARCH model for monthly returns on the New York Stock Exchange (NYSE) composite and we re-estimate it for the period 1926-87 by the method of maximum likelihood:[8]

$$(R_{m,t+1} - R_{F,t+1}) = \alpha + \beta\sigma_{t+1} + \varepsilon_{t+1} - \theta\varepsilon_t$$

$$\sigma^2_{t+1} = a + b\sigma^2_t + c_1\varepsilon^2_t + c_2\varepsilon^2_{t-1}$$

$$RP_t = E_t(R_{m,t+1} - R_{F,t+1}) = \alpha + \beta\sigma_{t+1} - \theta\varepsilon_t$$

with

$\alpha = -.0004698$ (.006169)	$a = .00008719$ (.00003471)
$\beta = .1852$ (.1420)	$b = .8293$ (.03274)
$\theta = -.07216$ (.03756)	$c_1 = .06089$ (.03963)
	$c_2 = .08379$ (.04765)

where the sample size is 742 and the standard errors are in parentheses. The one-period discount rate for the stock market is then $k_t = R_{F,t+1} + RP_t$. Our first model for stocks allows for interest rate variation with a constant risk premium. The second method, which we call the time varying risk premium model, allows for variation in both interest rates and risk premia.

We also consider two different models for the one-period discount rates on bonds. The first model represents a version of the expectations theory of the term structure. We assume that the risk premium on bonds is zero and set $k_t = R_{F,t+1}$ in the calculation of $\hat{P}_t^*$. This model is similar to the expectations theory of the term structure which has been tested by Shiller (1979), Singleton (1980), and Campbell and Shiller (1987). $\hat{P}_t^*$ is a nonlinear function of one-period interest rates and the coupon rate and the model follows directly from a basic asset pricing relation with risk neutrality. The expectations theory tested by Campbell, Shiller, and Singleton follows from a linear approximation of the term structure. The second model that we use incorporates a risk premium in the discount rate. Since the variability of a bond price must decline as the bond approaches maturity, we assume that the risk premium is a function of maturity. In our data set for Treasury bonds, we have four different maturity groups: 1-2 year bonds, 4-7 year bonds, 8-13 year bonds and 15-30 year bonds. The average maturities are 1.5 years, 5.4 years, 10.8 years, and 23.1 years, respectively. We estimate an average excess return (relative to one-month Treasury bills) for each maturity group. Since the estimated risk premia are close for the two long-term bond groups, we use the average of those two for bonds with maturities over 10.8 years. The estimated risk premia increase with maturity out to 10 years. We use a zero risk premium for one month to maturity and a linear interpolation between the estimates to compute the risk premium out to 10 years. For this second model we compute $k_t = R_{F,t+1}$ + RP (time to maturity), and we refer to this model as our risk premium model for bonds.

The last model that we consider for both stocks and bonds is an MRS model that follows from the intertemporal CAPM relationship. We have

$$J_w(t)p_t = E_t[J_w(t+1)(p_{t+1}+d_{t+1})],$$

where p_{t+1} and d_{t+1} are prices and dividends in real terms and $J_w(t+1)$ is the marginal utility of wealth (in real terms). We define a new variable λ_{t+1} to be the marginal utility of wealth times the consumption price deflator. With this new variable we can rewrite the asset pricing model with nominal prices and dividends (or cash flows):

$$\lambda_t P_t = E_t[\lambda_{t+1}(P_{t+1}+D_{t+1})] \text{ or}$$

$$P_t = E_t[\frac{\lambda_{t+1}}{\lambda_t}(P_{t+1}+D_{t+1})], \tag{5}$$

where $\frac{\lambda_{t+1}}{\lambda_t}$ is the MRS. $E_t(\frac{\lambda_{t+1}}{\lambda_t}) = \frac{1}{1+R_{F,t+1}}$ so that discounting is incorporated in the MRS series. Equation (5) is also a stochastic difference equation with the following solution:

$$P_t = E_t[\sum_{j=1}^{\infty}(\frac{\lambda_{t+j}}{\lambda_t})D_{t+j}]. \tag{6}$$

Again we observe that one can add a bubble term to this solution, but the right side of (6) is an alternative representation of the market fundamental.

The ex post market fundamental that corresponds to (6) is

$$P_t^* = \sum_{j=1}^{\infty}(\frac{\lambda_{t+j}}{\lambda_t})D_{t+j}.$$

Given estimates of $(\frac{\lambda_{t+1}}{\lambda_t})$ over time, one can compute a finite sample version as follows:

$$\hat{P}^*_t = (\frac{\lambda_{T+1}}{\lambda_T})(P_{T+1}+D_{T+1})$$
$$\hat{P}^*_t = (\frac{\lambda_{t+1}}{\lambda_t})(\hat{P}^*_{t+1}+D_{t+1}) \text{ for } t=1, \ldots, (T-1) \tag{7}$$

Scott (1988) has recently developed a method for consistently estimating $(\frac{\lambda_{t+1}}{\lambda_t})$ from one-period returns by using both the large cross section and the long time series available for security returns.

