Order Number 9010478

Testing the pricing and informational efficiency of the S&P 500 stock index futures market

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The University of Arizona, 1989

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TESTING THE PRICING AND INFORMATIONAL EFFICIENCY OF THE S&P 500 STOCK INDEX FUTURES MARKET

by

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A Dissertation Submitted to the Faculty of the

COMMITTEE ON BUSINESS ADMINISTRATION

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1989

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Final Examination Committee, we certify that we have read

the dissertation prepared by Mahamood Mahomed Hassan

entitled TESTING THE PRICING AND INFORMATIONAL EFFICIENCY OF THE S&P STOCK INDEX FUTURES MARKET

and recommend that it be accepted as fulfilling the dissertation requirement

for the Degree of Doctor of Philosophy.

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	Date

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ACKNOWLEDGEMENTS

I would like to thank various people for their assistance and guidance in helping me complete this dissertation and the doctoral program. Firstly, to Dr. Gerald Bierwag, as the chair of the doctoral program and dissertation committee, for his encouragement, inspiration and guidance in helping me complete the program and the dissertation. I am also indebted to the other members of the dissertation committee, Dr. Willard Carleton and Dr. Edward Dyl, who provided valuable advice and direction.

I would also like to thank the faculty in the Departments of Finance and Management Science at California State University, Fullerton for their friendship and encouragement during the dissertation stage, especially Dr. John Emery, Ms. Erika Bakken, and Ms. Laurence Assailly. I also extend my gratitude to my family and friends in South Africa and in the USA for their support.

Finally, and most importantly, I am indebted to my wife, Ruwaida, and my eldest brother, Ahmed, for their love and unfaltering support which enabled me to attain the Ph.D. degree.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

ABSTRACT

Three empirical studies are conducted examining the efficiency of S&P 500 futures prices and the pricing of these futures contracts. In the first study, the ability of futures prices to predict the realized spot S&P 500 index prices on the expiration date is examined for near term contracts. The futures prices are found to be unbiased predictors of the realized spot index prices for the nineteen quarterly contracts from 1982 to 1986.

Previous studies report significant deviations in S&P 500 futures prices from theoretically determined Cost of Carry Model (CCM) prices. In the second study, it is found that the CCM using the federal funds rate, a proxy for the overnight repurchase rate, provides relatively better estimates of the S&P 500 futures prices over the 1984-1986 period. The futures mispricing also reflects the weekend effect anomaly: futures prices are "over-priced" relative to CCM prices on Mondays, whereas the opposite occurs on Fridays. The futures over-pricing (under-pricing) is characterized by "bull" ("bear") financial markets and the extent of price changes are relatively greater in the futures market. The futures under-pricing is supported by strong future market volume and open-interest positions.

The basis and changes in it over the futures contract period are measures of how well integrated the futures market and the underlying spot market are. In the third study, based on daily closing prices for the S&P 500 index and index futures for the 1984-1986 period, it is found that the basis decreases over the contract period but the rate of decrease is independent of the time to expiration. The change in basis on Mondays is generally positive which also reflects the weekend effect anomaly. The daily basis is negative on 107 days, which generally occurs during strong futures market trading volume and open-

interest positions. It is doubtful whether the negative basis can be attributed to a negative net financing cost, where the dividend yield on the spot index exceeds the cost of financing the spot index forward.

INTRODUCTION

A major financial innovation occurred in February 1982 with the introduction of stock index futures contracts for trading on an organized futures exchange and at present at least four stock indices are actively traded on different futures exchanges. The S&P 500 futures contract trades on the Chicago Mercantile Exchange (CME) and is the dominant contract representing almost seventy-five percent of index futures trading. In 1987 the dollar value of index futures trading was almost double that of the underlying stocks in the indices. The concept of a stock index futures contract is not new; Bakken (1959), Fisher (1966) and Miller (1986) discussed it at least a decade prior to its introduction.

The institutional trading aspects of stock index futures is comprehensively covered in most books on futures markets, for example, Fabozzi and Kipnis (1984), Figlewski (1986) and Kolb (1988). The proponents of organized futures markets usually claim the following benefits provided by these institutions: price discovery, hedging and speculation (in an orderly manner). The theories of how future prices are determined are based primarily on informational efficiency, the stability of spot price variance, and hedging and risk transfer. Working (1958), Powers (1970), Telser and Higinbotham (1977), Danthine (1978), Ederington (1979), Green (1981), Bray (1981) and Jaffee (1984) are some of the contributors.

The research on stock index futures can be divided into two broad categories: pricing and efficiency. Although closely related, pricing is principally concerned with arbitrage arguments, deviations from prices described by specific theoretical models and institutional constraints such as tax differentials, tax timing options and stochastic interest rates. The issues in efficiency concern the nature of price formation, market trading aberration and the importance of rational expectations. Cornell and French (1983a,b), Modest and Sundaresan (1983) and Cornell (1985a) are some of the contributors. These studies were restricted to a limited data base in the early years, but a sufficient body of market data is now available for a thorough study of many of these issues.

The following three aspects of the S&P 500 futures market are empirically examined: (a) the informational efficiency of futures prices as unbiased predictors of realized spot index prices on the expiration date (Chapter 1); (b) the pricing of futures contracts using the Cost of Carry Model (Chapter 2); and (c) the behavior of the S&P 500 basis over the futures contract period (Chapter 3). The three chapters are self-contained in that each has a statement of the problem, a literature review, the proposed methodology, the description of the data, the empirical results, and finally the conclusions. Thus, no separate chapter is assigned for the conclusions and summary. The tables and references are after Chapter 3.

CHAPTER 1

A TEST OF THE S&P 500 FUTURES PRICES AS UNBIASED PREDICTORS OF REALIZED INDEX PRICES ON MATURITY DATE

Statement of the Problem

A critical issue in the study of futures markets is whether the futures price is an unbiased predictor of the underlying asset's future spot or cash price on the expiration of the contract. The resolution of this issue has important implications for, among others, futures market speculating, the effective implementation of futures market hedges, and in a broader context, the social function of price discovery. Black (1976) argues that the price discovery role may be the most important function of futures markets, because these prices may affect the allocation of real economic resources. An unrecognized bias in the forecast of futures prices could possibly lead to the inefficient allocation of real resources. If futures prices are biased predictors, then speculators and arbitrageurs could derive above average profits on a risk adjusted basis, in a manner similar to other stock market anomalies, such as the weekend effect, the small firm effect and for low P.E. stocks. In the case of hedging, the biasedness of futures prices could affect the determination of the optimal hedge ratio and hence the effectiveness of hedging operations, particularly where the hedge is lifted prior to the expiration date. The latter issue is examined in Chapter 3 regarding stock index futures. Stein (1981) provides an index for measuring optimality, showing that the optimality of resource allocation, in an intertemporal context, is negatively related to a multiple of the square of the forecast error between the futures price and the subsequently realized spot price.

For futures markets, there is some evidence that futures prices are biased predictors of expected future spot prices. The institutional trading restrictions imposed by organized futures exchanges, the daily marking-to-market specifically, can induce such biases. A forward contract generally has no initial cash outlay, nor are there any interim cash outflows, whereas a futures contract requires an initial margin and there are daily inflows/outflows from marking-to-market. Black (1976), Cox Ingersoll and Ross (1981) and French (1983) have noted that the stochastically determined cash flows over the futures contract period may cause futures prices to be biased predictors. Kolb (1988) provides two other reasons: (a) the speculators will be prepared to take active positions only if the futures price is expected to differ materially from the future spot price, and (b) the "Cost of Carry" pricing model suggests a specific relationship between the futures price and the expected spot price so that no arbitrage opportunity exists.

Although there is substantial research in this area for commodities futures markets, only a small body of research relating to financial futures. This is primarily due to the short time in which futures markets have operated.

Literature Survey and Proposed Methodology

One of the long-standing research issues on futures markets is the relationship between the futures price and the expected spot price for the deliverable commodity at the expiration of the futures contract. The prevailing view comes from the theory of Keynes (1930) and Hicks (1946). The Keynes-Hicks hypothesis of "normal backwardation" suggests that the current futures price tends to be below the expected spot price but increases over the life of the contract. The excess of the expected spot price over the futures price is a "premium" which producers, who are risk averse, are willing to offer in order to sell futures contracts as a means of hedging against spot price fluctuations at harvest time. Thus, the producers are prepared to accept a price now with certainty, the futures price, which is at a discount relative to the expected spot price at harvest time, at the end of the futures contract period. On the other hand, speculators primarily participate in the market as buyers so as to obtain the premium resulting when the futures price increases. Under "normal backwardation" the producers predominantly take short positions and the speculators predominantly take long positions on the futures contract. The opposite positions are held under a "contango" when the futures price is above the expected spot price and is expected to fall over the life of the contract. A contango arises where the producers use the commodity as an input (for example, wheat converted into flour by millers) and hence take long positions, whereas speculators take short positions. In this case, the producers will purchase at the futures price, which exceeds the expected spot price, and the resulting premium is passed on to the speculators. Both Keynes (1930) and Hicks (1946) contemplated the presence of contangos in their respective treatises. Although this issue has been examined for a number of years the results are not unanimously in favor of the Keynes-Hicks hypothesis [See Kamara (1982) has a comprehensive survey of the futures market literature and Copeland and Weston (1988) and Kolb, Jordan and Gay (1983) summarizes these research findings]. The bulk of the research relates to commodities futures and it is an open question as to whether these findings could apply to stock index futures where there is no deliverable commodity on the expiration date of the contract. However, for commodities futures on average, less than 3% of the futures contracts eventually result in the delivery of the commodity involved. When stock index futures first began trading in February 1982, the professional market participants transferred the pricing knowledge accumulated over the past decade for interest rate futures to stock index futures. The basic logic used in pricing Treasury bond futures could be applied to index futures. In the initial period the observed futures prices were systematically lower than the suggested theoretical prices and this was attributed to a lack of appreciation of the differences in market structures, such as the cash settlement upon maturity of the contract and the institutional restrictions on short-selling of equity stocks. However, the market participants appear to have learned fairly rapidly, because the difference today is not as large as it was in the initial period [Zeckhauser and Niederhoffer (1983), Figlewski (1984a), Peters (1985) and Merrick (1987b)]. The pricing of stock index futures is covered in Chapter 2.

A review of the literature revealed no study which examined the issue as to whether the stock index futures prices are biased or unbiased predictors of the realized spot index on the maturity date. The following is a summary of some of the principal works on commodity futures. Cootner (1960) and Houthakker (1961) found evidence of a risk premium, which supports the normal backwardation hypothesis, but Telser (1960) found no such evidence in the commodities markets. Smidt (1965) suggested that the normal backwardation process requires the futures price to rise over time and thus futures prices exhibit positive autocorrelation. The tests showed that futures prices of some commodities exhibit statistically significant serial dependence, both negative and positive. Stevenson and Bear (1970) found corn and soybeans to exhibit negative dependence over short periods and positive dependence over long periods. By contrast Working (1958) developed a theory of anticipatory prices, where futures prices should follow a random walk and this view was supported empirically by Larson (1960). However, Cargill and Rausser (1972, 1975) found mixed evidence on random price behavior. The tests applied are the conventional weak-form tests of the efficient market theory, namely serial dependence, runs tests and mechanical trading rules. These conventional weak form efficiency tests have not been applied to index futures, but the tests for the day-of-the-week effect have been conducted to detect non-random price behavior across week days. This is discussed in Chapter 3. The following is a brief summary of the day-of-the-week findings. Based on the daily opening and closing prices for the period of May 3, 1982 to July 24, 1984, Cornell (1985a) confirms that the weekend effect exists in the returns on the S&P spot market and the bulk of the negative return is confined to the non-trading period from Friday's closing price to Monday's opening price. However, the S&P 500 futures reveal no weekly pattern of returns. On the other hand, Dyl and Maberly (1986a,b) report negative returns on Mondays for the S&P 500 futures market and the bulk of the negative returns can be attributed to returns based on Friday's closing price and Monday's opening price. They replicated the methodology and sample period used by Cornell and also enlarged the sample period from May 3, 1982 to December 31, 1985. In both cases the non-trading period weekend effect persisted. The authors allude to the possibility of errors in the data used by Cornell.

The questions of futures market efficiency and of whether the futures price is an unbiased predictor of the spot price on the expiration date are conceptually distinct issues. The latter refers to the movement of the futures price over the contract period relative to the spot price on the expiration date. For example, where the futures price is expected to trade below the realized spot price on the expiration date, which results in a risk premium as suggested by the Keynes-Hicks normal backwardation hypothesis. Furthermore, the futures price is expected to increase over the contract period which will reflect non-random price movements over the contract period. These non-random price movements do not necessarily result in a rejection of the weak-form futures market efficiency. The non-random price movements can be in terms of the submartingale version of market efficiency. A submartingale is a fair game where successive prices are expected to increase; thus, on average the price series is expected to yield positive returns and these positive returns would not necessarily violate the weak-form efficient market hypothesis. Therefore, the presence or absence of a risk premium does not directly affect the issue of market efficiency and this was initially discussed by Telser (1958) and Gray (1961) in the context of commodities futures markets.

In a classical paper, Samuelson (1965) showed that futures prices will fluctuate randomly although the seasonal pattern in spot (commodity) prices may be known. The basic feature of the model, assuming a stationary autoregressive process in spot prices, is that the variance of futures prices is inversely related to the number of days to delivery on the contract. The distant contracts will exhibit relatively lower variances because autoregressive prices will have a longer interval to self-correct, whereas the near term contracts will be more variable because prices have insufficient time to self-correct. The suggested result of the model is counter-intuitive since the variance is expected to become smaller as expiration time approaches, and the futures price is marked to the (expected) spot price. A review of the model confirms that the assumption of an autoregressive process in spot prices is central to Samuelson's hypothesis. However, the assumption of a stationary price-generating process may undermine the results of the model.

Stein (1979), Anderson and Danthine (1980) and Richard and Sundaresan (1981) have suggested an alternative model, the State Variable Hypothesis. The view is that changes in the volatility of futures prices depend on the pattern of information flow into the market. The futures prices are more volatile when substantial information flows into the market and relatively stable when less information becomes available. It is assumed that publicly available information helps to resolve uncertainty and prices move to new equilibrium levels. In summary, this hypothesis suggests that the volatility of futures prices over the contract period may be independent of the time to the expiration date, because it depends largely on the microstructure of the market for a particular commodity;

whereas Samuelson hypothesized that progressively greater futures price volatility occurs as the expiration date draws closer. Using daily data for nine commodities for the period 1966 to 1980, Anderson (1985) found evidence supporting both hypotheses but Milonas (1986) found support for the Samuelson hypothesis. In the latter paper, the author used a larger data base and, after removing seasonal factors, found a strong maturity effect on variance for ten of the eleven futures tested - including the financial futures (T-bills, T-bonds and the GNMAs) and metals (copper, gold and silver).

The research relating to the existence of a risk premium in futures prices and the biasedness of futures prices has concentrated on market structure and the decomposition of risk. For example, Gray (1960) provided evidence that thinly traded markets may reveal biased prices, but the bias may run in either direction. The CAPM was applied to the futures market by Dusak (1975) and no significant systematic risk was found. Furthermore, the returns on futures were indistinguishable from zero. By contrast, Bodie and Rosansky (1980) provided evidence of systematic risk in futures markets but their methodology has been questioned by Leuthold (1982).

A literature review reveals a wide range of findings and this can be attributed to the following factors. Different techniques were applied to different commodities over different time periods and many of the studies used only a few contracts over a short time period. In some of the studies, the data from different contracts were not aggregated thus the peculiarities of specific time periods were not avoided. Kolb, Jordan and Gay (1983), hereafter referred to as KJG (1983), devised a methodology that uses a long time span and aggregate data from different contracts (for the same commodity) in order to avoid any short-run expectational errors. The twelve contracts examined by them are listed in Table IV.

The near term S&P 500 futures daily prices will be studied from the inception of the first contract in April 1982 to the end of 1986 (a total of 19 quarterly contracts). The ability of S&P 500 futures prices to predict realized spot prices on expiration date will be tested in terms of the new methodology proposed by KJG (1983) and in terms of the traditional approach.

A recent study by Bigman, Goldfarb and Schechtman (1983), hereafter referred to as BGS (1983), of futures price efficiency in the grain market is an example of the traditional research methodology. The spot (cash) price on expiration date (at time n) is regressed on the futures prices (at time t) for n-t weeks prior to expiration for wheat, corn and soybeans contracts, where n-t ranges from 1 to 24 weeks. The following model is used:

$$S_n = \alpha + \beta F_{t,n} + \varepsilon_t; \text{ where:} \tag{1.1}$$

S_n = Spot price at time n, the maturity date

$F_{t,n}$ = Futures price at time t for contracts maturing at time n

α, β = Parameter estimates by OLS

ε_t = Error term with the standard assumptions for OLS

The Null Hypothesis is that futures prices are unbiased estimates:

H_0: $\alpha = 0$ and $\beta = 1$

BGS (1983) found that for the more distant contracts a > 0 and b < 1, implying that the more distant contracts provide inefficient estimates of the realized spot prices. The positive intercept value indicates a risk premium as suggested by the normal backwardation hypothesis. KJG (1983) developed a new methodology for testing on a large data bank. The intuition underlying this method relies on the assumption that with large samples, some biased estimators become asympotoically unbiased as the sample size increases. Based on this property of their model, the data from different contracts were aggregated so as to provide a more powerful test of the futures pricing relationship than previously available. The methodology was applied to twelve different CBOT futures contracts, including GNMAs and T-bonds.

