An Empirical Examination of Interest-Rate Futures Prices

Andrew H. Chen
Marcia Millon Cornett
Prafulla G. Nabar

INTRODUCTION

Interest-rate futures prices, like the prices of all other assets, are affected by changes in economic forces. Depending on their sensitivity to economic forces, these futures prices, therefore, reflect equilibrium risk premiums. The bulk of the previous empirical studies that have attempted to gain insights into the determinants of the risk premiums in futures markets have applied methodologies built upon the equilibrium asset pricing models to both financial and commodity futures. The study by Dusak (1973) was the first to empirically examine the risk premiums in the commodity futures price changes within the Sharp (1964)–Lintner (1965) Capital Asset Pricing Model (CAPM) framework. She found that the commodity futures contracts had no systematic risk in the context of the CAPM. In addition, she found that price changes over the life of wheat, corn, and soybean futures contracts over the period 1952–1967 were close to zero. In a subsequent study, utilizing a larger and broader sample, Bodie and Rosansky (1980) examined futures prices for 23 commodity contracts over the period 1950–1976 in the context of the CAPM. They confirmed that the commodity futures prices had no systematic risk. But in contrast to Dusak they found increasing prices over their sample period for 22 of the 23 commodity futures in their study.[1]

This article investigates the behavior of T-bill and T-bond futures prices in the context of APT. Certain prespecified macroeconomic variables are employed which other studies

The authors are grateful to two anonymous referees for helpful comments on the article.

[1]The value-weighted S&P 500 index was used as a proxy for the market portfolio in the context of the CAPM in both Dusak's (1973) and Bodie and Rosansky's (1980) studies.

Andrew H. Chen is a Distinguished Professor of Finance at Southern Methodist University.

Marcia Millon Cornett is an Associate Professor of Finance at Southern Illinois University.

Prafulla G. Nabar is a Senior Analyst at Lehman Brothers.

The Journal of Futures Markets, Vol. 13, No. 7, 781–797 (1993)

CCC 0270-7314/93/070781-17

have found to be driving forces in determining the price changes in financial markets.[2] The model is used to price T-bill futures contracts and T-bond futures contracts. Another objective of this study is to document any pricing differences between the two types of interest-rate futures contracts. Given the different uses for them, it seems logical to test for pricing differences between the two contracts. For example, a risk-averse investor seeking to hedge a floating rate loan would go short in a T-bill futures contract with a delivery date which coincides with the maturity date of the loan. The risk-averse investor with a long-position in a portfolio of government and/or corporate bonds, however, would achieve a more effective hedge by shorting T-bond futures contracts. In the first case the following of interest rate variations on the short bond market allows the investor to offset his/her exposure to interest-rate risk, while the T-bond futures contract alters the risk characteristics of the bond portfolio by tracking fluctuations in a longer-term bond index. Fortin and Khoury (1988) theoretically postulate that the hedging opportunities available with financial futures where the underlying asset is short-term in nature (such as T-bills) are different than those available with financial futures where the underlying asset is long-term in nature, such as a stock index or T-bonds. This article attempts to empirically document phenomena similar to those theoretically analyzed by Fortin and Khoury (1988). Finally, to examine any differences in the pricing of T-bill and T-bond futures contracts under various economic regimes, the sample is split into subgroups based on the phases of the business cycle, interest-rate volatility, and the slope of the yield curve.

DESCRIPTION OF FACTORS

As pointed out in earlier studies in the futures literature [e.g., Dusak (1973)], it is reasonable to expect that financial futures contracts are components of the portfolios held by investors: portfolios which do not necessarily include a spot position in the deliverable contract. Thus, futures prices like other financial asset prices are affected by variations in economic variables and, therefore, the expected returns to portfolios containing financial futures contracts should be consistent with opportunities available in the more traditional asset markets. That is, competitive equilibrium requires that, like other assets, futures prices adjust until there is no gain to the investor for adjusting his/her position in the futures contract. If this is true, the modern asset pricing models applied to portfolios that include futures positions predict a linear relationship between expected returns and systematic risk. These asset pricing models formalize the equilibrium relation between the risk premia in the integrated markets. Specifically, the risk premium in the futures market (which takes the form of a forecastable time trend in the futures prices) and the risk premium in the associated spot market (which takes the form of an expected return that exceeds the zero-beta rate) should differ only to the extent that the systematic risk of future and spot positions differ. Thus, systematic risk and hence risk premia should not differ significantly across spot and future markets when the spot–future basis is predictable, but differences in equilibrium returns could exist in markets where the spot–futures basis is characterized by more unpredictable variability. Analyses of portfolios containing futures contracts in the framework suggested here provide testable

[2]Most recently, Chen, Cornett, and Nabar (1991) studied the price behavior in the futures markets in the context of the Arbitrage Pricing Theory (APT). Using the methodology of Chen, Roll, and Ross (1986), they employed a multifactor APT using prespecified macroeconomic factors and found that a substantial portion of the price movements in a portfolio of seven different commodity and financial futures contracts was explained. Erhardt, Jordan, and Walkling (1987) used a similar approach to study normal backwardation and Bailey and Chan (1990) applied similar methodology to investigate cash/futures basis. See also Fama and French (1987).

hypotheses which rely on the joint assumptions that: (i) the asset pricing relationship is linear; and (ii) the spot and futures markets are integrated.