Here we provide a brief description of the estimator. From equation (5) we have the following model for nominal returns:

$$E_t[\frac{\lambda_{t+1}}{\lambda_t}(1+R_{i,t+1})] = 1, \tag{8}$$

where the i indexes different securities. This relation implies the following unconditional moments:

$$E\{[\frac{\lambda_{t+1}}{\lambda_t}(1+R_{i,t+1})-1]\underline{z}_{it}\} = 0 \tag{9}$$

where $\underline{z}_{it}$ is a vector of information variables known at time t. We examine both time series sample moments

$$\frac{1}{T}\sum_{t=1}^{T}[(\frac{\lambda_{t+1}}{\lambda_t})(1+R_{i,t+1})-1]$$

and cross sectional sample moments

$$\frac{1}{K}\sum_{i=1}^{K}[(\frac{\lambda_{t+1}}{\lambda_t})(1+R_{i,t+1})-1].$$

The time series sample moments converge in probability to zero as T gets large, but the cross sectional sample moments do not necessarily converge in probability to zero as K gets large. The reason is that the error term $[\frac{\lambda_{t+1}}{\lambda_t}(1+R_{i,t+1})-1]$, may be correlated across securities. To handle this correlation we use a factor structure as follows:

$$u_{i,t+1} \equiv \frac{\lambda_{t+1}}{\lambda_t}(1+R_{i,t+1}) - 1 = \sum_{j=1}^{L} \beta_{ij}\xi_{j,t+1} + \varepsilon_{i,t+1}.$$

A cross sectional sample moment based on $\varepsilon_{i,t+1}$, instead of $u_{i,t+1}$, converges to zero as K gets large. These cross sectional sample moments have the following form for a two-factor model:

$$\frac{1}{K}\sum_{i=1}^{K}\varepsilon_{i,t+1} = (\frac{\lambda_{t+1}}{\lambda_t})\frac{1}{K}\sum_{i=1}^{K}(1+R_{i,t+1}) - 1 - \beta_1\xi_{1,t+1} - \beta_2\xi_{2,t+1},$$

where β_1 and β_2 are cross sectional averages. By setting this sample moment equal to its expected value of zero we get

$$(\frac{\hat{\lambda}_{t+1}}{\lambda_t}) = \frac{1 + \beta_1\xi_{1,t+1} + \beta_2\xi_{2,t+1}}{\frac{1}{K}\sum_{i=1}^{K}(1+R_{i,t+1})}. \qquad (10)$$

Scott finds that a two factor model, in which the factors are innovations in stock market returns and innovations in an interest rate, works quite well. The β's are estimated from the time series moments and these estimates are then plugged into (10) to provide consistent estimates of $(\frac{\lambda_{t+1}}{\lambda_t})$, for t=1, ..., T. Scott finds that this model is not generally rejected by data on one-period returns but it is rejected for one-period returns on the NYSE composite for the period

1952-85; the model is not rejected for returns on the NYSE over a longer time period, 1927-85. The MRS estimates from Scott are available over the period 1927 to 1985 and we use these estimates to compute estimates for the ex post market fundamentals for stocks and bonds according to (7). We refer to this model for $\hat{P}_t^*$ as our MRS model. The regression tests then proceed as in equation (4) for stocks and equation (3) for bonds.

II. Empirical Results

In this section we apply the tests of Section I to stock prices over the period 1927-87 and bond prices over the period 1932-85. We use monthly data, with prices taken at the end of each month. Our data set for aggregate stock prices is the NYSE value-weighted index computed from the CRSP tapes. The CRSP tapes provide returns, with and without dividends, on a value-weighted portfolio of all stocks on the NYSE. With the two return series one can compute an index for the price level and an index for dividends. We fix the price index so that the level at the end of 1985 matches the NYSE composite index. The Treasury bond prices and their coupon rates and maturities have been collected from the Wall Street Journal and the Bank & Quotation Record. For the one-period risk-free return, we use the return on one-month Treasury bills found in Ibbotson and Sinquefield (1982) and updated by Ibbotson & Associates.

We first examine the regression tests for our measure of aggregate stock prices, the NYSE Composite. The three different models for computing ex post market fundamentals, $\hat{P}_t^*$, are the constant risk premium model, a time varying risk premium model, and the MRS model. In the constant risk premium model, we use the average excess return over the sample period as our estimate of the risk premium: the estimate is .006397789 per month or 7.68 percent on an annual basis. For the time varying risk premium model, we use the G-ARCH model estimated in Section I. The variation in the monthly one-period risk premium is substantial for this model: the average is .009017 with a standard deviation of .006036 and the range is -.003884 to .055188. With the two risk premia models, we are able to extend our sample to the end of 1987 and include the Crash of October 1987. The estimates of the MRS from Scott are available through the end of 1985 and the sample period for the MRS model is 1927-85.

The regression results for stocks are contained in Table I. The slope coefficients on the price-dividend ratio are significantly less than one for all three models. The t statistics for the tests that the slope coefficients are one are -3.03, -2.46, and -3.39. These results indicate that stock prices are not unbiased predictors of ex post market fundamentals. The R^2's of the regressions for the risk premium models are extremely low indicating that asset prices are very poor predictors of future cash flows and discounted rates according to these models. Of course a low R^2 could be the result of large forecast errors. The R^2 for the regression with the MRS model is much higher at .17 and the slope coefficient is closer to one, .3944, but prices do not pass the test for an unbiased predictor in this model. We also present the sample variances of $\hat{P}^*_t/\overline{D}_t$ and $P_t/\overline{D}_t$ in Table 1. In all three cases the sample variance of the price-dividend ratio is greater than the sample variance of $\hat{P}^*_t/\overline{D}_t$, with the variation in $\hat{P}^*_t$

being greatest for the MRS model. We find that the present value relation for stock prices is easily rejected for the NYSE composite in all three models. We originally ran the regressions for the risk premium models with data through December 1985, and the original results, not reported here, are virtually the same as those contained in Table 1 with data through December 1987. The inclusion of the stock market crash of 1987 does not alter the results of these tests.

We turn now to the regression tests with bond prices from our four different maturity groups. As we state in the introduction, our purpose for examining bond prices is to determine whether the rejection of the present value model for stock prices is related to long-term expectations or something unique to the stock market. When we test the present value relation for short-term bonds, we are in effect testing market expectations of interest rates and inflation over a short time horizon. When we test the present value relation for long-term bonds, we extend our horizon and we effectively test long-term expectations for interest rates and inflation. We have already noted that bonds have a natural terminal condition which can be used to rule out rational speculative bubbles. If the present value relation is rejected for long-term bond prices, then we can interpret the results as evidence that long-term expectations are not formed rationally.