Let E_t (.) represent an expectations operator formed at time t. Based on the following three assumptions: (a) no systematic risk; (b) markets operate perfectly; and (c) interest rates over the futures contract period are non-stochastic; then equation (1.2) is assumed to be true:

$$F_{t,n} = E_t(S_n)+u_t \tag{1.2}$$

Where u_t is a random error term, such that $E(u_t) = 0$.

The three assumptions are necessary to derive equation (1.2) for the following reasons: (a) with systematic risk, $F_{t,n}$ is at a discount relative to $E_t(S_n)$ as suggested by Keynes (1930) and Hicks (1946); (b) the absence of transaction costs, information acquisition costs and taxes are captured by assuming market perfections; and (c) the futures price ($F_{t,n}$) is equal to a forward price by assuming non-stochastic interest rates which avoids the difficulties of daily marking-to-market of futures contracts [Black (1976), Cox, Ingersoll and Ross (1981) and French (1983)].

Furthermore, if the Unbiased Expectations Hypothesis (UEH) is valid, then $E_t(s_n)$ would be an unbiased expectation, such that:

$$E_t(S_n) = S_n \tag{1.3}$$

(1.2) and (1.3) implies (1.4):

$$F_{t,n} = S_n + u_t \tag{1.4}$$

But $E(u_t) = 0$; thus the relationship in (1.4) implies that on the average, based on a large sample size covering a long period, the futures price is equal to the realized spot price on maturity date. Furthermore, if the relationship in (1.4) holds, it implies the absence of a risk premium, as suggested by the Keynes-Hicks hypothesis of normal backwardation. Thus, a rejection of the hypothesized relationship in (1.4), implies the presence of a risk premium embedded in the futures price.

At maturity the no-arbitrage condition must hold:

$$F_{n,n} = S_n \tag{1.5}$$

Since expectations cannot be observed, (1.2) cannot be tested directly, but with the assumption in (1.3) and (1.5), a test of (1.4) would imply the truth of (1.2). Therefore, a test of (1.4) is a joint hypothesis test because a test of (1.4) also tests the validity of (1.2) and (1.3) simultaneously. The question of biased expectations and the equality of futures prices and expected future spot prices cannot be separated by the methodology developed by KJG (1983).

If (1.4) holds, then:

$$F_{t,n}-S_n = 0; \text{ because } E(u_t) = 0 \tag{1.6}$$

for any single contract this gives rise to the vector:

$$(F_{t,n}-S_n) = (F_{t+1,n}-S_n) = \ldots = (F_{n,n}-S_n) = 0 \tag{1.7}$$

The above is the expected relationship for any contract over a long peiiod. Furthermore, other contracts with different maturities could be used to form similar vectors, the results being arranged into a matrix:

$$
\begin{array}{cccc}
(F^1_{t,n}-S^1_n), & (F^1_{t+1,n}-S^1_n), & \ldots\ldots, & (F^1_{n,n}-S^1_n) \\
. & . & & . \\
. & . & & . \\
. & . & & . \\
(F^i_{t,n}-S^i_n), & (F^i_{t+1,n}-S^i_n), & \ldots\ldots, & (F^i_{n,n}-S^i_n)
\end{array}
\quad (1.8)
$$

where the superscripts act as contract indentifiers.

A vector of column averages can be formed from (1.8), of the form:

$$D_t,\ D_{t+1}, \ldots\ldots D_n \quad (1.9)$$

Every element of (1.8) should have a zero value on average if (1.4) holds; then (1.9) should be a vector of zeros as well and it may be called the Difference Vector. The elements of (1.9) are averages and should be relatively free of any expectational errors that may have been present in (1.8), since the above is based on the Unbiased Expectations Hypothesis.

The elements in the Difference Vector in (1.9) is regressed against the number of days to maturity to test the hypothesis of (1.4) and hence of (1.2):

$$D_t = \alpha + \beta(q) + \varepsilon_t \quad (1.10)$$

<u>NULL HYPOTHESIS</u>: H_o: α=o and β=o

The days to maturity of the futures contract is represented by q, where q = n-t, and the null hypothesis should be rejected, if (1.4) holds. This version is preferred because it can also address the Keynes-Hicks hypothesis but it needs to be transformed to address the following econometric problems encountered by KJG (1983):

(i) Price series typically exhibit strong serial correlation and this would most probably affect (1.7) and therefore (1.8) and (1.9). The conventional approach is to express the price series in log normal form [Fama(1965), Cornell (1985) and Dyl and Maberly (1986a,b)].

(ii) The existence of heteroskedasticity. Samuelson (1965) postulated that futures prices should increase as contracts approach maturity and this hypothesis received support from Rutledge (1968), Dusak (1979) and Milonas (1986).

The problem of serial correlation may be addressed by transforming the above into logarithms of successive price relatives or Log-Link-Relatives (LLR), as termed by KJG (1983). These are daily rates of return with continuous compounding.

If (1.4) holds, then for each contract:

$$F_{t,n} = F_{t+1,n} = \ldots = F_{n,n} = S_n \qquad (1.11)$$

From (1.11) it follows that:

$$\frac{F_{t+1,n}}{F_{t,n}} = \frac{F_{t+2,n}}{F_{t+1,n}} = \ldots = \frac{F_{n,n}}{F_{n-1,n}} = \frac{S_n}{F_{n,n}} = 1 \qquad (1.12)$$

Furthermore:

$$\mathrm{Log}\,\frac{(F_{t+1,n})}{(F_{t,n})} = \mathrm{Log}\,\frac{(F_{t+2,n})}{(F_{t+1,n})} = \ldots = \mathrm{Log}\,\frac{(F_{n,n})}{(F_{n-1,n})} = 0 \qquad (1.13)$$

This vector (1.13) comprises the logs of the link-relative of futures prices and each element should equal zero. Since (1.13) will be formed for each contract some values of (1.13) may not equal zero. Vectors of the form of (1.13) can be combined to form a matrix isomorphic to (1.8) and a vector average LLRs isomorphic to (1.9).

The matrix and vector of LLRs should exhibit the same properties as matrix (1.8) and the Difference Vector (1.9).

One can also express vector (1.13) in a form similar to (1.10) to test whether there is any systematic movement in returns over the life of the contract, testing the Keynes-Hicks hypothesis.

Vectors of column average can be formed from (1.13), of the form:

$$L_{t+1}, L_{t+2}, \ldots L_n \tag{1.14}$$

The following regression is similar to (1.10):

$$L_{t+1} = \alpha + \beta\,(m) + \varepsilon_{t+1} \tag{1.15}$$

NULL HYPOTHESIS: H_o: $\alpha = 0$ and $\beta = 0$

Here m refers to the number of days to maturity of the futures contract, where m = n-t+1. A significant β coefficient value implies that the returns deviate systematically over the life of the contract. A significantly positive α can indicate the presence of normal backwardation, that is, futures prices on average will increase over the life of a contract so as to realize a premium. Conversely, a significant negative α would indicate a contango.

The presence of any further autocorrelation, as shown by the Durbin-Watson test, was corrected by the Cochrane-Orcutt iterative least squares techniques. The presence of heteroskedasticity, as shown by the Goldfeld-Quandt (1965) test, can be corrected by the methods suggested in Johnston (1984).

KJG (1983) found that the Null Hypothesis to (1.15) could be rejected for seven of the twelve commodities on the CBOT, which includes the GNMAs and T-bonds, refer to Table IV.

The near term S&P 500 futures contracts will be examined. The equities market has many differences compared to the commodities markets. Portfolio insurers are mainly financial institutions holding substantial equity portfolios, selling stock index futures contracts to hedge their equity portfolios against the threat ot a "bear" market. They play the role of producers because they hold long cash positions and short futures positions. There are also other major participants, namely asset-allocation traders, arbitrageurs and speculators. Furthermore, the use of computer program trading and the absence of actual delivery on the expiration date are other distinguishing features of the stock index futures market. It will be interesting to observe whether the S&P 500 futures prices are unbiased predictors of realized spot prices on the expiration date and whether a risk premium, as suggested by the Keynes-Hicks hypothesis of normal backwardation, can be discerned.

Data and Empirical Results

Daily futures and spot prices were taken from the Chicago Mercantile Exchange (CME) Yearbook for the period 1982 to 1986. The S&P 500 futures commenced trading on April 21, 1982 on the CME and the contracts mature on the Thursday/Friday of the third week of March, June, September and December. A total of 19 quarterly contracts were examined. The daily futures prices were examined for 61 trading days prior to expiration because the near term contract represents at least 80% of the trading volume and open-interest position. The observations beyond 61 days would result in over-lapping of contracts and the futures prices for the different S&P 500 futures contracts will not be independently determined. For example, on March 1, 1986, the futures prices for March 1986, June 1986, September 1986, December 1986 and March 1987 contracts can be observed but these prices are not independently determined. This criticism was levelled by a discussant of the KJG (1983) paper and he questioned the validity of the degrees of freedom by pooling across contracts existing at the same time To avoid this problem the observations are restricted to 61 days and in some cases to a shorter period, for example the initial futures contract for June 1982 traded for 39 days only. The S&P 500 futures price refers to the daily settlement price set by the CME and the S&P 500 index price refers to the daily closing price. The CME closes fifteen minutes after the NYSE and the Settlement Committee, whose role is to establish a settlement price, takes this non-synchronized trading into account.

The first series of tests uses the traditional approach and regresses the spot price on the expiration date (S_n) on the daily futures prices (F_t) for t=1, ...60 days prior to the expiration date. The results are presented in Table I and can be interpreted as follows:

(i) The R^2 value is consistently high and its lowest value is .874 on the 54th and 60th day prior to expiration. The value increases consistently with the arrival of the expiration date as more information becomes available.

(ii) As expected, the standard error of the regression lines decrease uniformly as the expiration date arrives confirming the improved predictive power of futures prices with the passing of time.

(iii) The Durbin-Watson (DW) statistics show no autocorrelation over the 60 days period except for the 4th, 7th and 9th day prior to expiration, using a 5% significance level. However, these exceptions fall into the region of uncertainty and are fairly close to the critical value of 2.72 for a two-tailed 5% significance test. These three days are not corrected and re-estimated since appropriate adjustments will be made under the KJG (1983) approach.

(iv) The parameter estimates of the constant term are not statistically significant from zero over the entire 60 day period at a 5% significance level. This casts doubt on the presence of a significant risk premium as suggested by the Keynes-Hicks hypothesis of normal backwardation. The absence of a risk premium in the S&P 500 futures prices is not entirely unexpected since the nature of the participants in the commodities markets and the index futures markets are different. The normal backwardation hypothesis was suggested in the context of the commodities markets where producers go short in futures contracts to off-set the long position in the actual commodity and in the stock index markets this role is played by the holders of portfolio insurance. However, there are also other major participants in the stock index markets, namely asset-allocation traders, arbitrageurs and speculators. Furthermore, the use of computer program trading and the absence of actual delivery on the expiration date distinguishes the S&P 500 futures market from the commodities market.

(v) The slope coefficients are all statistically significantly different from zero but not significantly different from one at a 5% confidence level. The daily futures prices prove to be unbiased predictors of the realized spot prices for the near term contracts. The highest coefficient is 1.067 on the 34th day and the lowest is 0.942 on the 60th day prior to expiration.

(vi) These results can be used to maintain the Null Hypothesis:

$$H_O: \alpha = 0 \text{ and } \beta = 1$$

The second series of tests is a variation of the traditional approach and was suggested by Kolb, Jordan and Gay (1983). A matrix of the natural log of daily price relatives (LLRs) is constructed as shown in equation (1.8) above. The statistical description of the column means are shown in Table II. Based on the t-test (5% confidence level) the mean LLRs are not statistically different from zero, except for the relative prices for the 11th and 48th day prior to the expiration date. These results substantially confirm the results of the traditional approach reported in Table I.

The mean LLRs are regressed on time to expiration, for up to 60 days, to test the Null Hypothesis to equation (1.15):

H_o: $\alpha = 0$ and $\beta = 0$

The regression results are shown in Table III. The constant term and slope parameter estimates are not statistically significant from zero at a 5% confidence level. The low R^2 of .017 confirms the lack of any significant linear changes in futures prices over time to expiration. The Durbin-Watson (DW) statistic shows an absence of autocorrelation. A regression of the residuals against time to expiration revealed an absence of a linear relationship, thus heteroskedasticity is not a problem. The Null Hypothesis can be maintained. These results confirm the earlier findings that no significant risk premium is embedded in the S&P 500 futures prices and also that the futures prices are unbiased predictors of realized spot prices on maturity for the near-term contracts (for trading periods up to three months). It should be reiterated that the near term S&P 500 contracts represents the major trading volume and open-interest position of all stock index futures.

The results of the tests by KJG (1983) are presented in Table IV for comparison purpose. To summarize the results, many commodities appear to indicate rising futures prices over their respective contract lives, while the interest rate futures (GNMAs and T-bonds) generally had falling prices. Of the 12 commodities examined, eight showed price behavior that is inconsistent with the hypothesis that futures prices are unbiased predictors of spot prices at maturity date. The authors conclude that no single explanation, such as normal backwardation or stochastic interest rates, can account for the price behavior of all commodities. Since each commodity appears to show its own peculiarities and the key to understanding the price behavior of each commodity depends on the microstructure of the market for that particular commodity.

Conclusion

The S&P 500 daily futures prices are informationally efficient for the near term contracts, where the expiration date of the contract is within sixty trading days. Specifically, the daily futures prices are unbiased predictors of the realized spot prices on maturity date for the 19 quarterly contracts studied from 1982 to 1986. Furthermore, little evidence is found to support the Keynes-Hicks hypothesis of a risk premium in S&P 500 futures prices. The efficiency of the index futures market and the absence of a risk premium can partly be attributed to the low transaction costs of trading in stock index futures which helps to attract the large number of participants with different investment objectives, such as portfolio insurers, asset allocators, arbitrageurs and speculators.

CHAPTER 2

AN APPLICATION OF THE DAILY FEDERAL FUNDS RATE, A PROXY FOR THE OVERNIGHT REPURCHASE RATE (REPO RATE), IN THE "COST OF CARRY" PRICING MODEL TO DETERMINE S&P 500 FUTURES PRICES

Statement of the Problem

The stock index market is relatively new and the principles of pricing index futures are not well established. When stock index futures first began trading in February 1982, the professional market participants transferred the pricing knowledge accumulated over the past decade for interest rate futures to stock index futures. In the initial period, the observed futures prices were systematically lower than the theoretical prices suggested by the Cost of Carry Model (CCM) and this was attributed to a lack of appreciation of the differences in market structures, such as the cash settlement upon maturity of the contract, the institutional restrictions on short-selling of equity stocks, and the absence of the tax timing option in futures contracts. The persistent discount in futures prices relative to the theoretical CCM prices in the initial period (1982-1983) was reported by, among others, Cornell (1985 a), Cornell and French (1983 a,b), Figlewski (1984 a,b, 1985), Gastineau and Madansky (1983), Modest (1984), Modest and Sundaresan (1983), Peters (1985) and Zeckhauser and Neiderhoffer (1983). The recent studies by, among others, Merrick (1987 a,b), MacKinlay and Ramaswamy (1988) and Saunders and Mahajan (1988) show that the futures prices since 1984 traded both at a discount and at a premium relative to the theoretical CCM prices. In this chapter, the empirical behavior of the deviations in pricing is addressed and this will be achieved by examining the validity of certain proposed hypotheses regarding the stochastic behavior of these deviations.

Literature Survey and Proposed Pricing Model

The futures market literature is dominated by the following two pricing models, which attempt to explain the behavior of futures prices. These models are discussed in the works of Fabozzi and Kipnis (1984), Figlewski (1986), Schwarz, Hill and Schneeweis (1986), Copeland and Weston (1988) and Kolb (1988). The first model is based on the Unbiased Expectations Hypothesis (UEH) which predicts that futures prices on average equal realized spot prices at maturity; if this did not hold true, an opportunity for speculative profits would arise. In Chapter 1 it was found that daily futures prices tend to be unbiased predictors of realized spot prices at maturity date. The expectations model does not specify the expectations formation mechanism and it is the task of the investor or researcher to specify an appropriate expectations mechanism. The second model is the Cost of Carry Model (CCM), which is based on arbitrage opportunities between the futures market and its underlying spot market. The basic model and variations of it has received wide support among market participants and researchers [Modest and Sundaresan (1983), Cornell and French (1983 a,b) and Figlewski (1984 a)].

The CCM uses the spot price (also called cash price or current price or market price) as an important element in pricing futures contracts. According to classical stock valuation theory, the current stock price is the equilibrium price of the collective market assessment, which in turn reflects the expected dividend flows and stock appreciation in relation to the investment risk over some holding period. If the investors collectively assess a lower expected price and dividend flows, the current stock price would have to be adjusted downwards accordingly. The spot price movements continuously reflect the market assessment process, because equity markets are liquid and assumed to be efficient and any short-term shocks will be discounted quickly by the market. Therefore, the spot price is taken as the point of departure for determining the futures price.

The basic CCM for stock index futures is based on the following assumptions (some of these assumptions are relaxed in later developments):

1. There are no transaction costs, which implies that the cost of carry equals the financing rate and the latter is known at the beginning of the contract;
2. There is actual delivery of the underlying stock index at the end of the contract;
3. The end of the investment holding period coincides with the expiration date of the futures contract;
4. The spot prices of the stocks are known at the beginning of the contract;
5. The stocks can be sold short at any time;
6. The full proceeds from the short sales are either available to the investor or "invested" on his behalf;
7. The dividends on the stock portfolio are known at the beginning of the contract period and will be paid at the end of the contract period;
8. The stock index selected is a "good" proxy for the market, such as the value weighted S&P 500 Index and the NYSE Index.