Bessembinder (1991) provides a detailed financial model which relies on the integration of asset and futures markets and the validity of the traditional linear asset pricing models. As Bessembinder points out, his purely financial model of futures premia is linked to traditional storage models in the futures literature, "in which the futures price differs from the contemporaneous spot price of the good as a function of interest rates and the net cash flow (dividend or convenience yield less storage costs) from holding a spot position, by the fact that the futures price will converge to the spot price at the delivery day." Bessembinder's Proposition 1 formally proves that for portfolios of assets and futures, the expected percentage change in futures price j, $E(R_j^f)$, is represented as $E(R_j^f) = \beta_j^f \gamma_1$, where β_j^f is a 1xp vector of sensitivities (multiple regression coefficients) of percentage change in futures price j to the economic aggregates and γ_1 is a px1 vector of risk premiums.

Similar to Chen, Roll, and Ross (1986) and Bessembinder (1991), macroeconomic variables are used as economic aggregates for the purpose of measuring systematic risk on T-bill and T-bond futures contracts. In the context of Chen, Roll, and Ross (1986) it is consistent with asset pricing theory to include market portfolios that capture the pricing impact of some other unspecified macroeconomic state variables. Accordingly, the return on the S&P 500 index is included as one of the macroeconomic factors. Breeden (1980) argues that even financial futures prices are subject to consumption risk since shocks to the aggregate real consumption would get translated into altered demands for different assets. To capture this risk premium, the Dow Jones Commodity index (discussed in detail below) is incorporated as a second macroeconomic factor.

Previous research in the determinants of futures prices has reported the presence of maturity effect, showing that commodity futures prices exhibit greater price volatility the closer they are to maturity.[3] Thus, using spot prices on the S&P 500 index and Dow Jones Commodity index to explain the fluctuations in futures prices will result in biases due to differing price volatilities depending on the maturity of the futures contract being priced. To eliminate, to the extent possible, the impact of maturity effect on the prices of futures contracts, in addition to tests using spot values, the S&P 500 index futures and the Dow Jones Commodity Futures (DJCF) index are employed. The maturity on the market index is set close to the maturity on the futures contract being priced.

It may be argued that the use of futures contracts on the market indices is quite different from the use of a spot index for the market measures. That is, for example, an index of commodity futures prices is not the same thing as a measure of real consumption in the U.S. economy. However, the regressions employing the maturity matched DJC futures contract include a measurement of expected consumption in the U.S. when the T-bill or T-bond contract being evaluated matures. Therefore, in the regressions employing the futures indices, rather than using a measure of the spot stock and commodity market portfolio to represent systematic risk, a measure which estimates the systematic risk when the contract matures is used. This may be equally important when evaluating a futures contract.

Chen and Boness (1975); Friend, Landskroner, and Losq (1976); Long (1974); and Roll (1973) have extended the CAPM to include the impact of uncertain inflation on equilibrium returns. According to the capital asset pricing model with uncertain inflation (CAPMUI), asset prices should reflect the risk due to unexpected changes in the

[3]See, for example, Milonas (1986) for documentation and a discussion of the maturity effect.

inflation rate. Furthermore, Chen, Roll, and Ross (1986) point out that unanticipated inflation changes will have a systematic effect on security prices. In addition, it is well known that much of the movement in interest rates is due to changes in inflation. The model, therefore, includes a measure of uncertain inflation as a factor which affects the pricing of interest-rate futures contracts.

Finally, to capture the possible effects of the slope of the term structure, the difference between the 30-year treasury rate and the 90-day treasury rate is included as a factor in the estimation equation. As Chen, Roll, and Ross (1986) argue, this variable can be interpreted as proxying the unanticipated return on long-term bonds. The inclusion of a term structure variable allows for an isolated look at the impact of differential relative movements of long-term versus short-term interest rates on futures prices.

DATA

Futures Prices Series

The data in this study consist of daily returns on T-bill and T-bond futures contracts during the period 1982–1986. In the case of the Treasury-bill contracts, which trade on the Chicago Mercantile Exchange, four contract maturities are included in the sample (March, June, September, and December). The same four maturities are selected for Treasury-bond contracts which trade on the Chicago Board of Trade.

When futures contracts are first listed for trading there is generally little interest in them. In fact, in some cases trading does not become active until several weeks after the contract first trades. Trading activity generally increases until just prior to maturity. To guarantee that the contract is actively trading, a contract is included in the sample only when it is between 75 and 100 trading days from maturity.

Market Index Series

The market portfolio used in the pricing equations is measured in two ways: (1) daily returns on the S&P 500 index; and (2) daily returns on the DJC index. Separate regressions are run which employ the spot values for these market indicators and a futures contract on the indices. Data for the S&P 500 spot index are from the *Center for Research in Security Prices* (CRSP) data tapes. Data for the S&P 500 index futures, which started trading in April of 1982, are from the Chicago Mercantile Exchange. There are several S&P 500 index futures contracts trading on any given day. These contracts are differentiated by their maturity dates. The specific S&P 500 index futures contract used to price a particular futures contract is the one that most closely matches the maturity of the futures contract being priced. Data on the DJC indices (both spot and futures) are from the Dow Jones Company.[4] These indices are equally weighted portfolios containing 12 commodities (cattle, coffee, copper, corn, cotton, gold, hogs, lumber, silver, soybeans, sugar, and wheat). While the spot DJC index is calculated using the spot values of the commodities, the futures index is based on commodity futures contracts approximately 5 months from maturity. Since the data employed on the T-bill and T-bond futures contracts are those returns for the period from 75 to 100 days (approximately 5 months)

[4]The DJC indices are reported daily in *The Wall Street Journal*. The indices have been reported since 1975 and the composition of the portfolio has changed only once, in January of 1982 (before the period of study). Similar to the S&P 500 index the DJC indices are intended to provide investors with a general indication of any trends in futures prices.

from maturity, any maturity mismatch between the futures contract being examined and the commodity futures index is eliminated.