Before we present the results, we need to mention a special feature of our data on long-term bonds. All of our series on Treasury bond prices run roughly from 1932 to 1985, but we do not use observations on long-term bonds during the period 1966-72. Specifically, we have a gap from January 1966 to December 1971 in our 8-13 year bond series and a gap from December 1965 to December 1972 in our 15-30 year bond series. This period was one during which the Treasury did not issue any new long term bonds due to legal restrictions on coupon rates. There were some existing long-term bond issues, but all of these had a special tax provision: these bonds could be redeemed early at par value to pay federal estate taxes and they became known as flower bonds. When these bonds were selling at or above par value, the effect of the tax provision was negligible. As interest rates rose, these bonds began selling at discounts and the effect of the tax provision became important. In more recent years during periods of high interest rates, these bonds have sold with much lower yields than other Treasury bonds. We do not use prices on these flower bonds after 1965 because they were selling at significant discounts and they were priced effectively as shorter-term bonds. The Treasury did not issue any new long-term bonds, without the special tax provision, until 1971. As a result, there are gaps in our long-term bond series and these gaps show up in the graphs, Figures 5 and 6. We have also modified the calculation of the covariance matrix for the parameter estimates in our regression tests to account for the missing values.

The results of the bond price regressions are presented in Tables 2, 3, and 4. The results in Table 2 are for the model with no risk premium in $\hat{P}_t^*$. Table 3 contains the results for the model in which the risk premium declines as we approach maturity. In Table 4, we present the results for the model in which the estimated MRS is used to compute $\hat{P}_t^*$. In all 12 regressions, bond prices (short, medium, and long term) pass the test for unbiasedness; we do not reject the hypothesis that bond prices are unbiased predictors of their ex post market fundamentals. It does not matter whether we compute $\hat{P}_t^*$ with a pure expectations theory for the term structure or a risk premium for the discount rates or with estimates of the MRS. The risk premium models have slope coefficients that are positive and reasonably close to one and the R^2's for the regressions are relatively high. Naturally the R^2 is higher for short-term bonds and lower for long-term bonds, because the magnitude of the forecast error increases as we increase the time horizon. We also note that in all 12 cases bond prices pass the volatility test. In Table 4, we note that there is extreme variation in $\hat{P}_t^*$ for the MRS model. The estimates of the MRS are based on a sample that places more weight on stock returns and the estimates exhibit variability similar to that of stock returns.

The regression tests focus on asset prices as unbiased predictors of ex post market fundamentals. In cases of rejection, the regression tests do not reveal the reasons for rejection. A slope coefficient significantly less than one indicates two possibilities: the market has a tendency to be overvalued or asset prices have a tendency to fluctuate too much. At this point, a peek at the data may help. In Figures 1-6, we present plots of asset prices and ex post market fundamentals over time. The two risk premium models for the NYSE are presented in Figure 1. The plot gives the impression that for a long period, roughly 1952-75, the market was overvalued. This observation has been previously noted by Grossman and Shiller (1981). The market also appears to be too volatile during this period. For the periods before 1952 and after 1975, the market does not appear to be consistently overvalued and it does not appear to be too volatile. There are, however, two exceptions: the increase in stock prices during the late 1920's and the increase in stock prices during 1987. In Figure 2, we present the plot of stock prices (price-dividend ratios) with $\hat{P}_t^*$ computed for the MRS model. This plot gives the impression that volatility of asset prices is not the problem; instead this plot suggests that the stock market is consistently overvalued. We offer the following interpretation for stock prices: the market appears to be consistently overvalued and this overvaluation may be due to a bias in long-term expectations, speculative bubbles, or fads. One might argue that expectations, short and long term, are formed irrationally, but we note that there is a large body of evidence showing that short-term returns are difficult to predict.

By looking at the bond market, both short-term and long-term, we can examine some additional evidence regarding the nature of long-term expectations. In Figures 3-6, we present plots of bond prices with ex post market fundamentals calculated by the risk premium model and the pure expectations model. We do not include plots of $\hat{P}_t^*$ calculated from the MRS model because the variation is too extreme. Figures 3 and 4 indicate that short-term and medium-term bond prices are reasonably good predictors of ex post market fundamentals. In Figures 5 and 6 for the long-term bonds, we see much larger forecast errors and greater variation in ex post market fundamentals. One very important difference in the plots for bond prices is that over this period, 1932-85, we observe both positive and negative forecast errors. Because the forecast errors for long-term bonds extend over a longer time horizon, the serial correlation in these errors is much greater, but this phenomenon is consistent with rational pricing. There is no tendency for the bond prices to be systematically above or below ex post market fundamentals. From the results and observations in bond prices, we conclude that there is no bias in long-term expectations with respect to interest rates and inflation. These results indicate that rejection of the present value model for stock prices must be associated with something unique to the stock market.

III. Conclusions

We present some new tests of present value models and we apply the tests to both stock prices and bond prices. We use two different methods for incorporating variation in discount rates. Our first method is to model one-period discount rates as the combination of short-term rates on Treasury bills and a risk premium, and we use several models for the risk premium. Our second method is to use estimates of the marginal rate of substitution computed from one-period security returns. The results of our tests can be summarized as follows: the present value model is not rejected for bond prices, but it is rejected by the data on stock prices. All of our sample periods extend over 50 years and we examine an aggregate index of stock prices as well as short, medium, and long-term Treasury bond prices. We interpret the results as follows: long-term expectations, implicit in long-term bond prices, are formed rationally, but there is something unique to the stock market that leads to rejection of the present value model. From our analysis, we rule out variability in interest rates and risk premia and the state of long-term expectations as explanations for the observed variability of stock prices.