The basic CCM is as follows:

$$TF_{t,n} = S_t\,(1 + r_{t,n})^{n-t} - D_1;\ \text{where} \tag{2.1}$$

$TF_{t,n}$ = Theoretical futures price at time t for a contract maturing at time n

S_t = Spot price of index at time t

$r_{t,n}$ = Risk-free rate of interest at time t for n-t days

D_1 = Dividends on stock index portfolio to be paid at maturity of the futures contract.

Prior to the trading of index futures, the prevailing view was that the futures price would exceed the spot price by an amount equal to the interest- rate on risk-free securities minus the dividend yield on the index portfolio.

The basic CCM has been developed further by relaxing most of the above assumptions, such as: multi-period analysis, the presence of transactions costs, the actual timing of dividend payments, a limited or no access to the proceeds from short-sales, different borrowing and lending interest rates [Modest and Sundaresan (1983), Modest (1984), Figlewski (1984 b), Merrick (1987 a,b) and MacKinlay and Ramaswamy (1988)].

The CCM has been tested empirically by, among others, Cornell and French (1983 a,b), Modest and Sundaresan (1983), Modest (1984), Figlewski (1984 a), Cornell (1985 a), Peters (1985) and MacKinlay and Ramaswamy (1988). The earlier studies unanimously show that the observed futures prices were on average below the theoretical futures prices since their introduction in April 1982 for both the NYSE Index and the S&P 500 Index. In the initial years (1982-1983), the observed prices were systematically lower than the theoretical prices but since 1984 the price difference has become smaller and less predictable. The following reasons are provided for the persistent discount during the first two years of the index futures trading and some of them may also explain the positive and negative mispricing in subsequent years:

1. The arbitrage argument, which is the basis for the CCM, depends upon a theoretical world of perfect markets. In the real world there are markets with transaction costs, time delays in executing trades and restrictions on short sales. Arbitrage operations

are more difficult to implement; thus a band of values around the theoretical futures price can prevail without inducing arbitrage trading.

2. Modest and Sundaresan (1983) suggest that the futures discount may reflect the short-seller's inability to procure regularly the full proceeds of the short sales. A short-seller must pay the dividends on the borrowed share, but if the full proceeds of the short sale are not available for investing in the money market, the short stock-long futures arbitrage becomes profitable only when the futures price is below the current spot index by an amount greater than the dividend yield on the index portfolio.

3. Cornell and French (1983 a,b) suggest that the cash position offers a valuable "tax timing option." Prior to 1987, the benefits of long-term capital gains could be activated by the holder of a cash index position. However, for futures contracts, both the realized and unrealized gains or losses are accounted for at the end of the fiscal year for determining the tax liability. Thus, for a tax-paying investor, the stock index futures may be priced below the theoretical level by an amount equal to the value of the tax timing option. later, Cornell (1985 a) studied this issue in detail and found that the tax timing option is not an important factor in pricing stock index futures. The following two explanations are offered: (i) the marginal investor is a tax-exempt institution, thus, the tax timing option is worthless, or (ii) the transaction costs, limitations on capital loss deductions for determining the tax liability and other tax-related constraints reduce the value of the timing option.

4. The cost of the initial margin and changes due to the daily marking-to-market could explain some of the discount. Most researchers ignore the margin requirements by suggesting that it does not always represent an opportunity cost because it can be discharged by means of a bank letter of credit or by posting Treasury bills and the interest continues to accrue to the investor. However, Telser (1981) provides an

interesting argument for costly margin requirements in that interest-bearing securities such as Treasury bills are part of an investor's precautionary balance. If the securities are committed for margin requirements, then they are unavailable for other uses.

5. Hanson and Kopprasch (1984) suggest that since the stock index does not have a simple asset underlying the contract, it requires a large number of securities to be assembled to duplicate the index itself and the transaction cost can be prohibitive. The changes in the stock index reflecting stock splits, stock dividends, or changes in the composition of the index itself further complicate the matching process. The cash settlement procedure on maturity date prevents delivery of the underlying stock portfolio, resulting in transaction costs which may be significant. The entire portfolio has be be liquidated (or repurchased if short) simultaneously, if the investor does not want to have any unhedged long (or short position) on the expiration date.

6. To evaluate the potential arbitrage transactions, the value of the stock index must be available during trading hours of the futures contract. The values of the index are available during trading hours but they may lag market movements, as reflected in the index futures. Using intra-day prices, Kawaller, Koch and Koch (1987) show that S&P 500 futures price movements consistently lead the index movements by twenty to forty-five minutes, while movements in the index rarely affect futures beyond one minute. Similar results are reported by Merrick (1987 b). Thus, while a trade may look attractive, where the index looks "cheap" relative to the futures, the arbitrageur may find that the surrogate portfolio turns out to be more expensive than the indicated index value.

7. The seasonality of dividends received from stocks comprising the index based portfolio may affect the price of the futures contract. It is apparent from the CCM equations (2.1) and (2.2) that large dividends received on earlier dates will increase the reinvestment income from dividends, and this increase in dividends and reinvestment income will reduce the futures price. It is possible for the futures price to trade below the spot price without attracting arbitrage activities. However, in Chapter 3, it is shown that it is doubtful whether the reverse futures-spot price relationship can be adequately explained by large dividend payments. It is known that the dividends on the stock index varies non-linearly with time and this is called the "lumpiness of dividends over time" [Gastineau and Madansky (1983), Hanson and Kopprasch (1984), Kipnis and Tsang (1984), Modest (1984) and Schwarz, Hill and Schneeweis (1986)]. Furthermore, the CCM pricing formula requires an estimate of the expected dividends over the contract period and this increases the uncertainty. However, Figlewski (1984 b) suggests that dividends are a small component of total return and fairly stable over time.

In summary, Figlewski (1984 a) suggests that the above "equilibrium" arguments attempt to explain the existence of the discount on stock index futures within the context of a market in which all investors are behaving optimally, given their expectations and the institutional constraints of the market place. However, the discounts are too large to be accounted for by the above factors to maintain the CCM equilibrium relationship.

The inadequacy of the CCM to predict observed futures prices is also found with some of the other rational pricing models in financial economic theory. The findings of LeRoy and Porter (1981), Shiller (1981 a,b, 1982) and Grossman and Shiller (1981) suggest that the observed movement in stock prices appear to be significantly higher than the movement predicted by the valuation models commonly used in financial economic theory. For example, Shiller applied the S&P 500 prices (or a proxy for S&P 500) for the period 1889-1981 to the classical Dividend Discount Model (DDM) suggested by Gordon and Shapiro (1956). The results of these tests question the validity of numerous efficiency market tests in support of the semi-strong form of the efficiency market hypothesis (EMH). One of the responses to the empirical evidence presented by Shiller, LeRoy and Porter is by Flavin (1983), suggesting that in small samples the "volatility" or "variance bounds" tests tend to be biased, often severely, toward rejecting the null hypothesis of market efficiency. Thus, the apparent violation of market efficiency may reflect the sampling properties of the volatility measures, rather than a failure of the EMH itself. In a recent study, Campbell and Shiller (1988) reviewed the evidence on whether stock prices are too volatile to behave according to the simple present value models. They found that the ratio of a long moving average of real earnings to the current stock price is a powerful predictor of stock returns particularly when the returns are measured over several years. The tests covered the S&P 500 index and related dividends and earnings for the 1871-1987 period.

Returning to the main purpose of this chapter, the basic CCM described in equation (2.1), with some changes, will be examined, using the overnight federal funds rate as an appropriate cost of financing as opposed to the Treasury bill rate. It is customary to use the rate on the Treasury bill whose maturity date is closest to the expiration date of the stock index futures contract. Kipnis and Tsang (1984) and Kawaller (1987) suggest that, contrary to traditional theory, in practice it is not possible to arrange a truly risk-free arbitrage using stock index futures. The reasons given are similar to those provided above for the persistent discount in the futures price during the first two years. Although the interest rate is tied to the time to expiration of the futures contract in calculating the theoretical value, in practice arbitrageurs will typically finance this activity using an overnight rate. Arbitrageurs are exposed to an interest rate risk because the rate realized upon completion of the arbitrage may differ from the term rate anticipated at the initiation of the arbitrage [Kawaller and Koch (1984), and Kawaller (1987)]. The latter suggests using two different rates: (i) a rate for determining a threshold for buying stocks and selling futures, and (ii) another rate for determining a threshold for the reverse trade. Both these rates will be greater than the risk-free rate, and will be based on the marginal cost of funds for arbitrageurs and on the available alternative fixed income investment returns.

The short-term interest rates usually associated with carrying costs in the cash and futures market are rates on repurchase agreements (repo rates) on Treasury securities. The repo market is commonly used to finance short-term government bonds and for investing cash held by financial and non-financial institutions on a very short-term basis. It is a large dealer market in which most volume consists of overnight sales of government securities with an agreement to repurchase these securities a day later at a price reflecting overnight interest charges. There is also a term repo market for periods longer than a day, but this is a relatively thinner market than the overnight repo market [Schwarz, Hill and Schneeweis (1986)]. The repo market is essentially a dealer market and the rates are not widely published, but the daily rates on federal funds are widely published and these two rates are very close to each other as shown in Table VI. These rates are discussed in the next section. Commercial banks lend one another funds through the Federal Reserve System or through a correspondent bank which is a member of the System. Federal fund loans are usually for one day and the rates are marginally above the repo rates since the latter is a secured loan. Schwarz, Hill and Schneeweis (1986) also use the federal funds rate as a proxy for the overnight repo rate.

The basic CCM will be tested using (a) the daily federal funds rate as the appropriate rate of financing the spot rate forward to the expiration date, and (b) assuming dividends are paid evenly during the year, which in turn will be reinvested at the risk-free rate (Treasury bill yield) from the date of payment to the expiration date. The suggested version of CCM:

$$TF_{t,n} = S_t\,(1+f_t)^{n-t} - D_{t,n}\text{ ; where:} \tag{2.2}$$

$TF_{t,n}$ = Theoretical futures price of contract at time t, which matures at time n

S_t = Value of cash index at time t

f_t = Federal funds rate (overnight rate) at time t

$D_{t,n}$ = Cumulative value of dividends payable on the cash index (S_t) during the period t to n, assuming reinvestment at the Treasury bill yield.

As discussed earlier, cumulative dividends should represent the expected dividends during the futures contract period, assuming reinvestment at the Treasury bill yield from date of dividend payment to expiration date. Daily expected dividend information is not readily available, although large stockbrokerage firms produce the series for their own arbitrage trading operations. The procedure used to establish the cumulative value of dividends, presented in Table V and discussed in the next section, has the effect of removing dividend risk, but the dividend yield remains [Figlewski (1984 b)]. Furthermore, it is assumed that the overnight federal funds rate is a reasonable proxy for the overnight repo rate. For pricing purposes, futures contracts have generally been treated like forward contracts in the futures markets literature. In the case of stock index futures it is generally assumed that interest rates and dividend payments are known at the beginning of the futures contract. Black (1976) made a theoretical distinction in the cash flows associated with forward and futures contracts, and the differences in the pricing of these two types of contracts have also been examined by Cox, Ingersoll and Ross (1981), Richard and Sundaresan (1981), Jarrow and Oldfield (1981) and French (1983). A common point is that if interest rates are nonstochastic, then the futures price is equal to the forward price.

In a reasonably frictionless market, deviations from the CCM prices should be transitory and should be accompanied by opposing price pressures generated by arbitageurs. However, Modest and Sundaresan (1983), Cornell and French (1983 a,b), Figlewski (1984 a,b), Merrick (1987 a) and MacKinlay and Ramaswamy (1988), among others, report varying degrees of significant deviations from fair relative pricing for stock and stock index futures contracts. Similar evidence of mispricing in Treasury bill futures market is reported by, among others, Elton, Gruber and Rentzler (1984) and Hedge and Branch (1985). The documented mispricings indicate that futures and cash positions are less than perfect substitutes (net of carrying costs) for the majority of market participants, and that arbitrageurs and other investors are unable to exert sufficient pressure to keep these prices continuously in their correct theoretical relationship. Garbade and Silber (1983) suggest that, in practice, the supply of arbitrage services may be less than perfectly elastic and in a recent paper, Rubenstein (1987, p. 84) concludes that "the growth in index futures trading continues to outstrip the amounts of capital that are available for arbitrage." The following comments by MacKinlay and Ramaswamy (1988, p. 138) summarizes the problems encountered by researchers in testing the pricing of stock index futures contracts:

> "It should be emphasized at the outset that it is extremely difficult to specify a <u>model</u> for the deviations of futures prices from "fair values." These deviations are, presumably, affected by the flow of orders as well as by the difference of opinion among participants regarding parameters of the valuation model that provides "fair values." It is well known that the conventional strategies pursued by <u>arbitrageurs</u> to take advantage of these deviations are <u>not</u> risk free, and are influenced further by the transaction costs they involve. The purpose of this article is to examine the <u>empirical</u> behavior of these deviations; in doing so, we examine the validity of certain proposed hypotheses regarding the stochastic behavior of these deviations given that market participants will attempt to exploit these as profit opportunities."

The recent study by MacKinlay and Ramaswamy (1988), hereafter referred to as M&R (1988), comprehensively covers the stock index pricing literature and numerous hypotheses are put forward, of which not all relate to stock index pricing. The authors provide a detailed theoretical and empirical analysis of S&P 500 futures contracts using intraday data in the form of observations at 15-minute intervals for the September 1983 to June 1987 contracts (16 contracts). Their hypotheses and findings are discussed and analyzed in the next section. An attempt will be made to support/refute their findings.

In this chapter, the following additional issues and questions will be examined:

(i) Does the CCM using the federal fund rate provide better estimates of futures prices?

(ii) Can a weekly pattern be observed in the futures mispricing series?

(iii) Can a trend over time be observed in the futures mispricing series?

(iv) What are the economic circumstances surrounding the futures mispricing series? Are variables such as returns on spot index, returns on index futures, volume and open-interest positions in the futures market relevant?

Data and Empirical Results

The following data were taken from the Chicago Mercantile Exchange (CME) Yearbook for 1984, 1985 and 1986: daily spot prices, futures prices, volume, open-interest and the overnight federal funds rate. The Treasury bill yield was taken from the Wall Street Journal. A total of twelve quarterly contracts are examined, providing 716 daily observations. The daily prices are for up to 67 trading days prior to the expiration of the near term futures contract, which represents at least 80% of the total trading volume and open-interest.

The S&P 500 futures price refers to the daily settlement price set by the CME Settlement Committee and the S&P 500 index price refers to the daily closing value. The CME closes fifteen minutes after the NYSE and the Settlement Committee takes the longer trading period into account. The daily risk-free rate is represented by the yield on Treasury bills, selecting those with maturity dates closest to the expiration date of the near term contracts. The futures contract matures on the third Thursday in March, June, September and December. The Wall Street Journal reports daily on Treasury bills: the bid discount, the ask discount and the yield, which is based on the asking price. These bills mature on Thursdays and they cover the full range of maturities from one week up to the maximum fifty-two weeks. The Treasury bill yield based on the asking price is used in this study.

Dividends were taken from Standard and Poor's Security Price Index Record (1986) and Current Statistics Book (published quarterly). At the end of each quarter, dividends per share (DPS, adjusted to index) for the previous twelve months are reported. The reported DPS is divided by four to give a quarterly dividend, which in turn is spread over the number of trading days for the near term contract. This gives a daily dividend which will be the same over an approximately sixty-day trading period. In applying the above procedure, it is assumed that the dividends for the forthcoming twelve months will be the same as the previous twelve months' dividends. This procedure has the effect of removing the dividend risk, but the dividend yield remains [Figlewski (1984b)]. The dividend data are presented in Table V. Dividends have increased steadily over the three year period.

In Table VI, the overnight federal funds rate is analyzed. The following two issues are addressed:

1. Is the federal funds rate a "good" proxy for the overnight repo rate?

2. The conventional wisdom is that the federal funds rate on Wednesdays is significantly higher than on other days of the week, because the minimum average weekly federal reserve requirements for commercial banks are established on Wednesdays. Therefore, should there be any adjustment to Wednesdays' rate?

The overnight repo rate on Fridays for the period March, 1986 to October, 1988 was obtained from a private source (a large nationally known savings and loan association). The 139 weekend repo rates are compared to the weekend overnight federal funds rates. The federal fund rate has a mean of 6.80% versus 6.67%; a standard deviation of 0.70% for federal funds rates versus 0.68% for repo rates. The paired differences show that the federal funds rate is on average 13 basis points above the repo rate, which is significantly different from zero at a 1% level. However, the federal funds rate is not consistently above the repo rate; the federal funds rate exceeds the repo rate on 92 occasions (66% of total observations.). The federal funds rate exceeds the repo rate by a maximum of 185 basis points; while the repo rate exceeds the federal funds rate by a maximum of 65 basis points. There are also statistical tests which require no assumption regarding the probability distribution of the time series data, such tests are usually referred to as nonparametric tests or distribution-free tests. They test for stationarity and randomness and are discussed in any standard statistics book. The runs test is a simple test for randomness, which is based on the premise that any observation from a horizontal time series with independent error terms is equally likely to be above or below the median of the series. First, the median of the series is determined, then assign a plus sign to observations above the median and a minus sign below it. Finally, the pluses and minuses are listed in chronological order and the number of "runs," or blocks of pluses and minuses are counted. The runs test can be specified around any value, including zero. The latter is more meaningful in finance because it signifies gains and losses. The statistical runs test shows that the paired differences are randomly distributed around zero at a 5% significance level. Based on the above analyses, the overnight federal funds rate may be regarded as an "acceptable" proxy for the overnight repo rate.