Interest-Rate Series

Following Fama and Schwert (1977), it is assumed that the realized rate of inflation is measured as the daily return on 90-day T-bills. To gain insight into the inflation-hedging capabilities of futures contracts, inflation is separated into anticipated and unanticipated components. To accomplish this, the 1-day lagged return on 90-day T-bills is used as the anticipated inflation rate. Unanticipated inflation is then defined as the realized inflation rate (the return on the 90-day T-bill) minus the anticipated inflation rate (the one-day lagged return on the 90-day T-bill). Finally, the slope of the yield curve is measured as the difference between the returns on a 30-year T-bond and the 90-day T-bill.

Descriptive Statistics

Table I provides descriptive statistics (mean, standard deviation, skewness, and kurtosis) for the returns (measured as the natural log of successive daily price changes) on the interest-rate futures contracts. The statistics reported in Table I are computed using all available returns during the period from 75 to 100 days from maturity for each contract. There is a total of 20 T-bill and 16 T-bond contracts in the sample. The values reported in Table I are computed using data for all contracts traded. For example, the standard deviation of returns reported in Table I for T-bill futures contracts is calculated as the average of the standard deviation of the time series of returns across all 20 T-bill contracts traded during the period from April 1982 through 1986. Thus, for the 20 T-bill futures contracts, 0.13×10^{-2} is the average standard deviation, -0.25 is the average skewness, and 3.77 is the average kurtosis. Table I shows that the coefficient of skewness is insignificant for both T-bill and T-bond contracts.[5] Thus, the distributions appear to be symmetric. The coefficient of kurtosis is insignificant for T-bills but significant at the 1% level (leptokurtic) for T-bonds.[6] Thus, for T-bond contracts, although the tails of the return distributions are symmetric, they are shorter and thinner than those for a perfectly normal distribution.[7] It is possible that the kurtosis is related to the price limits on the futures contracts. T-bond futures contracts have a daily limit of three points above or below the previous day's settlement price, but T-bill futures have no daily limit. Although the descriptive statistics show that the return distributions on the T-bond futures contracts deviate somewhat from the normal distribution, this should not result in any serious problems in running the time series regressions. Ordinary least squares regression requires only that regression errors be independently and identically distributed (iid) as normal. This requirement is satisfied. Table I also provides the average autocorrelations for futures returns for the T-bill and T-bond contracts. As reported, both types of financial futures have insignificant autocorrelations in raw returns.

Table II presents the correlation matrices for the various economic variables used in the study. Panel A reports correlations using the futures contracts on the S&P 500 and DJC indices, while panel B lists results for the spot values of the market indices. The reported correlations are averages of the correlations found for T-bills and T-bonds data. Strong

[5]See Pearson and Hartley (1966) for tables used to carry out the test.

[6]See footnote 5 above. The finding regarding leptokurtic distributions is consistent with that of Cornew et al. (1984) and Hudson et al. (1987).

[7]The same set of descriptive statistics were computed for excess returns (i.e., log price relative less risk-free rate) and the conclusions remain unaltered.

Table I
DESCRIPTIVE STATISTICS OF THE RETURNS (MEASURED AS THE NATURAL LOG OF SUCCESSIVE DAILY PRICE CHANGES 75 TO 100 TRADING DAYS FROM CONTRACT MATURITY) ON THE FUTURES CONTRACTS

	T-Bill	T-Bond
Mean	0.85×10^{-4}	3.03×10^{-4}
Standard deviation	0.13×10^{-2}	0.61×10^{-2}
Skewness	−0.25	0.01
Kurtosis	3.77	0.55[a]
Autocorrelation	0.03	0.04

[a]Significant at the 0.01 level.

collinearity between the independent variables tends to weaken the individual impact of the economic variables. It appears from the statistics in Table II that collinearity is not significant between most of the independent variables. The strongest correlation reported in Table II is that between the S&P 500 index and the DJC index (0.26 for the futures contracts and 0.18 for the spot indices). Thus, any finding of insignificance in the regression coefficients for these variables reported in the next section do not necessarily mean that the variables are, in fact, insignificant in explaining T-bill or T-bond futures returns.

METHODOLOGY

This study uses time series analysis to examine which of the economic factors described in the previous section are significant in explaining the time series behavior of futures prices. The time series methodology applied is multifactor time series analysis. Using the state variables defined above, a factor model is estimated in the form:

$$R_{\mathrm{FUT}} - R_{\mathrm{TB}} = \beta_{\mathrm{FSP}}(R_{\mathrm{FSP}} - R_{\mathrm{TB}}) + \beta_{\mathrm{FCI}}(R_{\mathrm{FCI}} - R_{\mathrm{TB}}) + \beta_{\pi}\pi + \beta_{\mathrm{YC}}\mathrm{YC} + e \tag{1}$$

Table II
CORRELATION MATRIX FOR ECONOMIC VARIABLES

Economic Variable	DJC Index[a]	Unexpected Inflation[b]	Slope of Yield Curve[c]
Panel A: Using futures contracts on market indices			
S&P 500 futures index[a]	0.26	−0.16	0.00
DJC futures index		−0.15	0.01
Unexpected inflation			−0.10
Panel B: Using spot values on market indices			
S&P 500 spot index[a]	0.18	−0.10	0.00
DJC spot index		−0.04	−0.02
Unexpected inflation			−0.08

[a]Measured as the natural log of successive daily prices on the market indices.
[b]Measured as the return on the 90-day T-bill minus the one-day logged return on the 90-day T-bill.
[c]Measured as the difference between the returns on the 30-year T-bond and the 90-day T-bill.

where R_{FUT} = log price relative for the futures contract;
R_{TB} = log price relative for the 90-day T-bill;
R_{FSP} = log price relative for the S&P 500 index futures contract;
R_{FCI} = log price relative for the DJCF index contract;
π = unexpected inflation;
YC = slope of the yield curve;
β_k = loadings on factor k; and
e = an idiosyncratic error term.