FOOTNOTES

[1]For a discussion, see LeRoy and LaCivita (1981) and Michener (1982).

[2]For a survey of the early literature, see Fama (1970). For some more recent results see Fama and French (1988b).

[3]For examples, see Campbell and Shiller (1987, 1988a,b), Mankiw, Romer, and Shapiro (1985), Scott (1985), Shiller (1979, 1981), and Singleton (1980).

[4]In two recent papers, Durlauf and Hall (1988, 1989) show that the regression test has the power to detect noise in asset prices.

[5]Because P_t is not strictly exogenous in this regression, any attempt to apply GLS will result in inconsistent parameter estimates.

[6]Marsh and Merton (1986) examine a theoretical model in which the price-dividend ratio is stationary.

[7]The excess return is the return on the aggregate minus the return on a nominally risk-free security such as short-term Treasury bill. For the stock market aggregate, we use the value-weighted NYSE index from the CRSP tapes.

[8]For a discussion of the maximum likelihood estimator, see Engle, Lilien, and Robins (1987).

REFERENCES

Bergman, Yaacov Z., "Time Preference and Capital Asset Pricing Models," Journal of Financial Economics, 14 (March 1985): 145-59.

Black, Fischer, "Noise," Journal of Finance, 41 (July 1986): 529-43.

Blanchard, Olivier J. and Mark W. Watson, "Bubbles, Rational Expectations, and Financial Markets," in Paul Wachtel, Ed., Crisis in the Economic and Financial Structure, (Lexington: D.C. Heath and Company, 1982).

Breeden, Douglas T., "An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities," Journal of Financial Economics, 7 (1979): 265-96.

Campbell, John Y. and Robert J. Shiller, "Cointegration and Tests of Present Value Models," Journal of Political Economy, 95 (October 1987): 1062-88.

___________, "Stock Prices, Earnings, and Expected Dividends," Journal of Finance, 63 (July 1988a): 661-76.

___________, "The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors," forthcoming, Review of Financial Studies, 1988b.

Durlauf, Steven N. and Robert E. Hall, "Bounds on the Variances of Specification Errors in Models with Expectations," Stanford University, November 1988.

___________, "Measuring Noise in Stock Prices," Stanford University, January 1989.

Engle, Robert F., David M. Lilien, and Russell P. Robins, "Estimating Time Varying Risk Premium in the Term Structure: The Arch-M Model," Econometrica 55 (March 1987): 391-407.

Fama, Eugene F., "Efficient Capital Markets: A Review of Theory and Empirical Work," Journal of Finance, 25 (May 1970): 383-417.

___________, "Permanent and Temporary Components of Stock Prices," Journal of Political Economy, 96 (April 1988): 246-73.

Fama, Eugene F. and Kenneth R. French, "Dividend Yields and Expected Stock Returns," Journal of Financial Economics 22 (October 1988): 3-26.

Flavin, Marjorie, "Excess Volatility in the Financial Markets: A Reassessment of the Empirical Evidence," Journal of Political Economy, 91 (December 1983): 929-56.

Flood, Robert P. and Robert J. Hodrick, "Asset Price Volatility, Bubbles, and Process-Switching," Journal of Finance, 41 (September 1986): 831-42.

__________ and Paul Kaplan, "An Evaluation of Recent Evidence on Stock Market Bubbles," NBER Working Paper No. 1971, July 1986.

French, Kenneth R., G. William Schwert, and Robert F. Stambaugh, "Expected Stock Returns and Volatility," Journal of Financial Economics, 19 (September 1987): 3-29.

Grossman, Sanford and Robert J. Shiller, "The Determinants of the Variability of Stock Market Prices," American Economic Review, 71 (May 1981): 222-27.

Hansen, Lars P., "Large Sample Properties of Generalized Method of Moments Estimators," Econometrica, 50 (July 1982): 1029-54.

__________ and Robert J. Hodrick, "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," Journal of Political Economy, 88 (October 1980): 829-53.

__________ and Kenneth J. Singleton, "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models," Econometrica, 50 (September 1982): 1269-86.

Ibbotson, R. G. and Rex A. Sinquefield, Stocks, Bonds, Bills and Inflation: The Past and the Future, (Charlottesville: The Financial Analysts Research Foundation, 1982).

Keynes, John Maynard, The General Theory of Employment, Interest, and Money, (London: MacMillan Press, 1936).

Kindleberger, Charles P., Manias, Panics and Crashes: A History of Financial Crises, (New York: Basic Books, 1978).

Kleidon, Allan W., "Bias in Small Sample Tests of Stock Price Rationality," Journal of Business, 59 (April 1986a): 237-61.

__________, "Variance Bounds Tests and Stock Price Valuation Models," Journal of Political Economy, 94 (October 1986b): 953-1001.

LeRoy, Stephen F., and Richard D. Porter, "The Present-Value Relation: Tests Based on Implied Variance Bounds," Econometrica, 49 (May 1981): 555-74.

__________, and C. J. LaCivita, "Risk Aversion and the Dispersion of Asset Prices," Journal of Business, 54 (October 1981): 535-47.

Lucas, Robert, "Asset Prices in an Exchange Economy," Econometrica, 46 (November 1978): 1429-45.

Mackay, Charles, Memories of Extraordinary Popular Delusions and the Madness of Crowds, (New York: Farrar, Straus & Giroux, 1932).

Malkiel, Burton G., A Random Walk Down Wall Street, 4th Edition, (New York: W. W. Norton & Company, 1985).