The daily federal funds rate was on a down trend during the 1984-1986 period. Wednesdays' rates are compared to the rates on Tuesdays, Thursdays and a simple average of the Tuesday and Thursday rates. The paired differences between the rate on Wednesdays and each of the other three rates are also reported in Table VI. Wednesdays' rates on average lies between the rates on Tuesdays and Thursdays; however, the rate on Wednesdays is substantially greater than on Tuesdays, but the rate on Thursdays is not significantly above the rate on Wednesdays. The paired differences test shows that Wednesdays' rate exceeds Tuesdays' rate on average by 13 basis points, which is significantly different from zero at a 1% level. The paired difference test shows that Wednesdays' rate exceeds Thursdays' rate on average by 1 basis point, which is not significantly different from zero at a 5% level. Similarly, the paired difference tests shows that Wednesdays' rate exceeds the average rate based on Tuesdays' and Thursdays' rates, by 6 basis points, which is not significantly different from zero at a 5% level. The above analyses show that the federal funds rate on Wednesdays is above the rate on Tuesdays, but the higher rate on Wednesdays is sustained on Thursdays; thus no adjustment is suggested.

In Table VII, statistical data for the spot index, index futures, and basis are presented. Daily closing index and settlement prices move in a fairly close range to each other. This is expected, since the spot index and futures price must converge on the expiration date. The futures price traded above the spot price on 619 of the 726 days examined, for about 85% of the observations. The basis, which is the difference between the futures price and the spot index, has a mean of 1.037 and standard deviation of 1.137, which shows great volatility. The mean is statistically different from zero at a 1% significance level. The stochastic behavior of the daily basis is examined in Chapter 3. Daily returns on the spot index and futures index are also reported in Table VII. The spot index returns have a higher mean value and lower standard deviation relative to the returns on the futures index. The minimum and maximum values confirm the greater volatility in futures index returns. The mean return on the spot index is statistically different from zero, but at a 10% significance level, whereas the mean return on the futures index is not significantly different from zero at a 5% level. However, the equal means test shows that one cannot reject the null hypothesis that the two means are equal at a 1% significance level. These results are consistent with those reported by Cornell (1985), although he used daily opening and closing prices. The statistical runs test for the spot index returns shows that the null hypothesis that returns are randomly distributed around zero cannot be rejected at a 5% significance level. The 355 observed runs versus the 364 expected runs indicates a small degree of positive autocorrelation. M&R (1988) using intraday data (observations at 15-minute intervals), found that the positive autocorrelation diminished as the observation interval increased (none at 60-minute observation intervals). In the case of the futures index, the statistical runs test results show that the null hypothesis that returns are randomly distributed around zero cannot be rejected at a 5% significance level. The 383 observed runs versus the 364 expected runs indicates a slight degree of negative autocorrelation.

M&R (1988) found that the autocorrelations of the futures series are close to zero at all eight lags (15-minute intervals), with only a slight tendency for the first order autocorrelation coefficient to be negative. They speculated that it could be induced by observed futures prices bounding between the bid and asked prices. It is doubtful whether such an explanation can account for the small degree of negative autocorrelation, based on daily settlement prices in the futures market. The negative autocorrelation implies frequent price reversals and it may be attributed to the faster reaction time to new information of futures prices relative to the spot market. Kawaller, Koch and Koch (1987 b) investigated the lead and lag relationship between the two markets using minute-by-minute data. The empirical results from their causality tests indicate that the futures price leads the spot price by twenty to forty-five minutes on the days prior to expiration and on expiration days, whereas the lead from the spot price to the futures price seldom exceeded one minute.

The results of the empirical analyses of the Cost of Carry Model (CCM) for pricing S & P 500 near term futures contracts for the 1984-1986 period are reported in Tables VIII to XVI. In Table VIII, the theoretical CCM prices, using the federal funds rate, are evaluated relative to the actual closing futures prices. Furthermore, the CCM prices based on federal funds rates for forward financing are compared to the CCM prices based on Treasury bill yields. The riskless rate, represented by Treasury bills or certificate of deposits, is the most frequently used rate in futures contracts pricing literature. The arguments for and against using the riskless rate has been discussed in the literature survey section.

S & P 500 futures prices were generally increasing during the 1984-1986 period, with a mean daily return of 0.034%. The mean daily futures price was 195.04, while the CCM projected mean price was 194.99. The standard deviation of the futures price was

32.23 versus 32.56 for the CCM. Thus, the CCM prices, based on the federal funds rate, are relatively more volatile than the actual futures prices. The actual difference, defined as the futures price minus the theoretical CCM price, has a mean of 0.050, which is not significantly different from zero at a 5% level. The futures price exceeds the CCM price on 386 days (53% of total observations), called a futures premium; while the CCM price exceeds the futures price on 340 days (47%), called a futures discount. The statistical runs test shows that the null hypothesis that the actual differences are randomly distributed around zero can be rejected at a 5% significance level. The conventional approach is to normalize the actual difference so that any mispricing is measured in relative terms. The approach taken by Figlewski (1984 a, b, 1985), and many others, is to measure the mispricing relative to the theoretical price:

Futures Mispricing = $100\,(F_{t,n} - TF_{t,n})/TF_{t,n}$; where: (2.3)

$F_{t,n}$ = Futures price at time t of a contract maturing at time n

$TF_{t,n}$ = Theoretical futures price of contract at time t, which matures at time n.

A futures discount (futures premium) is where (2.3) is negative (positive). An approach taken by M&R (1988), and others, is to divide by the spot index itself (S_t). The approach taken by Figlewski will be followed here, because it expresses in percentage terms the extent that the theoretical price is over-stated (under-stated). The futures mispricing has a mean of 0.054%, which is significantly different from zero at a 1% level. Therefore, although the mean of the actual differences is not significantly different from zero, but in relative terms the mean of the deviations is statistically significant. When analyzed separately, the mean of the daily futures discount is -0.321%, while the mean of the daily futures premium is 0.385%, both of which are significantly different from zero at a 1% level.

The above results are based on using the federal funds rate in the CCM. Where the spot index is financed at the Treasury bill yield, the new CCM prices are shown in Table VIII. The mean of the CCM prices is 194.75, which is below the mean of both the futures price and the federal funds rate CCM price. However, the Treasury bill yield approach has a smaller standard deviation (32.47) than under the federal funds rate approach (32.56), but both of these are greater than the standard deviation of futures prices (32.23). The actual difference test shows that the Treasury bill yield approach has a mean deviation of 0.221 relative to the futures price, which is significantly different from zero at a 1% level. Whereas, the same test for the federal funds rate approach reveals a mean value of 0.054, which is not significantly different from zero at a 5% level. Thus, the CCM prices, with federal funds rate, provide relatively superior estimates of futures prices and this approach will be adhered to for the remainder of this chapter.

M&R (1988) hypothesized that the magnitude of the mispricing is positively related to the time to expiration date. The empirical evidence, based on intraday data, supports their hypothesis. The regression results of a similar test are reported in Table IX. The absolute value of the futures mispricing is regressed against the number of days to expiration date:

$$\text{ABS [Futures Mispricing]} = \alpha + \beta\,(n-t) + \varepsilon_t;\ \text{where} \qquad (2.4)$$

ABS [Futures Mispricing] = Absolute value of futures mispricing

n-t = Number of days to expiration of futures contract

α,β = Parameter estimates

ε_t = Standard OLS error term

Hypothesis H_o: $\alpha=0$ and $\beta=0$

H_a: $\alpha \neq 0$ and/or $\beta \neq 0$.

The constant coefficient (α) has a mean of 0.153%, with a standard deviation of 0.036%. The slope coefficient (β) has a mean of 0.006%, with a standard deviation of 0.001%. Both coefficients are statistically different from zero at a 1% significance level. These results confirm the findings of M & R (1988). However, the low R^2 of 5.9%, reported in Table IX, questions the explanatory power of the model itself; a non-linear model may provide improved results.

The deviation in futures pricing is examined, in Tables X and XI, to determine whether a weekly pattern of price deviations is discernible. The initial 726 observations are reduced by 37 observations which represent the first trading day subsequent to a public holiday. This is to conform with the research methodology relating to the day-of-the-week effect. In this study, only daily closing prices are available, whereas the results presented by, among others, Rogalski (1986), Cornell (1985), and Dyl and Maberly (1986 a,b) are based on opening and closing prices. They show that the bulk of the negative returns on Mondays can be attributed to the non-trading period from Friday's close to Monday's opening price.

In Table X, the daily distribution of the futures mispricing is presented. The 689 observations are almost evenly spread across the five trading days, except Mondays and Tuesdays have fewer observations, because public holidays and the following day are excluded from the test sample. The sample is further analyzed by futures discount and premium. The 318 observations (40% of the total 689) where the futures price is at a discount are not evenly spread across the five trading days: only 15% of these observations occur on Mondays, whereas 25% of these observations occur on Fridays and 23% on Thursdays. The reverse situation occurs where the 371 observations (54% of the total 689) representing futures premium are analyzed: only 15% of these observations occur on Fridays, whereas 23% of the observations occur on Mondays and Wednesdays. It should be noted that the relatively frequent occurrence of futures price premia on Wednesdays, supports the earlier finding, reported in Table VI, that the relatively higher federal fund rate on Wednesdays is not of a sufficiently large magnitude to suggest any downward adjustment.

In Table XI, the magnitude of the day-of-the-week effect is examined. The net mean is the sample mean minus the grand mean, where the latter is based on the total 689 observations. The studies by Cornell (1985) and Dyl and Maberly (1986 a,b) also examine the grand mean and net mean as in this study. The t-statistic tests the null hypothesis that the mean (net mean) is equal to zero. The test of the actual differences ($F_{t,n}$ - $TF_{t,n}$) show that the deviations on Mondays and Tuesdays are positive, 0.190 and 0.167 respectively, which are significantly different from zero at a 5% level. Only Friday's deviation had a negative mean (-0.111), but it is not significantly different from zero at a 5% level. The F-statistic shows that the null hypothesis that the daily coefficient are equal can be rejected at a 5% level. The test of the net means show that the deviations on Mondays and Tuesdays on average exceed the grand mean of 0.055, but they are not significantly different from the grand mean at a 5% level. The net means for the remaining three days are below the grand mean, but only Friday's net mean of -0.166, is significantly different from the grand mean of 0.055 at a 5% level. These results confirm the findings in Table X.

The pricing deviations are also analyzed in relative terms in Table XI, where the futures mispricing is defined in equation (2.3) as: $100\,(F_{t,n}-TF_{t,n})/TF_{t,n}$. The futures mispricing on Mondays and Tuesdays are positive, which are significantly different from zero at a 1% significance level. This confirms the above findings, but at a higher significance level. Furthermore, only Friday's futures mispricing has a negative mean (-0.022%), but it is, as previously, not significantly different from zero at a 5% level. The F-statistic, as previously, shows that the null hypothesis that the daily coefficients are equal can be rejected at a 5% level. The test of the net means show that the futures mispricing on Mondays and Tuesdays are above the grand mean of 0.057%, while the net means for the remaining three days are below the grand mean. However, only Monday's net mean of 0.074% and Friday's net mean of -0.079% are significantly different from the grand mean of 0.057%, but only at a 10% level. These results confirm the findings based on the actual price deviations.

In summary, futures price deviations from the theoretical CCM prices appear to follow the well documented weekend effect anomaly. There is a tendency for futures prices to be above the CCM prices on Mondays, whereas the opposite occurs on Fridays. There is no satisfactory explanation in the academic literature as to the cause of the weekend effect. Therefore, no attempt is made here to give reasons for the weekend futures mispricing. It should be reiterated that there is no evidence of research studies relating the futures pricing deviations to the financial markets weekend anomalies, although both these phenomena are independently well documented in the literature.

The futures pricing analysis is examined by calendar year in Tables XII and XIII, where each year comprises four quarterly futures contracts. The futures prices and CCM prices increased in each of the three years: 1984, 1985, 1986. The futures price deviations expressed in actual index values and in relative terms both give the same results, refer to Table XII. In 1984, the futures mispricing on average was 0.227% per day, which is significantly different from zero at a 1% level. The futures contracts traded at a premium on 166 days (69% of 240 observations) and at a discount on 74 days (31% of 240 observations). The reverse situation occurred in 1986, with a mean futures mispricing of -0.488% per day, which is significantly different from zero at a 1% level. The standard deviation of 0.526% for 1985 is the highest over the three years. The historical S & P 500 futures pricing pattern has fluctuated since its inception in 1982: The 1982-1983 period was dominated by futures discounts; while the 1984-1985 period was characterized with futures premia; the 1986 period was dominated by futures discounts, but the trend towards futures discounts commenced in the latter part of 1985. The twelve futures contracts are analyzed separately in Table XIV and the results are reconciled to the findings of M & R (1988).

To further test the deterministic power of the CCM described in equation (2.2), the following regression equation is run:

$$F_{t,n} = \alpha + \beta\, TF_{t,n} + \varepsilon_t \qquad (2.4)$$

Hypotheses H_o: $\alpha=0$ and $\beta=1$

H_a: $\alpha\neq0$ and/or $\beta\neq1$

The regression results are presented in Table XIII, where the equation is tested on the full sample and separately for each of the three calendar years. For the full sample, both α and β are significantly different from zero at a 1% level; but the proposition that $\beta=1$ can be rejected at a 1% level. Thus, the null hypothesis is rejected at a 1% significance level. However, the R^2 of 99.7% shows that virtually all the variation in the futures price can be related to variations in the CCM price, a finding substantiated with the very small standard deviation for β. The results for 1984 and 1985 are almost identical to the findings for the full sample, where the null hypothesis is rejected at a 1% significance level. The null hypothesis cannot be rejected for the 1986 data, where α=-2.511 and β=1.15. The two-tailed t-tests show that the null hypothesis that α=0 and β=1 cannot be rejected at a 5% significance level. The R^2 continues to have a high value of 98.6%. These results show that the CCM has been relatively more successful in determining futures prices in the latter part of the sample period. These results confirm the findings of, among others, Merrick (1987 a, b), M & R (1988), and Saunders and Mahajan (1988) that progressively the futures pricing deviations have narrowed because the futures market has matured.

The futures mispricing over the life of each contract is presented in Table XIV. The mean deviation for the full sample was 0.054% per day, with a standard deviation 0.485%. The mean is significantly different from zero at a 1% level (refer to Tables VIII and XII). M & R (1988) reported an average mispricing of 0.12%, with a standard of 0.44%. The mean of eight of the twelve contracts are significantly different from zero at a 1% level. The twelve contracts have an equal number of positive and negative values. The largest mispricing is detected in the December 1984 contract (0.647% per day), which is also identified by M&R (1988) with 0.78% per day. The lowest average mispricing is detected in the September 1985 contract (0.016% per day), but M & R (1988) identified the December 1986 contract with a mean of -0.20%.

One of the main hypothesis of M & R (1988) is that the futures mispricing is path dependent. An implication of this hypothesis is that, conditional on the mispricing having crossed one arbitrage bound, the contract is less likely to cross the opposite bound. The upper and lower bounds are set at ± 0.4%, ± 0.6%, ± 0.8% of the index value to take account of the variation in transaction costs. Based on conditional probability theory, they conclude that the arbitrageurs' option to unwind a strategy prematurely introduces path dependence into the mispricing series. In Table XIV, the number of daily observations for each contract are separated into futures discount and futures premium, and statistical runs tests are conducted. For five of the contracts, the statistical runs tests show that the null hypothesis that the discounts/premia are randomly distributed around zero can be rejected at a 5% significance level. These five near term contracts traded consecutively, with the following maturities: June 1985, September 1985, December 1985, and September 1986, December 1986. Thus, it appears that futures prices tend to trade above (below) the CCM prices for an appreciable length of time over the contract period. For the other seven contracts, the statistical runs tests show that the null hypothesis that the discounts/premia are randomly distributed around zero can be rejected at a 5% significance level. However, many of these seven contracts reveal relatively greater number of either futures price discounts or price premia over a contract's life. Thus, some support can be found in the analyses in Table XIV for the "path dependent hypotheses" suggested by M&R (1988).

The final series of tests focus on the behavior of various economic variables under conditions of futures discounts and futures premia. In Table XV, the daily returns on spot index, futures index and the daily change in basis are divided into two samples: when the futures mispricing is at a discount and at a premium. The mean daily return on spot index when the futures price is at a discount is -0.054%, but it is not significantly different from zero at a 5% level; whereas, the spot index mean daily returns is 0.149% under conditions of a futures premium, which is statistically different from zero at a 1% level. The mean return on the futures index when the futures index is at a discount is -0.201% and 0.241% when at a premium, both of which are significantly different from zero at a 1% level. Similar results are found for the mean of the daily change in basis under conditions of futures discount and futures premium. For all three variables, the daily mean for the futures discount sample is significantly different from the daily mean for the futures premium at a 1% level. In summary, futures pricing discounts are generally associated with "bear" financial markets; futures pricing premia are associated with "bull" financial markets. Furthermore, the futures price decreased (increased) by a larger amount relative to the spot price in the case of futures price discounts (futures price premia). Thus, futures mispricing is associated with stronger price reactions in the futures market relative to the underlying spot index market.