Alternatively, eq. (1) is estimated using the spot values for the return on the S&P 500 index and the DJC index. All returns are calculated as the natural log of successive daily price changes on the various assets during the period 75–100 days from maturity of the contract. Of course, the concept of a return on a futures contract is somewhat misleading because the heavy use of margins in futures trading results in very little initial investment. Thus, it is commonly accepted in the literature that the returns on the futures contracts are more of a measure of the price movements than of actual returns on investments.

RESULTS

Full Sample

Table III presents the APT regression results for the full samples of T-bill and T-bond contracts. Panel A summarizes the regression results when futures contracts on the market indices are used as independent variables, while panel B lists results when spot values on the market indices are used. The results of the time series regressions shown in Table III clearly indicate that regardless of whether spot or futures values are used for the market portfolios, all four factors help to explain the risk premiums on interest-rate futures contracts and that much of the risk premiums is explained. In panel A, for the regression on the T-bill contracts, the t-statistics on the betas are all significant at better than the 0.01, while for the T-bond contracts all betas except β_{YC} are significant. Furthermore, the R-squared values are 41% for T-bill and 24% for T-bond futures contracts.[8] The results reported in panel B differ from those in panel A only in that the significance of the DJC index diminishes; significant at the 0.10 level for T-bills and insignificant for T-bonds. The differences may be due more to the fact that the measure of expected real consumption at the time the futures contract matures (DJCF index) is more pertinent in determining price changes on the futures contract than is a measure of current real consumption (DJC spot index). Finally, note that the Durbin–Watson statistic for both regressions does not indicate serial correlation in the residuals.

For both types of interest-rate futures it appears that risk premiums on the futures contracts are generally positively and (except for the T-bonds in panel B) significantly related to risk premiums on the S&P 500 (futures or spot) index as well as that on the DJC (futures or spot) index. Note that the t-statistics for the S&P 500 index, however, are larger for both interest-rate futures contracts. Given that the S&P 500 index contains only financial and no real assets, the stronger relationship between the risk premium on this index and risk premium on interest-rate futures is not surprising.

Table III also reports that in all regressions, the interest-rate futures contracts' risk premiums are significantly and negatively related to changes in unexpected inflation.

[8]The F-statistics are significant at the 0.01 level for all regressions reported in Tables III–VI.

Table III
APT REGRESSION RESULTS FOR FUTURES CONTRACTS (*t*-STATISTICS ARE IN PARENTHESES)

Panel A: Using futures contracts on market indices

$$R_{FUT} - R_{TB} = \beta_{FSP}(R_{FSP} - R_{TB}) + \beta_{FCI}(R_{FCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}YC + e$$

Type of Contract	β_{FSP}	β_{FCI}	β_{π}	β_{YC}	R^2 (%)	Number of Observations
T-bills	0.03	0.02	−147.73	−2.25	41.17	540
	(6.74)[a]	(3.19)[a]	(−15.57)[a]	(−4.47)[a]		
T-bonds	0.20	0.06	−310.74	−0.72	23.91	480
	(8.46)[a]	(1.93)[b]	(−6.44)[a]	(−0.27)		

Panel B: Using spot values on market indices

$$R_{FUT} - R_{TB} = \beta_{SSP}(R_{SSP} - R_{TB}) + \beta_{SCI}(R_{SCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}YC + \epsilon$$

Type of Contract	β_{SSP}	β_{SCI}	β_{π}	β_{YC}	R^2 (%)	Number of Observations
T-bills	0.03	0.01	−153.64	−2.37	40.18	540
	(7.08)[a]	(1.71)[b]	(−16.22)[a]	(−4.66)[a]		
T-bonds	0.25	0.03	−337.39	−1.71	24.67	480
	(9.42)[a]	(0.71)	(−7.08)[a]	(−0.65)		

[a]Significant at the 0.01 level.
[b]Significant at the 0.10 level.

Thus, increases in unexpected inflation are strongly associated with decreases in interest-rate futures contract prices indicating potential for serving as a hedge against unexpected inflation. Although both are significant at the 0.01 level, notice that the relationship between unexpected inflation and risk premiums is much stronger for T-bills than T-bonds. Given the strong positive correlation between spot and futures prices and the inverse relationship between T-bill prices and T-bill rates, it seems logical that when T-bill spot rates rise (unexpected inflation increases), T-bill futures prices fall.

Finally, the results for the impact of the change in the yield curve, viz. YC are considered. The coefficient on the yield curve variable, β_{YC}, is significant for the T-bill contract in both panels A and B. Thus, the changes in the slope of the yield curve appear to be significant in explaining the risk premia on T-bill futures. This seems reasonable when one considers that the slope of the yield curve used here is, in the futures literature, the cost of carry for these financial futures.[9] When the cost of carry is positive it is expected that the spot contract will be priced at a premium over the futures contract. As a result, a negative coefficient, β_{YC}, is obtained for T-bill contracts. The yield curve variable, on the other hand, is not significant in explaining the risk premia on

[9]In the futures literature cost of carry consists of interest that must be paid to finance the asset plus any storage costs less income receivable from the asset during the life of the contract. For a T-bill or T-bond futures contract, the latter two of these items is zero. The first can be measured as the slope of the yield curve.