Mankiw, N. Gregory, David Romer, and Matthew D. Shapiro, "An Unbiased Reexamination of Stock Market Volatility," Journal of Finance 40 (July 1985): 677-87.

Marsh, Terry A. and Robert C. Merton, "Dividend Variability and Variance Bounds Tests for the Rationality of Stock Market Prices," American Economic Review, 76 (June 1986): 483-98.

__________, "Dividend Behavior for the Aggregate Stock Market," Journal of Business, 60 (January 1987): 1-40.

Merton, Robert C., "An Intertemporal Capital Asset Pricing Model," Econometrica, 41 (September 1973): 867-87.

__________, "On Estimating the Expected Return on the Market: An Exploratory Investigation," Journal of Financial Economics 8 (1980): 323-61.

Michener, Ronald W., "Variance Bounds in a Simple Model of Asset Pricing," Journal of Political Economy, 90 (February 1982): 166-75.

Nerlove, Marc, David M. Grether, and Jose L. Carvalho, Analysis of Economic Time Series: A Synthesis, (New York: Academic Press, 1979).

Poterba, James M. and Lawrence H. Summers, "Mean Reversion in Stock Prices: Evidence and Implications," Journal of Financial Economics 22 (October 1988): 27-59.

Scott, Louis O., "The Present Value Model of Stock Prices: Regression Tests and Monte Carlo Results," Review of Economics and Statistics, 67 (November 1985): 599-605.

__________, "Estimating the Marginal Rate of Substitution in the Intertemporal Capital Asset Pricing Model and Testing Stock Market Rationality," University of Illinois, August 1988, forthcoming Review of Economics and Statistics.

Shiller, Robert J., "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure," Journal of Political Economy, 87 (December 1979): 1190-1219.

__________, "The Use of Volatility Measures in Assessing Market Efficiency," Journal of Finance, 36 (May 1981a): 291-304.

____________, "Do Stock Prices Move too Much to be Justified by Subsequent Changes in Dividends?" American Economic Review, 71 (June 1981b): 421-36.

____________, "Stock Prices and Social Dynamics," Brookings Papers on Economic Activity 1984(2): 457-98.

____________, "A Scott-Type Regression of the Dividend Ratio Model," Yale University, August 1988.

Singleton, Kenneth J., "Expectations Models of the Term Structure and Implied Variance Bounds," Journal of Political Economy, 88 (December 1980): 1159-76.

Summers, Lawrence H., "Does the Stock Market Rationally Reflect Fundamental Value?" Journal of Finance, 41 (July 1986): 591-600.

West, Kenneth D., "Dividend Innovations and Stock Price Volatility," Econometrica, 56 (January 1988): 37-61.

TABLE 1

Regression Tests, Stock Prices
NYSE

$$\frac{\hat{P}^*_t}{\bar{D}_t} = a + b\,\frac{P_t}{\bar{D}_t} + e_t$$

	Constant Risk Premium	Time Varying Risk Premium	MRS Model
Sample Period	1927-87	1927-87	1927-85
Sample Size	731	731	707
a	22.800	17.008	1.629
(standard error)	(8.921)	(11.032)	(4.8332)
b	-.1514	-.06316	.3944
(standard error)	(.3802)	(.4314)	(.1785)
t(a=0)	2.56	1.54	.34
t(b=1)	-3.03	-2.46	-3.39
R^2	.04	.01	.17
$\chi^2(2)$	15.11	45.50	103.43
$\mathrm{Var}(\hat{P}^*_t/\bar{D}_t)$	26.90	22.23	37.89
$\mathrm{Var}(P_t/\bar{D}_t)$	41.54	41.54	42.16
Estimated Risk Premium	.006397789 per month	Varies	--

TABLE 2

Regression Tests, Bond Prices
No Risk Premium

$$\hat{P}^*_t = a + bP_t + e_t$$

	1-2 Year Bonds	4-7 Year Bonds	8-13 Year Bonds	15-30 Year Bonds
a (standard error)	5.4160 (12.9781)	33.826 (112.374)	10.951 (118.615)	14.091 (229.997)
b (standard error)	.9510	.6907	.9537	.8976
t(a=0)	.42	.30	.09	.06
t(b=1)	-.38	-.27	-.04	-.04
R^2	.57	.38	.34	.12
$\chi^2_{(2)}$	2.32	3.03	2.53	.24
$Var(P^*_t)$	8.74	49.69	230.85	642.34
$Var(P_t)$	5.52	39.66	85.19	92.11
Sample Size	640	634	575	562

NOTE: The sample periods run from 1932 to 1985. There are no observations for 8-13 year bonds from January 1966 to December 1971 and no observations for 15-30 year bonds from December 1965 to December 1972.

TABLE 3

Regression Tests, Bond Prices
Risk Premium Declines with Maturity

$$\hat{P}^*_t = a + bP_t + e_t$$

	1-2 Year Bonds	4-7 Year Bonds	8-13 Year Bonds	15-30 Year Bonds
a (standard error)	3.4393 (12.6497)	32.766 (133.37)	25.641 (150.483)	51.186 (198.103)
b (standard error)	.9631 (.1254)	.6548 (1.3445)	.6850 (1.5034)	.3270 (2.0303)
t(a=0)	.27	.25	.17	.26
t(b=1)	-.29	-.26	-.21	-.33
R^2	.58	.33	.22	.03
$\chi^2_{(2)}$	.83	.67	2.33	3.60
$Var(P^*_t)$	8.84	51.02	182.66	379.18
$Var(P_t)$	5.52	39.66	85.19	92.11
Sample Size	640	634	575	562

NOTE: Estimated risk premium (average excess return over 1-month return)