In Table XVI, the volume and open-interest for the near term contract and for all S&P 500 futures contracts are analyzed. Total volume and total open-interest are included in the analysis because they can reflect broad market sentiments; the near term contract, generally, goes out of favor at the beginning of the expiration month, when portfolio insurers switch to the second near term contract.

There exists extensive empirical evidence of the positive relationship between trading volume and price volatility for the cash equity markets [Merrick (1987 a) provides a list of the major contributors]. The studies by Smirlock and Starks (1985), and Harris and Gurel (1986) deal specifically with the S&P 500 spot index. The positive relationship has also been reported for various futures markets, with contributions from Cornell (1981), Tauchen and Pitts (1983), Grammatikos and Saunders (1985), and Merrick (1987 a). The latter deals exclusively with the S&P 500 futures market. The volume and open-interest under futures pricing discounts are significantly greater than under futures pricing premia (equal means t-test shows significance at 1% level in all cases). Thus, the futures pricing discounts occurs during periods of strong futures market participation.

Conclusion

Numerous results are presented relating to the S&P 500 futures contract mispricing during the 1984-1986 period. The Cost of Carry Model (CCM) using the federal funds rate, a proxy for the overnight repo rate, provides relatively better estimates for near term futures contracts. The following findings of previous studies are confirmed: (i) the mispricing is positively related to the time to expiration date of the futures contract; (ii) the mispricing is path dependent over the contract period; and (iii) the magnitude of the mispricing has decreased over the years. However, it is also found that the direction of the mispricing appears to go in trends over the years: the initial 1982-1983 period was dominated by futures discounts; followed by futures premia in 1984-1985; and back to futures discounts in 1986, although the change in direction commenced in the latter part of 1985. Mispricing also reflects the weekend effect anomaly: there is a tendency for futures prices to be above the CCM prices on Mondays, whereas the opposite is detected on Fridays. However, the phenomenon calls for further investigation. Finally, the futures discount (futures premia) are characterized by "bear" ("bull") financial markets and the extent of price changes are greater in the futures market relative to the spot index market. The futures discounts occur during strong futures market participation, as measured by volume and open-interest positions, relative to trading during futures pricing premia. Thus, the decrease in futures and spot prices are supported by strong volume and open-interest positions.

CHAPTER 3

A STUDY OF THE BASIS DURING THE NEAR TERM S&P 500 FUTURES CONTRACT PERIOD, WITH SPECIAL ATTENTION TO THE CASES WHERE THE BASIS IS NEGATIVE

Statement of the Problem

Chapter 2's focus was on the pricing of the near term S&P 500 futures contract in terms of the Cost of Carry Model (CCM). The model is based on arbitrage opportunities between the futures market and its underlying spot (cash) market. A measure of the link between the two markets can be described by the basis, which is equal to the futures price minus the contemporaneously observed spot price. For stock index futures, the basis should reflect, theoretically, the financing cost of carrying the spot position forward to expiration date of the futures contract minus the cumulative value of the expected dividends to be paid over the contract period. Another important property is that the basis decreases as the expiration date approaches and has a value of zero on the expiration date. The change in the basis over time is referred to as basis risk and the management of basis risk is of primary importance to hedgers. Working (1953) was the first to acknowledge that cash and futures prices do not move perfectly in tandem. There are only a few papers dealing extensively with the behavior of the basis and the management of basis risk on stock index futures. Some of the contributors to the literature are Weiner (1981), Figlewski and Kon (1982), Tosini and Moriarty (1982), Cornell and French (1983 a,b), Modest and Sundaresan (1983), Figlewski (1984 b), Modest (1984), Figlewski (1985), MacKinlay and Ramaswamy (1988) and Harris (1989).

This chapter focuses on the behavior of the daily basis for the period 1984-1986, with particular attention to the situation where the basis is not positive. The latter may be regarded as an anomaly since the futures price is expected to be above the spot price (except on expiration date) by an amount at least equal to the excess of the financing cost over the dividend yield. However, a negative basis can arise where the dividend yield exceeds the financing cost, but Figlewski (1984 b) found no such evidence for the period June 1982 to September 1983.

Literature Survey and Research Methodology

The S&P 500 futures contract accounts for about 75 percent of the stock index trading volume and it has generally served as a successful medium for speculating and hedging operations. Speculators buy or sell the contract to take advantage of anticipated market moves. Investors hedge their stock portfolios in a declining market by selling stock index futures via a computerized trading system, known as portfolio insurance. The index futures markets have also attracted program traders (known as arbitrageurs) who attempt to arbitrage the cash and futures markets, using sophisticated computer systems to identify any relative mispricing between the two markets. The exceptionally strong growth in index futures trading is facilitated by the high-speed computerized order-execution system, Super-DOT (Designated Order Turnaround), to sell (buy) the overpriced (underpriced) futures contract and to buy (sell) the basket of stocks which track the S&P 500 index.

Basis risk can arise from a number of different sources and it is a more significant problem for stock index futures than for other financial futures, like Treasury bills and bonds [Elton, Gruber and Rentzler (1984), Hoag and Labarge (1983) and Figlewski (1984 b)]. The application of stock index futures in portfolio insurance usually involves a cross-hedge, where the composition of the cash stock portfolio is different from that of the index futures and the two do not track each other perfectly. The most apparent cause of basis risk is the non-market element (non-systematic element) of returns on the cash stock portfolio, because the behavior of the index futures is tied to the underlying stock market index. The non-market risk cannot be diversified by hedging operations.

It is also fairly difficult to implement a perfect arbitrage using the well-known index futures contracts, such as the S&P 500 and NYSE indices, since the underlying index consists of a large number of securities. Although, the Major Market Index (MMI) futures traded on the CBOT consists of only twenty blue-chip securities (eighteen of them constitution the thirty Dow Jones Industrial stocks), the S&P 500 and NYSE futures continue to account for at least 90% of the stock index futures trading. A trading portfolio consists of a small subset (about fifty) of stocks in the index and is traded against the index futures when substantial discrepancies are identified. This is commonly referred to as risk-arbitrage because these transactions are not risk-free and there are sizeable transaction costs. Hence, there exists a broad range of values within which the futures price can move relative to the spot index without inducing arbitrage trading,which implies that some amount of basis risk is expected.

Another source of basis risk is that dividends are included in the cash stock portfolio but are excluded from the stock index and the derivative index futures. However, Figlewski (1984 b) reports that dividends constitute a small component of total returns and are fairly stable over the short-term, therefore, they should not significantly contribute to changes in the basis.

The impact of changes in the basis on hedging can be demonstrated by means of the following equations [Figlewski (1984 b)]. Assuming the stock index is assembled on a cash portfolio which pays dividends, called a cash index portfolio; the expected return will be:

$$RS_{t,x} = \frac{S_x - S_t + D_{t,x}}{S_t}; \qquad \text{where:} \tag{3.1}$$

$RS_{t,x}$ = Expected rate of return on the cash index portfolio from time t (the beginning of the investment period) to time x (where x < = n; n is the expiration date of the index futures contract)

S_x = Expected spot price of cash index portfolio at time x

S_t = Spot price at t, the beginning of the investment period, of the cash index portfolio

$D_{t,x}$ = Expected cumulative value of dividends payable on the cash index portfolio (S_t) from time t to time x, assuming reinvestment at the risk-free rate of interest from date of payment to time x.

The rate of return on a futures contract is not a well-defined concept, since taking a futures position may not require an initial outlay of capital (the initial margin deposit to open a futures position can be posted in the form of interest bearing Treasury bills or a letter of credit). Black (1976) considers this issue at length and concludes that the expected returns should be in dollar terms. however, for expository convenience it will be defined in percentage terms [refer to Figlewski (1984 b)]:

$$RF_{t,x,n} = \frac{F_{x,n} - F_{t,n};}{S_t} \qquad \text{where:} \tag{3.2}$$

$RF_{t,x,n}$ = Expected return on the index futures contract from time t to time x, where the contract matures at time n

$F_{x,n}$ = Expected futures price at time x of contract maturing at time n

$F_{t,n}$ = Futures price at time t of contract maturing at time n

The return on the futures contract (3.2) can be expressed in terms of the basis by manipulating equations (3.1) and (3.2):

$$RF_{t,x,n}, = \frac{S_x - S_t + D_{t,x}}{S_t} - \frac{D_{t,x}}{S_t} + \frac{(F_{x,n} - S_x) - (F_{t,n} - S_t)}{S_t} \tag{3.3}$$

$$RF_{t,x,n}, = RS_{t,x} - \frac{D_{t,x}}{S_t} + \frac{B_{x,n} - B_{t,n}}{S_t}; \quad \text{where:} \tag{3.4}$$

$B_{x,n}$ = Expected basis at time x of contract maturing at time n; where $B_{x,n} = F_{x,n} - S_x$

$B_{t,n}$ = Basis at time t (beginning of investment period) of contract maturing at time n; where $B_{t,n} = F_{t,n} - S_t$

The expected rate of return on a stock index futures contract is equal to the total expected return on the underlying cash index portfolio, minus the expected dividend yield on the cash index portfolio, plus expected changes in the basis over the period as a fraction of the initial value of the cash index portfolio. All the terms in the equations are random variables, except those observed at time t, the beginning of the investment period. The term $D_{t,x}$ refers to the expected dividends payable from t to x, assuming each payment is reinvested at the then prevailing risk-free rate of interest from date of payment to time x. Both the dividend payments and the future risk-free rates are stochastically determined. Furthermore, the impact of daily marking-to-market is ignored since it can be covered by posting Treasury bills or by letter of credit, thus the future contract is treated as a forward contract.

Equation (3.4) can be manipulated to determine the rate of return on the cash index portfolio, so that:

$$RS_{t,x} = RF_{t,x,n} + \frac{D_{t,x}}{S_t} - \frac{B_{x,n} - B_{t,n}}{S_t} \tag{3.5}$$

The change in the basis over time could affect the rate of return on the cash index portfolio, if the investment strategy includes the use of index futures. An issue related to this is whether the introduction of stock index futures has created greater volatility in stock market prices. Edwards (1988 a, b) reports that stock market volatility in the pre-futures period (1973-1982) was greater than in the post-futures period (1982-1986). Therefore, stock index futures trading may induce only short-run volatility, for example on expiration days, but not long-run volatility. Merrick (1987 a) studied the relationship between arbitrage strategy and stock market volatility and he came to the same conclusion as did Edwards. The conventional wisdom is that the basis should systematically decrease over time so that it is zero on the maturity date. Thus it is expected that $B_{t,n} > B_{x,n} > B_{n,n}$, where the investment period ends on the maturity date of the futures contract, when x = n, then $S_n = F_{n,n}$ so as to eliminate any arbitrage opportunities and $B_{n,n} = 0$.

In practice, investors do not hold the cash index portfolio itself, but a portfolio of stocks that emulate the index which gives rise to a cross-hedge. The rate of return on the actual stock portfolio will be similar to (3.1):

$$RP_{t,x} = \frac{V_x - V_t + I_{t,x}}{V_t}; \quad \text{where} : \tag{3.6}$$

$RP_{t,x}$ = Expected return on the stock portfolio from t to x

V_x = Value of stock portfolio at time x

V_t = Value of stock portfolio at time t

$I_{t,x}$ = Expected cumulative value of dividends on the stock portfolio (V_t) from t to x, assuming reinvestment at the risk-free of interest from date of payment to time x.

On a hedged portfolio, futures contracts on N index "shares" are sold short against the long portfolio of stocks. An index share is defined to be an amount of the index portfolio itself, whose market value is equal to $1 times the spot index. Most currently traded stock index futures have contract sizes of 500 index shares. The expected rate of return on a hedged stock portfolio ($RH_{t,x}$) will be:

$$RH_{t,x} = \frac{V_x - V_t - I_{t,x}}{V_t} - \frac{N\,(F_{x,n} - F_{t,n})}{V_t} \tag{3.7}$$

$$RH_{t,x} = \frac{RP_{t,x} - NS_t}{V_t} \bullet \frac{F_{x,n} - F_{t,n}}{S_t} \tag{3.8}$$

$$RH_{t,x} = RP_{t,x} - \lambda RF_{t,x,n} \text{ ; where:} \tag{3.9}$$

λ = The hedge ratio, its the value of the index shares sold forward as a fraction of the value of the stock portfolio being hedged; $\lambda = \frac{NS_t}{V_t}$.

The hedge ratio (λ) determines the overall risk and expected return ($RH_{t,x}$) characteristics of the hedged portfolio, where the risk portfolio formula will be:

$$\sigma_{rh}2 = \sigma_{rp}2 + \lambda 2\ \sigma_{rf}2 - 2\lambda\ \sigma_{rp,rf} \text{ ; where:} \tag{3.10}$$

$\sigma_{rh}2$ = Variance of the hedged stock portfolio

$\sigma_{rp}2$ = Variance of the stock portfolio (not hedged)

$\sigma_{rf}2$ = Variance of the index futures contract

$\sigma_{rp,rf}$ = Covariance between the stock portfolio and the index futures contract

Taking the derivative of (3.10) with respect to λ and setting it equal to zero will provide the hedge ratio, which minimizes risk:

$$\lambda^* = \sigma_{rp,rf}/\sigma_{rf}2 \tag{3.11}$$

This is easily estimated by running a regression of $RP_{t,x}$ on $RF_{t,x,n}$ using historical data. The slope coefficient in the regression equation is λ^*, which is the beta of the stock portfolio with respect to the futures contract.

Substituting (3.11) into (3.10) yields the variance of returns for the minimum risk hedge:

$$\sigma_{min}2 = \sigma_{rp}2 \quad (1 - \psi 2_{rp,rf})\text{ ; where:} \tag{3.12}$$

$\psi 2_{rp,rf}$ = Correlation coefficient between the returns on the stock portfolio and the futures contract.

It is apparent from (3.12) that only with perfect correlation can risk be completely eliminated by hedging. A study of equation (3.4) reveals that the variance of the expected futures return is affected by: (a) The total expected return on the market index portfolio ($RS_{t,x}$); (b) expected dividends on the market index ($D_{t,x}$); and (c) the expected change in the basis over time ($B_{x,n}$-$B_{t,n}$). These will affect λ^* as well.

To complete the analysis, the special case is addressed in which dividends are not random and the hedged position is held until expiration date of the futures contract. The change in the basis will also be nonstochastic, thus (3.11) becomes:

$$\lambda^{**} = \sigma_{rp,rs}/\sigma_{rs}2 = \beta_{rp}\text{; where:} \tag{3.13}$$

$\sigma_{rp,rs}$ = Covariance between the stock portfolio and the index

$\sigma_{rs}2$ = Variance of the index

β_{rp} = Beta coefficient of the stock portfolio with respect to the index.

With regard to the above, Figlewski (1984 b) finds that while dividends tend to be relatively stable, the same is not true of the basis, which is quite volatile over short periods. Therefore, using the stock portfolio beta relative to the index as the hedge ratio is unlikely to be optimal, except when the position is to be held until maturity of the futures contract.

There has been extensive discussion of the hedging role of stock index futures against stock market volatility and the contributors to the literature, among others, are Weiner (1981), Figlewski and Kon (1982), Tosini and Moriarty (1982), and Figlewski (1984 b). The latter conducted an extensive empirical study of the S&P 500 futures contracts for the period June 1982 to September 1983 relative to the following stock market indices: S&P 500, NYSE, ASE, NASDAQ's OTC and the DJIA. Daily closing prices were used and in most cases the actual dividends paid on the index were available. The major findings were:

(i) The hedging effectiveness of the S&P 500 futures contract relative to the five stock market indices varied significantly and the unsystematic risk in cross-hedging is important. The hedging effectiveness may be achieved with specialized derivative instruments, such as an industry group index option or futures, or an individual stock option.

(ii) Dividend risk is not an important factor in basis risk.

(iii) The period of the hedge is important; one day hedges were subject to substantially more basis risk than one week hedges, but there was no further improvement when the holding period was extended to four weeks.

(iv) Time to the expiration date became an important factor when the futures contract had more than two months to the expiration date.

(v) Progressively fewer profitable arbitrage opportunities were identified than in the 1982-1983 period, because the futures price traded within the range of values specified by the cost of carry pricing model (CCM).

The change in the basis over time is directly affected by the "causal" relation between the stock index and the derivative futures contract. There are several recent studies on this issue, which include Finnerty and Park (1987), Kawaller, Koch and Koch (1987 a, 1987 b) and Stoll and Whaley (1987). They all show that the "causality" runs from the futures markets to the cash index markets. However, the authors acknowledge that the "causality" may be due to the lag that nonsynchronous trading induces into the indices. Harris (1989) shows that even after the nonsynchronous trading is removed, the S&P 500 futures price strongly leads the S&P 500 index. The study is confined to the intraday price changes surrounding the October 1987 stock market crash.

The recent study by MacKinlay and Ramaswamy (1988) provides a detailed theoretical and empirical analysis of the S&P 500 futures arbitrage conditions using intraday data: observations at 15-minute intervals for the September 1983 to June 1987 contracts (16 contracts). They find that futures price changes are not autocorrelated and that the variability of these price changes exceeds the variability of price changes of the spot index itself. This excess variability remains even after controlling for the nonsynchronous prices in the index quotes, which induces autocorrelation in the index changes. They also compared the observed futures prices against the theoretical prices as suggested by CCM. The average magnitude of the mispricing decreased as time to expiration decreased. The futures price was consistently above (or consistently below) the theoretical price over the life of a specific futures contract. A specific contract frequently had dominant violations either above or below the nonarbitrage pricing boundaries over long time periods for up to three months.