T-bond futures. During the sample period long-term rates are relatively stable compared to short-term rates. Since T-bond futures prices will be more closely related to long-term rates, the β_{YC} coefficient for T-bonds may be insignificant.

Results Based on Phase of Business Cycle

During the period studied in this article, the U.S. economy was in a recessionary phase of the business cycle between April 1982 through November 1982.[10] During the remainder of the period, December, 1982 through December, 1986, the country experienced expansion. It is therefore of great interest to examine possible changes in the risk premiums on interest-rate futures in the different phases of the business cycle. Table IV presents regression results based on the phases of the business cycle. Similar to Table III, panel A lists results when futures contracts on the market indices are used in the regression, while panel B reports results when spot values on the market indices are used. Also, like the results in Table III, the only difference in the results of panels A and B is that the significance level on the DJC index decreases. Accordingly, reference is made only to panel A as the results in Table IV are discussed.

It is evident from the results that the regressions explain a significant portion of the risk premiums on interest-rate futures regardless of the phase of the business cycle. The R-squares range from 18% to 58%. Interestingly, the significance of the various independent factors depends on the phases of the business cycle. During both the recessionary and expansionary periods, the risk premiums for T-bill and T-bond futures contracts are significantly related to unanticipated inflation. Thus, it appears that regardless of the degree of growth in the economy the interest-rate futures are useful as hedges against unanticipated inflation. Furthermore, similar to the results for the full sample, the coefficient on the DJC index is significant for T-bill futures contracts, the coefficient on the S&P 500 index is significant for T-bond futures contracts, and the coefficient on the slope of the yield curve is insignificant for T-bond futures contracts regardless of the phase of the business cycle.

Perhaps more interesting is the fact that only during expansionary periods are risk premiums on T-bill financial futures significantly related to risk premiums on the S&P 500 index and the slope of the yield curve. Following the logic from above, during a recessionary period, long-term rates would be falling or stable relative to short-term rates. Thus, the risk premium on short-term and near maturity futures contracts on short-term investments are not expected to decrease. Accordingly, an insignificant coefficient is found for S&P 500 index, β_{FSP}, and the slope of the yield curve, β_{YC}, during the recessionary period for T-bills. During the expansionary period, when long-term interest rates are rising relative to short-term, a significant relationship is evident between the risk premium on T-bill future contracts and the risk premium on the S&P 500 index as well as the slope of the yield curve.

Results Based on Volatility of Interest Rates

It is possible that the relationship between risk premiums on T-bill and T-bond futures contracts varies as the volatility in interest rates varies. Certainly, as interest-rate volatility increases, the ability to hedge with futures contracts becomes more valuable. To test the impact of interest-rate volatility on the regression

[10]The dates for the recessionary and expansionary phases are from the National Bureau of Economic Research, Boston, MA.

Table IV
REGRESSION RESULTS FOR DIFFERENT PHASES OF THE BUSINESS CYCLE (t-STATISTICS ARE IN PARENTHESES)

Panel A: Using futures contracts on market indices

$$R_{FUT} - R_{TB} = \beta_{FSP}(R_{FSP} - R_{TB}) + \beta_{FCI}(R_{FCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}\,YC + e$$

	T-Bills						T-Bonds					
Phase of Business Cycle	β_{FSP}	β_{FCI}	β_{π}	β_{YC}	R^2 (%)	Number of Observations	β_{FSP}	β_{FCI}	β_{π}	β_{YC}	R^2 (%)	Number of Observations
Recession	0.03	0.06	−160.73	−2.78	58.44	62	0.23	0.06	−240.84	1.82	41.89	56
	(1.54)	(2.14)[b]	(−7.12)[a]	(−1.41)			(3.87)[a]	(0.57)	(−2.90)[a]	(0.25)		
Expansion	0.03	0.01	−122.91	−2.09	27.50	478	0.19	0.07	−372.52	−1.09	18.27	424
	(6.60)[a]	(1.97)[b]	(−10.05)[a]	(−4.33)[a]			(7.27)[a]	(1.87)[c]	(−5.39)[a]	(−0.38)		

Panel B: Using spot values on market indices

$$R_{FUT} - R_{TB} = \beta_{SSP}(R_{SSP} - R_{TB}) + \beta_{SCI}(R_{SCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}YC + \epsilon$$

Phase of Business Cycle	T-Bills						T-Bonds					
	β_{SSP}	β_{SCI}	β_{π}	β_{YC}	R^2 (%)	Number of Observations	β_{SSP}	β_{SCI}	β_{π}	β_{YC}	R^2 (%)	Number of Observations
Recession	0.02	0.06	−175.58	−3.08	55.63	62	0.20	0.16	−306.53	0.12	35.78	56
	(1.18)	(1.70)[c]	(−7.88)[a]	(−1.50)			(2.67)[a]	(1.16)	(−3.68)[a]	(0.02)		
Expansion	0.03	0.00	−122.52	−2.16	28.25	478	0.26	0.01	−364.39	−1.88	20.79	424
	(7.51)[a]	(0.62)	(−10.07)[a]	(−4.49)[a]			(8.82)[a]	(0.31)	(−5.35)[a]	(−0.66)		

[a]Significant at the 0.01 level.
[b]Significant at the 0.05 level.
[c]Significant at the 0.10 level.