	Average Maturity	Monthly Premium (decimal)
1- 2 Year Bonds	1.5 years	.0005684916
4- 7 Year Bonds	5.4	.0008751095
8-13 Year Bonds	10.8	} .001306655
15-30 Year Bonds	23.1	

TABLE 4

Regression Tests, Bond Prices
MRS Model

$$\hat{P}^*_t = a + bP_t + e_t$$

	1-2 Year Bonds	4-7 Year Bonds	8-13 Year Bonds	15-30 Year Bonds
a (standard error)	387.16 (415.34)	122.49 (255.50)	29.913 (61.902)	23.589 (71.674)
b (standard error)	-2.9664 (4.0900)	-.5936 (2.5057)	.1149 (.6132)	.04457 (.74365)
t(a=0)	.93	.48	.48	.33
t(b=1)	-.97	-.64	-1.44	-1.28
R^2	.01	.01	.00	.00
$\chi^2_{(2)}$	3.68	18.60	87.08	236.33
$Var(P^*_t)$	3659.42	1982.81	848.09	354.10
$Var(P_t)$	5.52	39.66	85.19	92.11
Sample Size	640	634	575	562

FIGURE 1

NYSE, PRICE-DIVIDEND RATIOS
RISK PREMIUM MODELS

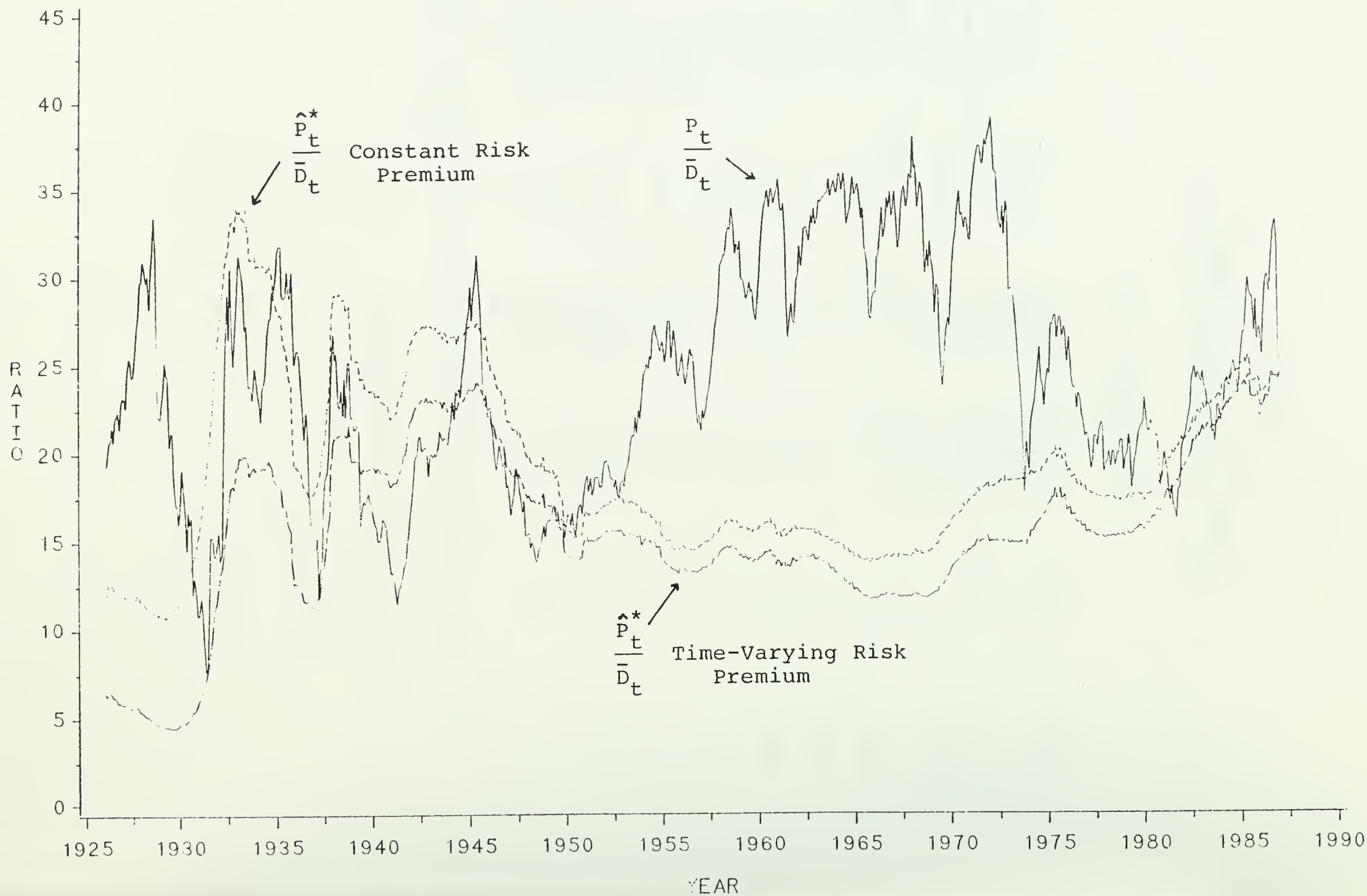

FIGURE 2

NYSE, PRICE–DIVIDEND RATIOS
MRS MODEL

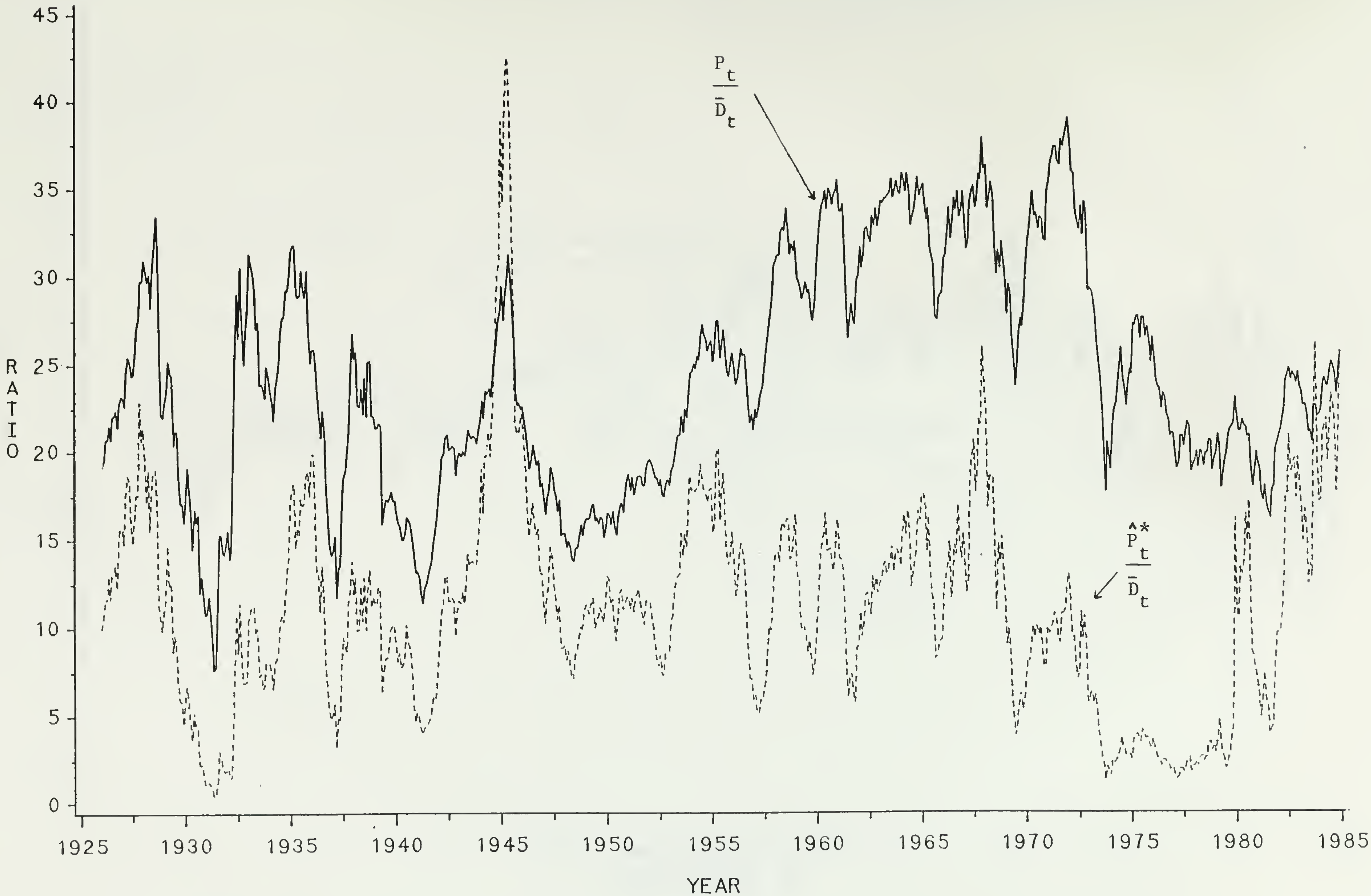

FIGURE 3

1–2 YEAR TREASURY BONDS

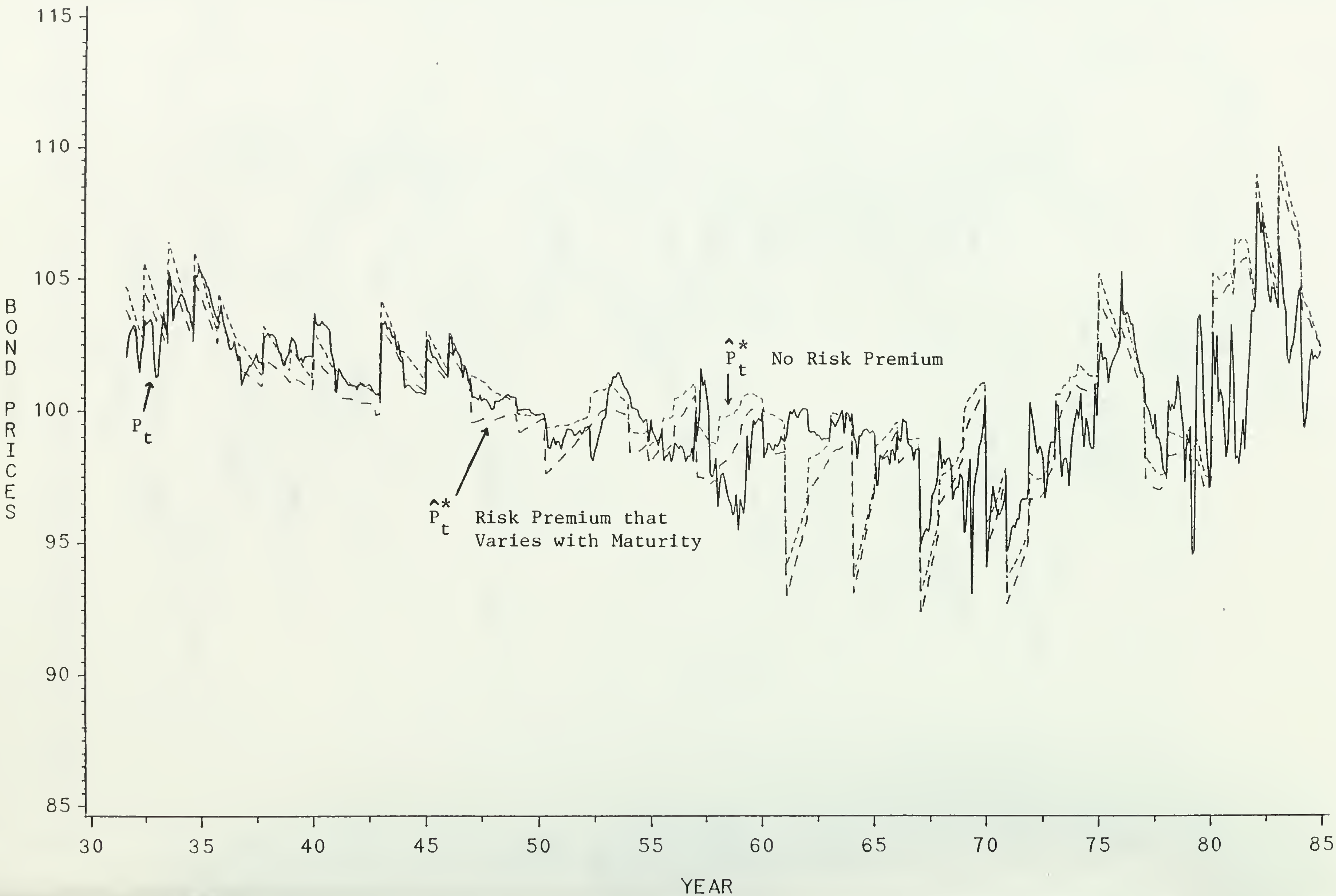

FIGURE 4
4-7 YEAR TREASURY BONDS

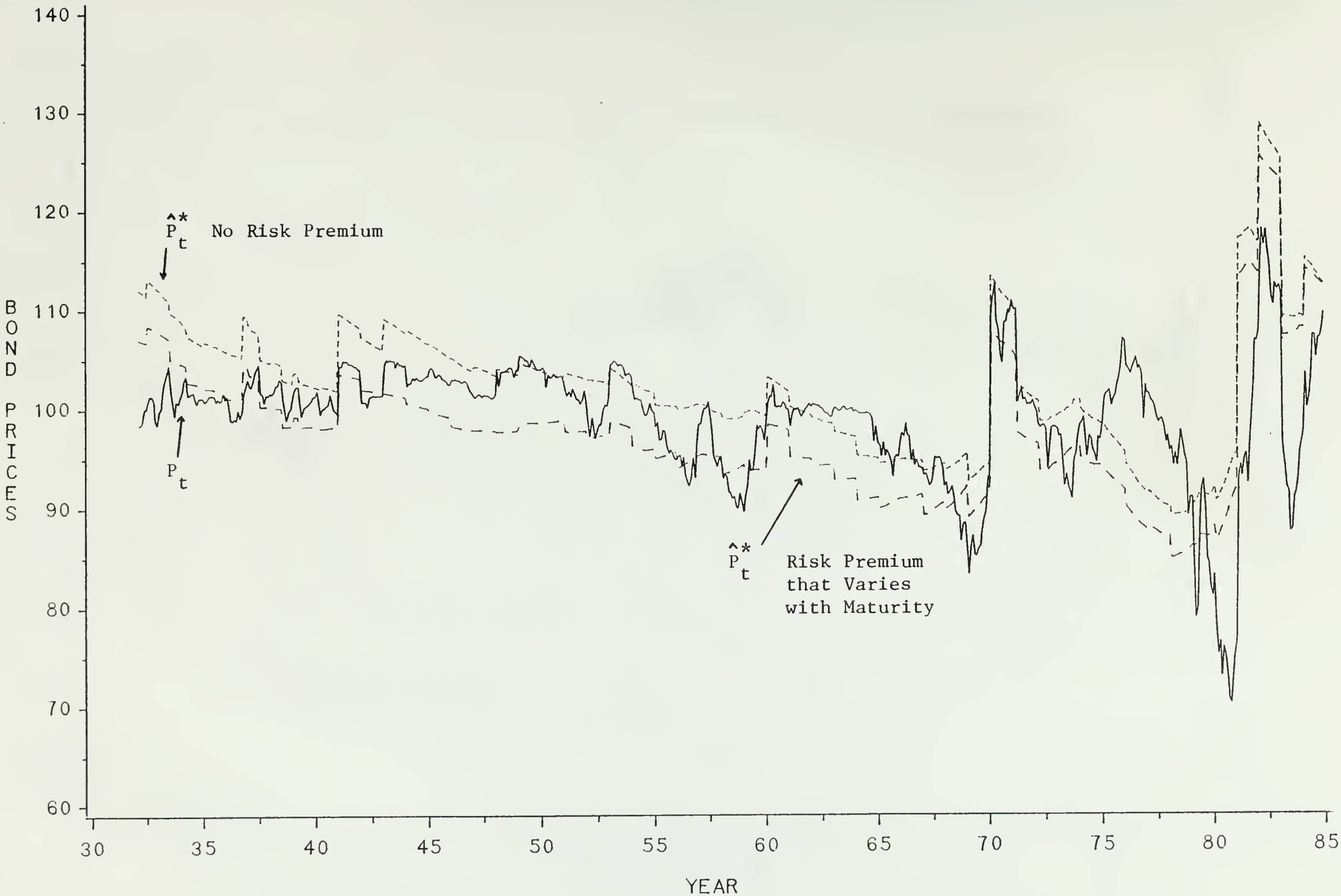

FIGURE 5

8-13 YEAR TREASURY BONDS

FIGURE 6

15–30 YEAR TREASURY BONDS