An issue which has received wide attention over the past fifteen years is the day-of-the-week-effect. Detailed research on the U.S financial markets by, among others, French (1980), Gibbons and Hess (1981), Lakonishok and Levi (1982), and Keim and Stambaugh (1984) clearly show that the mean return on Mondays is less than the returns for the other four days, and is negative in general. This anomaly is referred to as the "weekend effect." These studies also reveal unusually high returns on Wednesdays and Fridays. Similar findings in other countries are reported by Jaffe and Westerfield (1985). A substantial portion of the negative return can be accounted for by taking the return based on Friday's closing price and the opening on Monday, according to Rogalski (1984) and Harris (1985). This implies that unfavorable information comes to light over the weekend and stock prices adjust very rapidly at the opening session of trading on Monday, to reflect the unfavorable information.

The day-of-the-week effect on the S&P 500 index has been reported by French (1980), Keim and Stambaugh (1984) and Rogalski (1984), and the effect on the S&P 500 futures market was considered by Cornell (1985) and Dyl and Maberly (1986 a,b). Based on the daily opening and closing prices for the period May 3, 1982 to July 24, 1984, Cornell (1985) confirms that the weekend effect exists in the returns on the S&P spot market and the bulk of the negative return is confined to the non-trading period from Friday's closing price to Monday's opening price. However, the S&P 500 futures reveal no weekly pattern of returns. Surprisingly, the daily basis reveals a significant weekly pattern of returns, which tends to widen on Mondays and narrow on Tuesdays. On the other hand, Dyl and Maberly (1986 a,b) also using daily opening and closing prices report negative returns on Mondays for the S&P 500 futures market and the bulk of the negative returns can be attributed to returns based on Friday's closing price and Monday's opening price. They replicated the methodology and sample period used by Cornell and also enlarged the sample period from May 3, 1982, to December 31, 1985. For both sample period the non-trading period weekend effect persisted. The authors alluded to the possibility of errors in the data used by Cornell. In this chapter, the day-of-the-week effect will be examined, but the sample is confined to the daily closing prices for the 1984-1986 period. The opening prices are not available.

There exists extensive empirical evidence of the positive relationship between trading volume and price volatility for the cash equity markets [Merrick (1987 a) provides a list of the major contributors]. The studies by Smirlock and Starks (1985) and Harris and Gurel (1986) deal specifically with the S&P 500 spot index. The positive relationship has also been reported for various futures markets, with contributions from Cornell (1981), Tauchen and Pitts (1983), Grammatikos and Saunders (1985) and Merrick (1987 a). The latter deals exclusively with the S&P 500 futures market. The near term S&P 500 futures contract volume and open-interest will be examined to determine whether a weekly pattern of activity in futures contracts is discernible. This aspect has not been covered in the above mentioned studies.

Finally, the economic circumstances surrounding the presence of negative basis are examined. Conceptually, the basis should not be negative except where the expected dividend yield exceeds the cost of carrying the cash index forward to expiration date. Generally, a positive basis is expected because the cost of carrying the cash index forward to the expiration date is expected to exceed the expected dividend yield over the contract period, resulting in a positive net financing cost. A positive net financing cost implies a positive basis. There is no empirical evidence to show that the dividend yield exceeds the cost of carrying the cash index forward to expiration date [Figlewski (1984 b)]. Some of the economic variables examined include: returns on the spot index, returns on index futures, volume and open-interest activities, and the net cost of financing, using the federal funds rate and Treasury bill yield. A review of the literature reveals no published study dealing extensively with the issue of the negative basis. For example, the recent study by Harris (1989) examined changes at five-minute intervals in the S&P 500 index and futures contract over the ten-day period surrounding the October 1987 stock market crash. The main focus of his paper is to explain the large basis spread during this period, after adjusting for nonsynchronous trading. The basis was negative for long periods on October 19-20 (Monday-Tuesday).

In summary, the purpose of this chapter is to examine the empirical behavior of the basis, particularly where it is negative. The latter may be added to the growing array of financial market anomalies. The validity ot the following proposed hypotheses, based on conventional wisdom and ancedotal evidence, regarding the stochastic behavior of the basis over time is examined:

(i) The rate of decrease in the daily basis is independent of the time to expiration day;

(ii) The rate of change in the daily basis is the same across all days of the week: Cornell (1985) finds that Monday's basis change to be positive and significantly different from zero;

(iii) The volume and open-interest of futures trading is the same across all days of the week;

(iv) There are no significant differences in the behavior of stock index prices, index futures prices, volume and open-interest when the basis is negative as opposed to being positive;

(v) The CCM is able to produce values which are consistent with the presence of negative basis.

Data and Empirical Results

The following data were taken from the Chicago Mercantile Exchange (CME) Yearbook for 1984, 1985 and 1986: daily spot prices, futures prices, volume, open-interest and the overnight federal funds rate. The Treasury bill yield was taken from the Wall Street Journal. A total of twelve quarterly contracts are examined, providing 726 daily observations. The daily prices are for up to 67 trading days prior to the expiration of the near term futures contract, which represents at least 80% of the total trading volume and open-interest.

The S&P 500 futures price refers to the daily settlement price set by the CME Settlement Committee and the S&P 500 index price refers to the daily closing value. The CME closes fifteen minutes after the NYSE and the Settlement Committee takes the longer trading period into account. The daily risk-free rate is represented by the yield on Treasury bills, selecting those with maturity dates closest to the expiration date of the near term contracts. The futures contract matures on the third Thursday in march, June, September and December. The Wall Street Journal reports daily on Treasury bills: the bid discount, the ask discount and the yield, which is based on the asking price. These bills mature on Thursdays and they cover the full range of maturities from one week up to the maximum fifty-two weeks. The Treasury bill yield based on the asking price is used in this study.

The dividends were taken from Standard and Poor's Security Price Index Record (1986) and Current Statistics Book (published quarterly). At the end of each quarter, dividends per share (DPS, adjusted to index) for the previous twelve months are reported. Reported DPS is divided by four to give a quarterly dividend, which in turn is spread over the number of trading days for the near term contract. This gives a daily dividend which will be the same over an approximately sixty day trading period. In applying the above procedure, it is assumed that the dividends for the forthcoming twelve months will be the same as the previous twelve months' dividends. The dividend data are presented in Table V. Dividends have increased steadily over the three year period.

In Table VII, the statistical data for the spot index, index futures, and basis are presented. The daily closing index and settlement prices move in a fairly close range to each other. This is expected, since the spot index and futures price must converge on the expiration date. The futures price traded above the spot price on 619 of the 726 days examined, for about 85% of the observations. The basis, which is the difference between the futures price and the spot index, has a mean of 1.037 and standard deviation of 1.137, which shows great volatility. The mean is statistically different from zero at a 1% significance level. Daily returns on the spot index and futures index are also reported in Table VII. The spot index returns have a higher mean value and lower standard deviation relative to the returns on the futures index. The minimum and maximum values confirm the greater volatility in futures index returns. The mean return on the spot index is statistically different from zero, but at a 10% significance level, whereas the mean return on the futures index is not significantly different from zero at a 5% level. However, the equal means test shows that one cannot reject the null hypothesis that the two means are equal at a 1% significance level. These results are consistent with those reported by Cornell (1985), although he used daily opening and closing prices.

The statistical runs tests, which is discussed in Chapter 2, for the spot index returns shows that the null hypothesis that returns are randomly distributed around zero cannot be rejected at a 5% significance level. The 355 observed runs versus the 364 expected runs indicates a small degree of positive autocorrelation. MacKinlay and Ramaswamy (1988) using intraday data (observations at 15-minute intervals), found that the positive autocorrelation diminished as the observation interval increased (none at 60-minute observation intervals). In the case of the futures index, the statistical runs test results show that the null hypothesis that returns are randomly distributed around zero cannot be rejected at a 5% significance level. The 383 observed runs versus the 364 expected runs indicates a slight degree of negative autocorrelation. MacKinlay and Ramaswamy (1988) found that the autocorrelations of the futures series are close to zero at all eight lags (15-minute intervals), with only a slight tendency for the first order autocorrelation coefficient to be negative. They speculated that it could be induced by observed futures prices bouncing between the bid and asked prices. It is doubtful whether such an explanation can account for the small degree of negative autocorrelation, based on daily settlement prices in the futures market. The negative autocorrelation implies frequent price reversals and it may be attributed to the faster reaction time to new information of futures prices relative to the spot market. Kawaller, Koch and Koch (1987 b) investigated the lead and lag relationship between the two markets using minute-by-minute data. The empirical results from their causality tests indicate that the futures price leads the spot price by twenty to forty-five minutes on the days prior to expiration and on expiration days, whereas the lead from the spot price to the futures price seldom exceeded one minute.

In Tables XVII and XVIII, the behavior of the daily basis over the 1984-1986 period is examined. On 107 days the basis was not positive, which includes four non-expiration days, where the basis was equal to zero. The 726 observations are divided into two groups: where the basis is positive, called Sample P, and where it is non-positive, called Sample N. From Table XVII, it is apparent that the samples are substantially different from each other, which is confirmed by the equal means test at a 1% significant level.

The daily change in basis is defined as follows:

$$B_t - B_{t-1} = (F_t - S_t) - (F_{t-1} - S_{t-1}) \qquad (3.14)$$

$$B_t - B_{t-1} = (F_t - F_{t-1}) - (S_t - S_{t-1}) \qquad (3.15)$$

The change in the basis depends on the futures price changes relative to spot price changes over the contract period. It is expected that $B_t < B_{t-1}$ since the basis systematically decreases over time so that it has a value of zero on the expiration date. The daily change in basis has a mean of -0.055 and it is statistically different from zero at a 5% significance level. The standard deviation of 0.740 is high relative to the mean of -0.055. The minimum and maximum values confirm the volatility in the series. The statistical runs test shows that the null hypothesis that the daily change in basis is randomly distributed around zero can be rejected at a 1% significance level. The 443 observed runs versus 346 expected runs indicates substantial negative autocorrelation in the daily change in basis series. Only 52% of the observations showed the expected decrease in the daily change in the basis. The substantial basis risk during the life of the near term futures contract, suggests that portfolio insurers should maintain their hedged position until expiration, when the basis is marked to zero. If the hedge is lifted prior to expiration date, an unexpected gain or loss may be realized because the spot index and the futures index may not move in tandem. Thus, to achieve an effective hedging strategy the hedge should not be lifted prematurely.

In Table XVIII, the regression results involving the daily basis and daily change in basis are presented. The daily basis decreases as time to expiration approaches, but the linear relationship is of a modest degree, with an R^2 of 16% (R^2 of 19.4% where the basis is restricted to positive values). On avetage, the basis decreased by 3.6 points per day for the near term contract, which is statistically different from zero at a 1% significance level. Although, the basis on average decreased over time, the rate of decrease is not significantly affected by the time to expiration, as per the regression results. The basis decreased at a rate of 0.17 points per day, but it is not statistically significant from zero at a 5% level. However, the daily change in basis is directly related to the daily returns on stock index futures. The daily change in basis incorporate 32% of the daily returns on futures, which is statistically different from zero at a 1% significance level, with an R^2 of 15.5%. The daily returns on the spot index and on the futures index have a correlation coefficient of 0.89. Thus, the presence of basis risk is expected because the prices in the two markets do not move in tandem.

Daily returns on the spot index, futures index and the daily change in basis are analyzed to determine whether a weekly pattern of returns is discernible. The regression results are presented in Table XIX. The initial 726 observations are reduced by 37 observations which represent the first trading day subsequent to a public holiday. This is to conform with the research methodology relating to the day-of-the-week effect. In this study only daily closing prices are available, whereas the results presented by, among others, Rogalski (1986), Cornell (1985) and Dyl and Maberly (1986 a, b) are based on opening and closing prices. They show that the bulk of the negative returns on Mondays can be attributed to the non-trading period from Friday's close to Monday's opening price. The results in Table VII show that the daily returns on the spot index and index futures are not statistically different from each other at a 5% significance level, but the daily change in basis provides interesting results.

The net mean is the sample mean minus the grand mean, where the latter is based on the total 689 observations. Cornell (1985) and Dyl and Maberly (1986 a, b) also examined the grand mean and net mean as in this study. However, they also examined the opening and closing prices. The t-statistic is used to test the null hypothesis that the mean (net mean) is equal to zero. The mean return on Mondays for the spot index is negative but it is not significantly different from zero at a 5% level. The F-statistic shows that the null hypothesis that the daily coefficients are equal cannot be rejected at a 5% significance level. These findings are consistent with those reported by Cornell (1985), in the case where only closing prices are used. The returns on Mondays' index futures are not on average negative, whereas the Wednesdays' and Fridays' returns are on average negative. However, none of the day-of-the-week coefficients are significantly different from zero at a 5% significance level, nor are any of these coefficients different from each other at a 5%

significance level. These results are consistent with the findings of Cornell (1985) and Dyl and Maberly (1986 a), in the case where only closing prices are used.

The mean daily change in basis on Mondays is significantly above the grand mean, whereas the mean on Fridays is significantly below the grand mean. Both these coefficients are statistically different from the grand mean at a 1% significance level. Furthermore, each of the two coefficients, in turn, are statistically different from the mean daily change in the basis for the other four days at a 1% significance level. Based on closing prices, Cornell (1985) finds Monday's basis change to be positive and significantly different from zero at a 5% level, whereas the mean for the other four days are negative but only Tuesday's mean is significantly different from zero at a 5% level. He also reports that the daily means are not statistically equal to each other at a 1% significance level. The basis is expected to decrease over time, which implies that the daily change in basis should have a downward bias. Thus, the negative average values for the grand mean and the daily means, except for Mondays, have the appropriate negative signs.

The positive mean basis change for Mondays is an anomaly, which can be attributed to the negative returns on the spot index and the positive returns on index futures on Mondays. There is no satisfactory explanation in the academic literature as to the cause of the weekend effect. Therefore, no attempt is made here to give reasons for the weekend effect in the daily basis price series. The largest decrease in basis occurs on Fridays, which can be attributed to the positive returns on the spot index and the negative returns on index futures on Fridays. This will cause a narrowing of the basis on Fridays and in some cases may cause the futures price to fall below the spot price. The 107 observations, where the basis is non-positive, occur on the following days:

Monday	15	14%
Tuesday	22	21%
Wednesday	23	21%
Thursday	20	19%
Friday	27	25%
	107	100%

The daily distribution of observations confirm the Monday and Friday effects revealed by the regression analysis reported in Table XIX.

In Table XX, the regression results of the day-of-the-week effect relating to contract volume and open-interest are presented. Only the near term S&P 500 futures contracts will be examined. There exists extensive evidence of the positive relationship between price changes and volume of activity in both the spot and futures markets, which is discussed in the literature survey. The net mean is defined as the daily mean minus the grand mean, where the latter is based on all 689 observations. T-statistics show that the volume on Tuesdays and Wednesdays is, on average, above the grand mean and statistically significant at a 5% level. The volume of activity on Fridays is below the grand mean and statistically significant at a 1% level. The F-statistic confirms that the daily volume of activity is not the same across all days of the week at a 1% significance level. The second regression shows that the open-interest position reveals no weekly pattern of activity. The open-interest position is generally dominated by portfolio insurers for portfolio hedging purposes. The volume of activity generally reflects the positions taken by speculators and stock index arbitrageurs, who tend to hold their positions in the market for very short intervals, very seldom do they hold overnight positions. The bulk of daily trading occurs at the opening and closing of the futures markets [Stoll and Whaley (1986)].

The lower than average volume of activity on Mondays (although, not significantly different from the grand mean) and on Fridays, may be attributed to a "wait and see" attitude of stock index futures participants. The reasons for the weekend effect in near term futures volume may be added to the growing array of financial market anomalies.

The final series of tests focus on the behavior of various economic variables when the basis is either positive or negative. The latter comprises 107 observations which is about 15% of the total observations.

The distribution of the 107 negative bases by number of weeks from expiration of futures contract:

Week Number	Number of Observations
1 (Expiration Week)	18
2	19
3	10
4	8
5	3
6	5
7	4
8	12
9	11
10	5
11	4
12	4
13	4

The expiration month (weeks 1,2,3) represents 44% of the 107 observations. There is generally a switch around this period from the immediate near term contract to the second near term contract. It should be reiterated that the basis is expected to decrease as expiration date approaches, leading to the greater concentration of negative basis during the expiration month, when the basis spread is expected to narrow.

In Table XXI, daily returns on spot index, futures index and the daily basis change are divided into Sample P and Sample N. For all three variables, the mean of Sample P is statistically different from the mean of Sample N at a 1% significance level. The futures market shows greater volatility relative to the spot market in both situations, where the basis is positive and where it is negative. The mean of the daily basis change for Sample N has the appropriate negative sign since the change in basis should be negative over time. In Summary, the negative basis is generally associated with "bear" financial markets and the futures market decreases by a larger amount relative to the spot market.

In Table XXII, the volume and open-interest for the near term contract and for all S&P 500 futures contracts are analyzed. The total volume and total open-interest are included in the analysis since they can reflect broad market sentiments; the near term contract, generally, goes out of favor at the beginning of the expiration month, when portfolio insurers switch to the second near term contract. For the total volume and total open-interest position, Sample N is statistically greater than Sample P at a 1% significance level. The same result is found in the near term open-interest position at a 1% significance level. In the case of the near term contract volume, the mean of Sample P is greater than the mean of Sample N, but the difference is not statistically significant at a 5% level. However, the standard deviation of Sample N is greater than the standard deviation of

Sample P, implying greater volume movements when the basis is negative. In summary, the negative basis, generally, occurs during periods of strong futures market participation.