results interest-rate volatility in daily returns is calculated and ranked each quarter during the sample period. Interest rate volatility is measured in two ways: (1) volatility in the 90-day T-bill rate (expected inflation); and (2) volatility in the difference between the 90-day T-bill rate and the one-day lagged 90-day T-bill rate (unexpected inflation). For the volatility in expected inflation, the rankings over the 19 quarters ranges from a high of 5.7×10^{-5} for the daily return variance in the third quarter of 1982 to a low of 0.3×10^{-5} in the fourth quarter of 1985. The sample is split into subgroups using the median value of 0.85×10^{-5} as a cutoff point for volatility in the daily returns on the 90-day T-bill. For the volatility in unexpected inflation, daily return volatility ranges from a high of 11.5×10^{-6} in the third quarter of 1982 to a low of 1.5×10^{-6} in the fourth quarter of 1986. The sample is split into subgroups using the median of 2.5×10^{-6} as a cutoff. The results are presented in Table V. Again, panels A and B differ only in their use of a futures contract versus the spot value of the market portfolio and results differ only in that the significance on the coefficient for the DJC index falls. The discussion below, therefore, refers only to the results in panel A.

Section 1 (of both panels A and B) in Table V presents regression results for T-bill and T-bond futures contracts when daily interest-rate volatility is measured by expected inflation. For T-bill futures contracts the coefficients of the risk premium on the S&P 500 futures index, the risk premium on the DJCF index, and unexpected inflation are the same regardless of the volatility in expected inflation. Thus, in both interest-rate regimes, the risk premium on T-bill futures contracts are positively related to the risk premium on both the financial and physical asset market indices and negatively related to unexpected inflation. However, only during periods of low interest volatility is the coefficient on the slope of the yield curve significant. Since the sample is divided on the basis of the volatility of the expected short-term interest rate, a possible explanation for this result is that during periods of high interest-rate volatility, much of the variation in futures prices is captured by the variation in unexpected inflation. Changes in the long-term rate relative to those in the short-term rate, during periods of high short-term interest-rate volatility, have little impact on futures prices. When expected short-term interest rates are less volatile, however, changes in long-term interest rates are less likely to be dominated by changes in short-term interest rates, leading to a significant coefficient, β_{YC}.

Section 2 of Table V presents regression results when unexpected inflation is used to measure interest-rate volatility. Two differences from the results in section 1 are worth noting. First, the coefficient on the DJCF index is significant only during periods of high interest-rate volatility. Thus, unlike the case where volatility is measured by expected inflation, during periods of low volatility in unexpected inflation, the risk premium on the measure of consumption is unrelated to the risk premium on T-bill futures contracts. The fact that the DJCF index contains only real assets certainly contributes to these results. During periods of low unexpected interest-rate volatility, consumption risk is reduced. Thus, the impact of the risk premium on the consumption proxy becomes less significant in determining changes in the risk premium on a financial (T-bill) futures contract. Second, unlike the case in section 1 where expected inflation is used to measure volatility, section 2 reports a significant negative coefficient on the yield curve term for both high and low interest-rate volatility. Volatility in unexpected inflation is likely to impact both long- and short-term rates regardless of the degree of volatility. Thus, the differences between the two rates (the yield curve slope) is significantly related to the risk premium on T-bill futures in both regimes.

For T-bond futures contracts, section 1 of Table V reports that, when interest-rate volatility is measured using expected inflation, the coefficients on the S&P 500 futures

Table V

REGRESSION RESULTS FOR DIFFERENT LEVELS OF INTEREST RATE VOLATILITY (t-STATISTICS ARE IN PARENTHESES)

Panel A: Using futures contracts on market indices

$$R_{FUT} - R_{TB} = \beta_{FSP}(R_{FSP} - R_{TB}) + \beta_{FCI}(R_{FCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}YC + e$$

Volatility Measure	T-Bills β_{FSP}	T-Bills β_{FCI}	T-Bills β_{π}	T-Bills β_{YC}	T-Bills R^2 (%)	T-Bills Number of Observations	T-Bonds β_{FSP}	T-Bonds β_{FCI}	T-Bonds β_{π}	T-Bonds β_{YC}	T-Bonds R^2 (%)	T-Bonds Number of Observations
1: Volatility in 90-day T-bill rate												
High volatility	0.03 (3.29)[a]	0.04 (2.63)[a]	−132.24 (−9.79)[a]	−1.38 (−1.47)	45.52	189	0.23 (6.22)[a]	0.03 (0.62)	−249.83 (−4.83)[a]	0.50 (0.14)	30.81	183
Low volatility	0.05 (5.12)[a]	0.03 (2.36)[b]	−101.77 (−3.97)[a]	−2.54 (−3.47)[a]	33.67	135	0.33 (5.54)[a]	0.28 (3.55)[a]	−290.91 (−1.73)[c]	0.27 (0.05)	26.63	135
2: Volatility in unexpected inflation												
High volatility	0.03 (3.63)[a]	0.04 (2.88)[a]	−132.32 (−9.86)[a]	−2.61 (−2.70)[a]	46.70	189	0.21 (6.62)[a]	0.07 (1.27)	−221.62 (−4.25)[a]	−2.54 (−0.68)	33.47	183
Low volatility	0.02 (3.85)[a]	0.01 (0.99)	−266.84 (−9.63)[a]	−2.68 (−3.79)[a]	41.24	189	0.20 (3.40)[a]	0.10 (1.53)	−1208.04 (−4.56)[a]	−0.17 (−0.02)	23.13	135

(continued)

Table V (continued)