Finally, the cost of carry pricing model (CCM) is analyzed to explain the behavior of the basis over time. The CCM can be described as follows:

$$TF_{t,n} = S_t \ (1+f_t)^{n-t} - D_{t,n} \ ; \qquad \text{where:} \tag{3.16}$$

$TF_{t,n}$ = Theoretical futures price of contract at time t, which matures at time n

S_t = Value of cash index at time t

f_t = Federal funds rate (overnight rate) at time t

$D_{t,n}$ = Cumulative value of dividends payable on the cash index (S_t) during the period t to n, assume reinvestment at the Treasury bill yield.

The financing cost element based on the federal funds rate is:

$$S_t \ (1+f_t)^{n-t} - S_t \tag{3.17}$$

The net financing cost element based on the federal funds rate is:

$$S_t \ (1+f_t)^{n-t} - S_t - D_{t,n} \tag{3.18}$$

If the Treasury bill yield is used in place of the overnight federal funds rate, then f_t is replaced with $r_{t,n}$ in equations (3.16), (3.17), (3.18), so that $r_{t,n}$ is the Treasury bill yield at time t of a bill maturing at time n, the expiration date of the near term futures contract.

As discussed earlier, cumulative dividends are hypothesized to represent the expected dividends during the futures contract period, assuming reinvestment at the Treasury bill yield from date of dividend payment to expiration date. Daily expected dividends information is not readily available, although the large brokerage firms produce the series for their arbitrage trading operations. The procedure used to establish the cumulative value of dividends, presented in Table V, has the effect of removing the dividerd risk, but the dividend yield remains [Figlewski (1984 b)].

The possible impact of financing cost and dividend yield on the presence of negative basis is presented in Tables XXIII, XXIV, XXV. In each case, the full sample of 726 observations is divided into Sample P, where the basis is positive, and Sample N, where the basis is negative. The results in Table XXIII show that for the financing cost and dividend yield, the mean of Sample P is statistically greater than the mean of Sample N at a 1% significance level. The dividend yield exceeds the financing cost on only one day out of 726 days, where the federal funds rate is used, and on ten days, in the case of Treasury bills. This raises the following question: what amount of increase in the dividend yield from its present level, will be sufficient to explain the negative value of the basis. The results in Table XXIV show that on average the dividend yield will have to increase by 276%, where the CCM is based on the Treasury bill yield. In the case of federal funds rate, an increase of 296% in dividend yield. The 107 observations are also analyzed by the number of weeks to the expiration date. The minimum increase in dividends is 73% in week 13 and a maximum increase of 885% in the expiration week. If the 18 observations in the expiration week is excluded, the average increase in the dividend yield will have to be 157%, where the Treasury bill yield is used. Where the federal funds rate is used, an increase of 177% in dividend yield. These results show that there would have to be substantially large errors in the dividend yield measurements for the dividend yield phenomenon to explain the negative basis. Thus, the empirical test results of the CCM fail to provide adequate explanations of the negative basis.

In Table XXV, the regression results are presented where the daily basis, divided into positive or negative, is regressed against the net financing cost, using the federal funds rate and Treasury bill yield, respectively. For Sample P, the slope coefficients are statistically different from zero at a 1% significance level. For Sample N, the slope coefficients have very small values and are not significantly different from zero at a 5% level. Furthermore, the R^2 is equal to zero. The results for Sample P show that, on average, 83.4% of the changes in the net financing cost, with federal funds rate, is incorporated in changes in the basis, with an R^2 of 16.3%. Similar results are found where the Treasury bill yield is used, except that the basis is more sensitive (it incorporates, on average, 114.2% of changes in the net financing costs), with an R^2 of 24.1%.

The above results could impiy occasional periods of disequilibrium between the spot and futures markets, so that negative bases may arise. Figlewski (1984 a) observed that actual futures prices traded at a discount relative to the theoretical prices in the early years and he posited (Page 43):

> "It is more likely that the discount represented a situation of disequilibrium — a transitory phenomenon caused by unfamiliarity with new markets and institutional interia in developing systems to take advantage of the opportunities presented."

Figlewski (1984 b) found that the initial disequilibrium situation became less pronounced with the passage of time. The data in this chapter are for the 1984-1986 period and the two markets should be well integrated by then. However, some "disequilibrium/anomaly" may occasionally arise, the negative basis is one of them. The October 1987 stock market crash lends further support to the assertion of "disequilibrium/anomaly". Harris (1989) suggests that the dramatic drop in stock prices in October 1987 may be attributed to disintegration of the cash and index futures markets, which in turn may be due to institutional factors and/or investor behavior. For example, to take advantage of a negative basis the strategy calls for the purchase of the futures contract and the simultaneous sale of a portfolio of securities. However, the negative basis is characterized by falling stock prices and the "uptick trading" rule, set by the SEC, may prevent short-selling in the spot market. Thus, the negative basis may prevail.

Conclusion

Numerous results are presented relating to the basis for the S&P 500 futures during the 1984-1986 period. As expected, the daily basis generally decreases over the contract period, but the rate of decrease is independent of the time to expiration. Approximately 32% of the daily change in futures price is incorporated in daily basis change. The daily basis change also reflects the weekend effect anomaly: the change on Fridays is substantially negative, but the change on Mondays is, generally, positive. The Monday phenomenon calls for further investigation. The decrease in basis on Fridays has lower than average trading volume, while Tuesdays and Wednesdays have greater than average activity.

The daily basis is negative on 107 days (15% of all observations) and these days are characterized by greater volatility in futures prices relative to the spot index. The total volume and open-interest on these days are substantially greater than when the basis is positive, thus the negative basis anomaly occurs during strong futures market participation. It is doubtful whether the negative basis can be attributed to a negative net financing cost, where the dividend yield exceeds the financing cost of carrying the spot portfolio forward to expiration date. The negative basis is most probably due to a short-term disequilibrium between the spot and futures markets, which in turn may be due to institutional trading factors and investor behavior.

APPENDIX A:

TABLES I to XXV

TABLE I

REGRESSION RESULTS USING THE TRADITIONAL APPROACH

$S_n = \alpha + \beta F_{t,n} + \varepsilon_t$ [Equation (1.1)]

$H_o : \alpha = 0$ and $\beta = 1$

Number of Contracts Observed: 19 for days 1-39
18 for days 40-56
17 for days 57-60

Days to Maturity	Constant α	t_0	Slope β	t_1	R^2	S.E.	DW[a]
1	-3.374	-1.87	1.018	1.86	.998	1.68	2.50
2	-4.398	-2.06	1.023	2.00	.998	1.98	2.33
3	-4.795	-1.74	1.022	1.48	.996	2.55	2.22
4	-2.766	-0.84	1.013	0.73	.995	3.09	2.82*
5	-3.723	-1.02	1.019	0.96	.993	3.41	2.55
6	-5.400	-1.20	1.029	1.16	.990	4.15	2.90*
7	0.357	0.06	0.991	-0.28	.983	5.45	2.71
8	-2.007	-0.33	1.002	0.06	.982	5.59	2.76*
9	0.160	0.03	0.993	-0.22	.980	5.91	2.31
10	3.353	0.53	0.974	-0.74	.979	6.12	2.23
11	6.584	1.00	0.955	-1.25	.977	6.41	2.06
12	5.121	0.81	0.967	-0.96	.978	6.15	2.06
13	5.798	0.95	0.965	-1.06	.980	5.90	1.76
14	4.080	0.60	0.972	-0.75	.975	6.57	2.07
15	5.492	0.81	0.964	-0.96	.975	6.56	2.28
16	7.461	1.11	0.953	-1.29	.976	6.55	2.27
17	5.847	0.79	0.963	-0.92	.971	7.13	2.03
18	1.987	0.27	0.985	-0.38	.972	6.95	2.14
19	2.147	0.26	0.986	-0.32	.966	7.71	2.42
20	1.532	0.18	0.990	-0.22	.963	8.06	2.45
21	-1.650	-0.17	1.010	0.18	.953	9.10	2.46
22	1.400	-0.13	1.012	0.21	.948	9.53	2.35
23	-1.772	-0.18	1.013	0.24	.953	9.13	2.55
24	-1.190	-0.11	1.010	0.17	.944	9.93	2.49
25	-1.950	-0.18	1.017	0.28	.943	9.99	2.47
26	-0.630	-0.06	1.007	0.12	.942	10.06	2.42
27	-2.390	-0.23	1.018	0.31	.949	9.43	2.24
28	-4.650	-0.45	1.028	0.50	.950	9.40	2.26
29	-7.190	-0.68	1.046	0.79	.949	9.42	2.10
30	-6.970	-0.61	1.046	0.73	.942	10.12	1.99
31	-5.830	-0.53	1.043	0.71	.945	9.79	1.85
32	-8.560	-0.79	1.056	0.09	.948	9.57	1.72
33	-5.250	-0.48	1.039	0.65	.946	9.76	1.87

TABLE I (continued)

Days to Maturity	Constant α	t_0	Slope β	t_1	R^2	S.E.	DW[a]
34	-9.600	-0.86	1.067	1.07	.945	9.79	1.78
35	-6.890	-0.55	1.053	0.76	.930	11.06	1.90
36	-9.090	-0.73	1.066	0.94	.932	10.93	1.99
37	-7.200	-0.59	1.058	0.84	.933	10.82	2.00
38	-8.490	-0.67	1.063	0.90	.930	11.07	1.98
39	-8.250	-0.61	1.058	0.77	.921	11.77	2.01
40	-3.710	-0.24	1.036	0.44	.906	12.04	1.77
41	-4.250	-0.27	1.042	0.48	.899	12.52	1.79
42	-2.650	-0.17	1.033	0.42	.899	12.47	1.89
43	-1.250	-0.08	1.024	0.30	.907	12.00	1.94
44	-1.010	-0.07	1.023	0.22	.905	12.12	1.93
45	-0.400	-0.03	1.018	0.10	.911	11.75	1.97
46	1.970	0.14	1.008	0.52	.908	11.92	1.78
47	-4.050	-0.26	1.045	0.23	.900	12.43	1.79
48	0.860	0.06	1.019	0.03	.902	12.31	1.74
49	4.580	0.29	1.002	0.34	.893	12.84	1.78
50	10.610	0.68	0.971	-0.39	.886	13.26	1.74
51	11.770	0.79	0.967	-0.41	.893	12.83	1.74
52	11.360	0.80	0.968	-0.20	.903	12.27	1.72
53	8.710	0.56	0.983	-0.48	.888	13.14	1.78
54	12.870	0.79	0.956	-0.64	.874	13.95	1.91
55	14.620	0.91	0.944	-0.64	.876	13.82	1.89
56	13.900	0.90	0.945	-0.65	.884	13.37	1.86
57	11.220	0.70	0.959	-0.46	.887	12.64	1.93
58	12.760	0.78	0.952	-0.53	.882	13.94	1.78
59	12.320	0.76	0.954	-0.51	.884	13.80	1.81
60	14.780	0.88	0.942	-0.63	.874	14.40	1.78

a. There may be some autocorrelation since the DW statistic does not fall into the rejection region. For H_0: 1.28 = < DW = < 2.72 (no autocorrelation) at a 5% significance level. The DW statistic is inconclusive in these three cases.

t_0. T-statistic for testing the hypothesis that $\alpha = 0$

t_1. T-statistic for testing the hypothesis that $\beta = 1$

TABLE II

DAILY MEAN LOG-LINK-RELATIVES (LLR)

$$\text{Log-Link-Relative } (L_{t+1}) = \sum_{i=1}^{I} \text{Log } \frac{(F^i_{t+1,n})}{(F^i_{t,n})} \text{ ; where}$$

i= 1,2...I are the quarterly contracts;
F_t is the futures price at time t of contract maturing at time n.

Number of Contracts : 19 for days 0 to 39
18 for days 40 to 56
17 for days 57 to 60

Days to Maturity	Mean LLR	S.E. Mean	t_0
0	-0.00148	0.00206	-0.72
1	-0.00107	0.00176	-0.61
2	-0.00319	0.00182	-1.75
3	0.00265	0.00305	0.87
4	0.00037	0.00190	0.20
5	-0.00052	0.00239	-0.22
6	-0.00385	0.00366	-1.05
7	-0.00302	0.00226	-1.34
8	0.00333	0.00243	1.37
9	0.00015	0.00285	0.05
10	-0.00048	0.00233	-0.21
11	0.00312	0.00149	2.09*
12	0.00259	0.00321	0.80
13	-0.00330	0.00201	-1.64
14	0.00060	0.00174	0.34
15	0.00011	0.00205	0.05
16	0.00044	0.00194	0.22
17	-0.00060	0.00258	-0.23
18	0.00215	0.00304	0.71
19	0.00046	0.00135	0.34
20	0.00098	0.00235	0.42
21	0.00416	0.00293	1.42
22	-0.00159	0.00313	-0.51
23	0.00027	0.00234	0.12
24	0.00233	0.00228	1.02
25	-0.00178	0.00280	-0.63
26	-0.00009	0.00218	-0.04
27	-0.00209	0.00174	-1.20
28	0.00248	0.00301	0.83
29	0.00094	0.00212	0.45
30	0.00321	0.00254	1.27

TABLE II (continued)

Days to Maturity	Mean LLR	S.E. Mean	t_0
31	-0.00328	0.00226	-1.45
32	0.00290	0.00260	1.11
33	0.00183	0.00163	1.12
34	0.00233	0.00306	0.76
35	-0.00101	0.00234	-0.43
36	0.00310	0.00270	1.15
37	-0.00218	0.00295	-0.74
38	-0.00391	0.00293	-1.33
39	0.00094	0.00141	0.66
40	0.00215	0.00308	0.70
41	0.00024	0.00169	0.14
42	0.00003	0.00241	0.01
43	0.00008	0.00165	0.05
44	-0.00177	0.00205	-0.86
45	0.00378	0.00278	1.36
46	0.00207	0.00242	0.86
47	0.00267	0.00240	1.11
48	0.00468	0.00176	2.67*
49	0.00414	0.00311	1.33
50	0.00409	0.00271	1.51
51	-0.00178	0.00325	-0.55
52	-0.00087	0.00247	-0.35
53	-0.00248	0.00254	-0.98
54	-0.00277	0.00191	-1.45
55	-0.00314	0.00209	-1.50
56	-0.00701	0.00210	-0.34
57	0.00207	0.00269	0.77
58	-0.00054	0.00171	-0.32
59	0.00244	0.00235	1.04
60	0.00244	0.00363	0.67

t_0 T-statistic for testing the hypothesis that the mean is equal to zero.

* Statistically significant from zero at a 5% confidence level.

TABLE III

LOG-LINK-RELATIVES (LLR) REGRESSION RESULTS

$L_{t+1} = \alpha + \beta(m) + \varepsilon_{t+1}$; Where [Equation (1.15)]

L_{t+1} is the mean of the column log-link-relative for t=0,1....60.

α, β are parameter estimates

m is the days to maturity ($m = n - t+1$)

ε_{t+1} is the standard OLS error term.

NULL HYPOTHESIS: H_O: $\alpha = 0$ and $\beta = 0$

$$L_{t+1} = \underset{(-0.21)^*}{-0.0001224} + \underset{(1.02)^*}{0.00001698}\, m$$

60 observations $R^2 = .017$ DW=1.78**

* t-value not statistically significant from zero at a 5% confidence level.

** No autocorrelation at a 5% significance level.

Note: Tested for heteroskedasticity by regressing the residuals against time to maturity (independent variable) and found no linear relationship.

TABLE IV

These two exhibits are from Kolb, Jordan and Gay (1983), pages 120-121.