Panel B: Using spot values on market indices

$$R_{FUT} - R_{TB} = \beta_{SSP}(R_{SSP} - R_{TB}) + \beta_{SCI}(R_{SCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}YC + \epsilon$$

	T-Bills						T-Bonds					
Volatility Measure	β_{SSP}	β_{SCI}	β_{π}	β_{YC}	R^2 (%)	**Number of Observations**	β_{SSP}	β_{SCI}	β_{π}	β_{YC}	R^2 (%)	**Number of Observations**
1: Volatility in 90-day T-bill rate												
High	0.03	0.04	−141.62	−1.59	41.15	189	0.25	0.03	−283.97	−0.79	27.55	183
volatility	(2.57)[a]	(1.87)[c]	(−10.41)[a]	(−1.64)			(5.46)[a]	(0.46)	(−5.46)[a]	(−0.21)		
Low	0.05	0.00	−112.55	−2.76	31.18	135	0.40	0.50	−396.15	−0.99	21.78	135
volatility	(5.20)[a]	(0.24)	(−4.34)[a]	(−3.71)[a]			(5.80)[a]	(0.53)[a]	(−2.31)[b]	(−0.20)		
2: Volatility in unexpected inflation												
High	0.04	0.03	−141.40	−2.80	43.25	189	0.25	0.08	−254.76	−3.70	31.86	183
volatility	(3.61)[a]	(1.70)[c]	(−10.37)[a]	(−2.81)[a]			(6.60)[a]	(1.12)	(−4.89)[a]	(−0.98)		
Low	0.02	0.00	−266.60	−2.72	42.49	189	0.26	0.05	−1200.16	−1.35	24.81	135
volatility	(4.45)[a]	(0.34)	(−9.71)[a]	(−3.88)[a]			(4.07)[a]	(0.79)	(−4.57)[a]	(−0.19)		

[a]Significant at the 0.01 level.
[b]Significant at the 0.05 level.
[c]Significant at the 0.10 level.

index and unexpected inflation are significant regardless of interest rate volatility, and the coefficient on the slope of the yield curve is insignificant regardless of interest-rate volatility. Identical conclusions are drawn when interest-rate volatility is measured using unexpected inflation. These results are consistent with those reported in Table III for the full sample. The coefficient on the risk premium on the DJCF index, β_{FCI}, index is significant only when the volatility in expected inflation is low. When volatility is measured using unexpected inflation, the coefficient on the DJCF index is insignificant regardless of the volatility.

Results Based on Slope of Yield Curve

The one explanatory variable which has consistently produced varying results for T-bill versus T-bond futures contracts is the slope of the yield curve, YC. This was attributed above to the short-term nature of T-bills relative to T-bonds. To investigate this relationship in more detail, the full sample is split into subgroups based on the slope of the yield curve. To accomplish this, the time period studied is split again into 19 quarters and the sample is ranked according to the average daily yield curve slope during each quarter. The rankings range from 12.2×10^{-5} in the third quarter of 1982 to 4.3×10^{-5} in the second quarter of 1986. Note that the yield curve is upward sloping during the entire sample period. The median value used as the cutoff point for yield curve slope is 9.0×10^{-5}. The results are reported in Table VI. Consistent with the earlier results, no differences are reported between panel A (using futures contracts on market indices) and panel B (using spot values on the market indices) in Table VI.

Interestingly, no differences are found when the sample is divided on the basis of the yield curve slope. Thus, it appears that while a change in the slope of the yield curve is significant in explaining the risk premium on T-bill (but not T-bond) futures contracts, the slope itself does not affect the results. It should be pointed out again that over the entire sample period, the yield curve is upward sloping. This may be a contributing factor to the lack of any divergent results across the two subsamples. Also, the results in Table VI, based on the slope of the yield curve, differ from those for the full sample in Table III in that the coefficient on the DJC index is no longer significant. A possible explanation for this is that the correlation between this variable and the S&P 500 index (see Table II) is sufficient enough to weaken the reported impact of this economic variable.

SUMMARY AND CONCLUSIONS

This study applies the APT methodology of Chen, Roll, and Ross (1986) to examine the risk premiums on two interest-rate futures contracts (T-bill and T-bond). The S&P 500 index is used as a proxy for financial market-based factors. The Dow Jones Commodity index is used as the commodity market-based factor. In addition, unanticipated inflation and the slope of the yield curve are included as possible macroeconomic factors that may drive the price movements in futures contracts. In contrast to previous studies, it is found that T-bill and T-bond futures prices do have systematic risk relative to various economic factors. In particular, T-bill and T-bond futures prices display systematic risk in relation to both the financial and commodity market indices. Also, the interest-rate futures prices possess significant systematic risk related to unanticipated inflation. The slope of the yield curve is found to be significantly related to only the T-bill futures contracts. When the full sample is divided into subgroups based on the phases of the business cycle, interest-rate volatility and the slope of the yield curve, additional differences between the risk premiums on T-bill and T-bond futures contracts are documented.

Table VI

REGRESSION RESULTS BASED ON THE STEEPNESS OF THE YIELD CURVE (*t*-STATISTICS ARE IN PARENTHESES)

Panel A: Using futures contracts on market indices

$$R_{FUT} - R_{TB} = \beta_{FSP}(R_{FSP} - R_{TB}) + \beta_{FCI}(R_{FCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}\text{YC} + e$$

Steepness of Yield Curve	T-Bills β_{FSP}	T-Bills β_{FCI}	T-Bills β_{π}	T-Bills β_{YC}	T-Bills R^2(%)	T-Bills Number of Observations	T-Bonds β_{FSP}	T-Bonds β_{FCI}	T-Bonds β_{π}	T-Bonds β_{YC}	T-Bonds R^2(%)	T-Bonds Number of Observations
More steep	0.03 (2.91)[a]	0.02 (1.47)	−126.72 (−8.76)[a]	−1.74 (−2.26)[b]	42.26	162	0.25 (5.33)[a]	0.05 (0.76)	−221.45 (−3.16)[a]	1.14 (0.30)	25.18	162
Less steep	0.02 (4.46)[a]	0.01 (1.56)	−324.40 (−16.02)[a]	−4.71 (−4.64)[a]	63.70	189	0.24 (4.73)[a]	0.07 (1.18)	−681.24 (−4.58)[a]	−7.63 (−0.90)	28.61	129

Panel B: Using spot values on market indices

$$R_{FUT} - R_{TB} = \beta_{SSP}(R_{SSP} - R_{TB}) + \beta_{SCI}(R_{SCI} - R_{TB}) + \beta_{\pi}\pi + \beta_{YC}\text{YC} + \epsilon$$

Steepness of Yield Curve	T-Bills β_{SSP}	T-Bills β_{SCI}	T-Bills β_{π}	T-Bills β_{YC}	T-Bills R^2(%)	T-Bills Number of Observations	T-Bonds β_{SSP}	T-Bonds β_{SCI}	T-Bonds β_{π}	T-Bonds β_{YC}	T-Bonds R^2(%)	T-Bonds Number of Observations
More steep	0.03 (2.77)[a]	0.02 (1.14)	−134.55 (−9.55)[a]	−1.89 (−2.42)[b]	41.46	162	0.30 (5.43)[a]	0.00 (−0.01)	−274.95 (−4.05)[a]	0.14 (−0.04)	24.68	162
Less steep	0.03 (4.66)[a]	0.00 (0.38)	−334.71 (−16.82)[a]	−4.79 (−4.72)[a]	63.63	189	0.31 (5.17)[a]	0.02 (0.40)	−752.82 (−5.18)[a]	−9.83 (−1.16)	29.69	129

[a]Significant at the 0.01 level.
[b]Significant at the 0.05 level.
[c]Significant at the 0.10 level.

Bibliography

Baily, W., and Chan, K. (1991): "Economic Forces and Commodity Futures Prices: Further Evidence on Time Varying Risk Premia," unpublished manuscript.

Bessembinder, Hendrick (1991): "Risk Premia in Futures Markets: A Comprehensive Empirical Analysis," working paper.

Bodie, Z., and Rosansky, V. (1980): "Risk and Return in Commodity Futures," *Financial Analysts Journal,* May-June:27–39.

Breeden, D.T. (1980): "Consumption Risk in Futures Markets," *Journal of Finance,* May:503–520.

Chen, A.H., and A.J. Boness, (1975): "Effects of Uncertain Inflation on the Investment and Financing Decisions of a Firm," *Journal of Finance,* May:469–483.

Chen, A.H., Cornett, M.M., and Nabar, P.G. (1991): "Arbitrage Pricing Theory and the Behavior of Futures Prices," working paper.

Chen, N.F., Roll, R., and Ross, S.A. (1986): "Economic Forces and the Stock Market," *Journal of Business,* July:383–403.

Cornew, R.W., Town, D.E., and Crowson, L.D. (1984): "Stable Distributions, Futures Prices and the Measurement of Trading Performance," *The Journal of Futures Markets,* Fall:531–557.

Dusak, K. (1973): "Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums," *Journal of Political Economy,* December:1387–1406.

Erhardt, M., Jordan, J., and Walkling, R. (1987): "An Application of Arbitrage Pricing Theory to Futures Markets: Tests of Normal Backwardation," *The Journal of Futures Markets,* February:21–34.

Fama, E., and French, K. (1987): "Commodity Futures Prices: Some Evidence On Forecast Power, Premiums and the Theory of Storage," *Journal of Business,* Spring:55–74.

Fama, E., and Schwert, G. (1977): "Asset Returns and Inflation," *Journal of Financial Economics,* November:115–146.

Fortin, M., and Khoury, N.T. (1988): "Effectiveness of Hedging Interest Rate Risks and Stock Market Risks with Financial Futures," *The Journal of Futures Markets,* June:319–334.

Friend, I., Landskoner, Y., and Losq, E. (1976): "The Demand for Risky Assets Under Uncertain Inflation," *Journal of Finance,* December:1278–1297.

Hudson, M.A., Leuthold, R.M., and Sarassoro, G.F. (1987): "Commodity Futures Price Changes: Recent Evidence for Wheat Soybeans and Live Cattle," *The Journal of Futures Markets,* June:287–301.

Lintner, J. (1965): "Security Prices, Risk and Maximum Gains from Diversification," *Journal of Finance,* December:587–615.

Long, J.B., Jr. (1974): "Stock Prices, Inflation, and the Term Structure of Interest Rates," *Journal of Financial Economics,* July:131–170.

Milonas, N.T. (1986): "Price Variability and the Maturity Effect in Futures Markets," *The Journal of Futures Markets,* Fall:443–460.

Pearson, E., and Hartley, H. (1966): *Biometrika Tables for Statisticians* (3rd ed.), Cambridge University Press, England.

Roll, R. (1973): "Assets, Money and Commodity Price Inflation Under Uncertainty," *Journal of Money, Credit and Banking,* November:903–923.

Sharpe, W. (1964): "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk," *Journal of Finance,* September:425–442.