LOG LINK-RELATIVES REGRESSION RESULTS, OLS

Commodity	Observations	α (t)	β (t)	R^2	DW	Gauss-Markov violations
Wheat	292	.00047 (1.27)	-9.34×10^{-7} (.42)	.0006	1.81	O.K.
Corn	307	.00039 (1.34)	-3.75×10^{-7} (.24)	.0002	2.00	O.K.
Oats	245	.00035 (.82)	-1.53×10^{-6} (.51)	.0011	1.74	Autocorrelation
Soybeans	302	7.45×10^{-4} (2.41)*	-1.47×10^{-6} (.83)	.0023	1.90	O.K.
Soy oil	311	9.12×10^{-4} (2.58)*	-4.05×10^{-7} (.21)	.0001	1.87	Heteroskedasticity
Soy meal	289	-2.72×10^{-6} (.0076)	2.37×10^{-6} (1.11)	.0043	2.16	Heteroskedasticity
Plywood	291	4.80×10^{-4} (1.42)	-6.25×10^{-7} (.31)	.0003	1.86	O.K.
Broilers	206	8.78×10^{-4} (3.46)*	-5.71×10^{-6} (2.68)*	.0341	1.88	Heteroskedasticity
Gold	310	7.24×10^{-4} (2.27)*	-2.16×10^{-6} (1.21)	.0047	2.23	Autocorrelation
Silver	456	8.97×10^{-4} (3.77)*	2.26×10^{-7} (.25)	.0001	2.03	O.K.
GNMAs	500	-1.83×10^{-4} (2.10)*	3.02×10^{-7} (1.00)	.0020	1.98	Heteroskedasticity
T-bonds	272	-5.25×10^{-4} (2.18)*	5.13×10^{-7} (.34)	.0040	1.87	Heteroskedasticity

* Significant at the 5% level

LOG-LINK-RELATIVES REGRESSION RESULTS, CORRECTED

Commodity	Observations	α (t)	β (t)	ρ (t)	R^2
Oats	244	3.31×10^{-4} (.68)	-1.28×10^{-6} (.37)	.13 (2.01)*	.0171
Soy oil	311	9.38×10^{-4} (3.01)*	-5.81×10^{-7} (.30)	N/A	.0024
Soy meal	289	-1.75×10^{-4} (.46)	2.47×10^{-6} (1.17)	N/A	.0063
Broilers	206	9.02×10^{-4} (4.09)*	-5.96×10^{-6} (2.84)*	N/A	.0488
Gold	310	7.40×10^{-4} (2.61)*	-2.32×10^{-6} (1.46)	-.12 (2.09)*	.0194
GNMAs	500	-1.95×10^{-4} (1.99)*	3.47×10^{-7} (1.20)	N/A	.0011
T-bonds	272	-5.42×10^{-4} (2.07)*	6.27×10^{-7} (.42)	N/A	.0000

* Significant at the 5% level

TABLE V

RECORD OF DIVIDENDS (DPS)

Source: Standard and Poor's Security Price Index Record (1986) and Current Statitstics (Quarterly)

12 Month Period Ending	DPS-adjusted to S&P 500 Index	DPS[a] Quarterly	DPS[b] Daily	Futures Contract Maturing
12-31-83	7.09	1.7725	.02813	3-84
3-31-84	7.18	1.7950	.02849	6-84
6-30-84	7.31	1.8275	.02900	9-84
9-30-84	7.38	1.8450	.02883	12-84
12-31-84	7.53	1.8825	.03036	3-85
3-31-85	7.66	1.9150	.03040	6-85
6-30-85	7.74	1.9350	.03023	9-85
9-30-85	7.84	1.9600	.03063	12-85
12-31-85	7.90	1.9750	.03213	3-86
3-31-86	8.02	2.0050	.03123	6-86
6-30-86	8.10	2.0250	.03164	9-86
9-30-86	8.23	2.0575	.03215	12-86

a. It is assumed that the dividends for the forthcoming twelve months will be the same as for the previous twelve month period. This is 25% of the total DPS and it is assumed to be received evenly over the next quarter.

b. The quarterly DPS is spread over the number of trading days for the near term contract. The contracts do not have the same number of trading days.

TABLE VI

ANALYSIS OF OVERNIGHT FEDERAL FUNDS RATE

Description	Number of Observations	Mean[a]	Standard Deviation	Min.	Max.
Time Period: March 1986 to October 1988					
Federal Funds Rate on Fridays (Annualized)	139	6.80	0.70	5.63	8.75
Overnight Repo Rate on Fridays (Annualized)	139	6.67	0.68	5.62	8.25
Paired Difference Between Fed Runds Rate and Repo Rate[b]	139	0.13 (5.48)**	0.29	-0.65	1.85
Time Period: January 1984 to December 1986					
Federal Funds Rate on Wednesdays (Annualized)	152	8.40	1.67	5.25	13.00
Federal Funds Rate on Tuesdays	148	8.31	1.72	5.00	11.87
Paired Difference Between Wednesdays' and Tuesdays' Rates[c]	145	0.31 (2.70)**	0.57	-1.50	2.25
Federal Funds Rate on Thursdays	151	8.42	1.67	5.75	11.94
Paired Difference Between Wednesdays' and Thursdays' Rates[d]	148	0.01 (0.41)	0.43	-2.00	1.62
Federal Funds Rate Average based on Tuesdays' and Thursdays' Rates	144	8.38	1.69	5.44	11.78
Paired Difference Between Wednesdays' Rate and the Above Average Rate[e]	141	0.06 (1.60)	0.45	-1.69	1.72

TABLE VI (continued)

a. T-statistical test of the null hypothesis that the mean of the paired difference between the respective rates is equal to zero, where *, ** denotes significance at the 5%, 1% levels respectively.

b. The statistical runs test shows that the null hypothesis that the paired differences are randomly distributed around zero cannot be rejected at a 5% significance level (56 observed runs versus 63 expected runs).

c. The statistical runs test shows that the null hypothesis that the paired differences are randomly distributed around zero cannot be rejected at a 5% significance level (84 observed runs versus 73 expected runs).

d. The statistical runs test shows that the null hypothesis that the paired differences are randomly distributed around zero cannot be rejected at a 5% significance level (85 observed runs versus 75 expected runs).

e. The statistical runs test shows that the null hypothesis that the paired differences are randomly distributed around zero can be rejected at a 5% significance level (84 observed runs versus 70 expected runs).

TABLE VII

STATISTICAL DATA FOR THE 1984-1986 PERIOD

Description	Mean	Standard Deviation	Min.	Max.	t-Statistic[a]
Daily Spot Index (S_t)	194.01	32.67	147.82	254.00	-
Daily Near Term Futures Price ($F_{t,n}$)	195.04	32.23	148.85	254.65	-
Daily Basis (B_t) ($B_t = F_{t,n}-S_t$)	1.037	1.137	-1.76	5.06	24.59**
Daily Returns on Spot Index[b]	0.054	0.813	-4.81	2.84	1.80
Daily Returns on Futures [c,d]	0.034	0.910	-5.50	4.98	1.01

a. Two-tail test of the null hypothesis that the mean is equal to zero, where *,** denotes significance at the 5%, 1% levels, respectively.

b. This is defined as $100\ (S_t-S_{t-1})/S_{t-1}$. The statistical runs test shows that the null hypothesis that returns are randomly distributed around zero cannot be rejected at a 5% significance level (355 observed runs versus 364 expected runs).

c. This is defined as $100\ (F_{t,n} - F_{t-1,n})/F_{t-1,n}$. The statistical runs test shows that the null hypothesis that returns are randomly distributed around zero cannot be rejected at a 5% significance level (393 observed runs versus 364 expected runs).

d. The statistical test of the null hypothesis that the mean of the daily spot returns is equal to the mean of the daily futures returns cannot be rejected at a 5% significance level, because the t-value is -0.44 with 1432 degrees of freedom.

TABLE VIII

ANALYSIS OF COST OF CARRY MODEL (CCM)

CCM: $TF_{t,n} = S_t \ (1+f_t)^{n-t} - D_{t,n}$ [Equation (2.2)]

Futures Discout (Premium) = $100 \ (F_{t,n} - TF_{t,n})/TF_{t,n} < 0 \ (> 0)$
[Also called Futures Mispricing] [Equation (2.3)]

Description	Number of Observations	Mean	Standard Deviation	Min.	Max.
Daily Futures ($F_{t,n}$)	726	195.04	32.23	148.85	254.65
CCM ($TF_{t,n}$)	726	194.99	32.56	149.29	254.87
Actual Difference ($F_{t,n}-TF_{t,n}$)	726	0.050[a]	0.925	-2.640	4.176
Futures Mispricing	726	0.054[b]	0.485	-1.120	2.250
Futures Discount	340	-0.321	0.251	-1.120	0.000
Futures Premium	386	0.385	0.391	0.000	2.250
CCM, Forward Financing at Treasury Bill Yield[c]	726	194.75	32.47	149.03	254.31
Actual Differences with Treasury Bill Yield[c]	726	0.221[d]	0.886	-2.487	4.296

a. Two-tail test of the null hypothesis that the mean of the actual difference is equal to zero cannot be rejected at a 5% significance level (t-value of 1.44). The statistical runs test shows that the null hypothesis that the actual differences are randomly distributed around zero can be rejected at a 5% significance level (222 observed runs versus 362 expected runs).

b. The two-tail test of the null hypothesis that the mean of the futures mispricing is equal to zero can be rejected at a 1% significance level (t-value of 3.00).

c. The CCM is used, except that the federal funds rate ($f_{t,n}$) is replaced with the Treasury bill yield ($r_{t,n}$).

d. Two-tail test of the null hypothesis that the mean of the actual difference is equal to zero can be rejected at a 1% significance level (t-value of 6.71).

TABLE IX

REGRESSION RESULTS OF FUTURES MISPRICING

ABS [Futures Mispricing] = $\alpha + \beta\,(n\text{-}t) + \varepsilon_t$ [Equation (2.4)]

Null Hypothesis: H_0: $\alpha = 0$ and $\beta = 0$

Results: Constant Coefficient (α) of 0.153%, with standard deviation of 0.036%
t-statistic[a] (4.28)**

Slope Coefficient (β) of 0.006%, with standard deviation of .001%
t-statistic[a] (6.75)**

$R^2 = 5.9\%$
DW = 2.20[b]
725 observations

Reject Null Hypothesis at 1% significance level

a. Two-tail test of the null hypothesis that the coefficient mean is equal to zero, where *, ** denotes significance at the 5%, 1% levels respectively.

b. The intial regression results revealed strong positive autocorrelation (DW=1.03), which was corrected by the Cochrane-Orcutt iterative least squares technique. The corrected results show no autocorrelation at a 5% significance level. Also tested for heteroskedasticity by regressing the residuals against time to expiration date (independent variable) and found no linear relationship.

TABLE X

DAILY DISTRIBUTION OF FUTURES MISPRICING

	Total		Discount		Premium	
	Observ.	Percent	Observ.	Percent	Observ.	Percent
Mon.	132	19	48	15	84	23
Tues.	130	19	58	18	72	19
Wed.	145	21	61	19	84	23
Thurs.	147	21	73	23	74	20
Fri.	135	20	78	25	57	15
Total	689[a]	100	318[b]	100	371	100

a. There are 689 observations because all holidays and the following trading days are excluded. The futures mispricing is defined in Table VIII.

b. The 318 days that the futures price traded at a discount relative to the CCM, represents 46% of the 689 observations. The statistical runs test result, reported in Table VIII note (a), shows that the discounts and premia are not randomly distributed around zero.

TABLE XI

DAY-OF-THE-WEEK EFFECT IN FUTURES MISPRICING

	MON.	TUES.	WED.	THUR.	FRI.	F-stat.[b]
Observations[a]	132	130	145	147	135	-
Actual Futures Price minus CCM, using Federal Funds Rate[c] (Grand Mean = 0.055)						
Mean	0.190	0.167	0.015	0.024	-0.111	2.42*
t-statistic[d]	(2.38)*	(2.08)*	(0.20)	(0.32)	(-1.41)	
Net Mean	0.136	0.113	-0.039	-0.031	-0.166	
t-statistic[d]	(1.70)	(1.40)	(-0.52)	(-0.40)	(-2.10)*	
Futures Mispricinge (Grand Mean = 0.57%):						
Mean	0.131	0.114	0.029	0.040	-0.022	2.31*
t-statistic	(3.12)**	(2.70)**	(0.73)	(1.00)	(-0.54)	
Net mean	0.074	0.057	-0.028	-0.017	-0.079	
t-statistic	(1.77)	(1.35)	(-0 69)	(-0.43)	(-1.91)	

a. There are 689 observations because all holidays and the following trading days are excluded from this sample. Thus, all the data are "normal" one-day and weekend "price difference." The mean of all 689 observations is the grand mean. The net mean for each of the five days is the daily mean minus the grand mean.

b. The F-statistic is to test the null hypothesis that all the coefficients are equal in the regression $R_t = a_1 D1 + a_2 D2 + a_3 D3 + a_4 D4 + a_5 D5 + e_t$, where R_t is the "price difference" and D1 to D5 are day-of-the-week dummy variables. In both cases the daily coefficients are statistically different from each other at a 5% significance level, denoted with *.

c. This is the same as the Actual Difference ($F_{t,n}$ - $TF_{t,n}$) in Table VIII, except the sample is restricted to 689 observations.

d. The t-statistics are two-tail test of the null hypothesis that the mean (net mean) is equal to zero, where *, ** denotes significance at the 5%, 1% levels, respectively.

e. This is the same as in Table VIII, except the sample is restricted to 689 observations.

TABLE XII

ANALYSIS OF FUTURES MISPRICING BY YEAR

Description	Full Sample	1984	1985	1986
Number of Observations:				
Total	726	240	242	244
Discount	340	74	108	158
Premium	386	166	134	86
Daily Futures Price ($F_{t,n}$):				
Mean	195.04	161.84	186.78	235.90
Standard Deviation	32.23	6.09	8.42	12.63
CCM ($TF_{t,n}$):				
Mean	194.99	161.46	186.56	236.34
Standard Deviation	32.56	5.69	8.77	12.54
Actual Difference ($F_{t,n}$-$TF_{t,n}$):				
Mean	0.050	0.379	0.216	-0.439
t-statistic[a]	(1.44)	(7.98)**	(3.56)**	(-7.84)**
Standard Deviation	0.925	0.734	0.945	0.874
Futures Mispricing:				
Mean	0.054	0.227	0.126	-0.188
t-statistic[a]	(3.00)**	(7.90)**	(3.74)**	(-7.86)**
Standard Deviation	0.485	0.445	0.526	0.373

a. Two-tail test of the null hypothesis that the mean of the deviations (in actual and relative terms) is equal to zero, where *, ** denotes significance at 5%, 1% levels, respectively.

TABLE XIII

REGRESSION RESULTS BY YEAR

$F_{t,n} = \alpha + \beta\, TF_{t,n} + \varepsilon_t$;   where: [Equation (2.5)]

$F_{t,n}$ and $TF_{t,n}$ are the futures price and CCM price respectively

α, β are parameter estimates

ε_t is the standard OLS error term

Null Hypothesis: H_0: $\alpha = 0$ and $\beta = 1$

	Constant Coefficient (α)	Slope Coefficient (β)	t-stat:[b] $\beta = 1$	R^2	D.W[c]
Full Sample (726 observations):					
Mean	2.087	0.900	-5.38**	99.7%	2.29
t-statistic[a]	(5.38)**	(505.72)**			
Standard Dev.	0.387	0.002			
Reject Null Hypothesis at 1% significance level					
1984 (240 observations):					
Mean	-9.503	1.053	4.14**	96.6%	2.16
t-statistic[a]	(-4.57)**	(81.91)**			
Standard Dev.	2.076	0.129			
Reject Null Hypothesis at 1% significane level					
1985 (242 observations):					
Mean	8.938	0.953	-4.04**	96.6%	2.31
t-statistic[a]	(4.13)**	(82.40)**			
Standard Dev.	2.164	0.116			
Reject Null Hypothesis at 1% significance level					
1986 (244 observations):					
Mean	-2.511	1.009	1.15	98.6%	2.18
t-statistic[a]	(-1.40)	(132.79)**			
Standard Dev.	1.790	0.008			
Cannot Reject Null Hypothesis at 5% significance level					

a. Two-tail test of the null hypothesis that the coefficient mean is equal to zero, where *, ** denotes significance at the 5%, 1% levels, respectively.

b. Two-tail test of the null hypothesis that the slope coefficient (β) is equal to one, where *, ** denotes significance at the 5%, 1% levels, respectively.

TABLE XIII (continued)

c. The initial regression results revealed strong positive autocorrelation, which was corrected by the Cochrane-Orcutt iterative least squares technique. The reported results show no autocorrelation at a 5% significance level. Also tested for heteroskedasticity by regressing the residuals against the time to expiration date (independent variable) and no linear relationship was detected.

TABLE XIV

ANALYSIS OF FUTURES MISPRICING BY CONTRACT

Contract Maturing	Mean[a]	Standard Deviation	Number of Observations Total	Discount	Premium	Number of Runs[b] Actual	Expected
3/84	0.253 (5.07)**	0.353	50	11	39	16	18
6/84	-0.027 (-0.88)	0.245	63	35	28	26	32
9/84	0.070 (1.66)	0.344	67	23	44	27	31
12/84	0.647 (10.55)**	0.475	60	5	55	11	10
3/85	0.498 (5.80)**	0.631	54	13	41	18	20
6/85	0.262 (5.50)**	0.390	67	17	50	19*	26
9/85	-0.016 (0.30)	0.410	62	36	26	20*	30
12/85	-0.251 (-5.36)**	0.359	59	42	17	22*	31
3/86	-0.080 (-1.61)	0.384	60	33	27	28	30
6/86	-0.130 (-3.12)**	0.328	62	38	24	25	30
9/86	-0.250 (-5.32)**	0.366	61	41	20	15*	27
12/86	-0.290 -(5.95)**	0.381	61	46	15	10*	23

a. The t-statistics are in parenthesis, which are two-tail test of the null hypothesis that the coefficient estimate is equal to zero, where *, ** denotes significant at 5%, 1% levels, respectively.

b. These are statistical runs test results, where * denotes that the null hypothesis that the future mispricing is randomly distributed around zero can be rejected at a 5% significance level.

TABLE XV

ANALYSIS OF PRICE CHANGES ASSOCIATED WITH FUTURES MISPRICING

Description	Number of Observations	Mean[a]	Standard Deviation	t-stat.[b]	Equal Means t-stat.[c]
Daily Returns on Spot Index[d]:					
Full Sample	726	0.054	0.813	1.80	
Discount[a]	340	-0.054	0.846	-1.17	-3.36**
Premium[a]	386	0.149	0.771	3.80**	(690)
Daily Returns on Futures Index[d]:					
Full Sample	726	0.034	0.910	1.01	
Discount	340	-0.201	0.924	-4.02**	-6.70
Premium	386	0.241	0.845	5.61**	(691)
Daily Change in Basis:					
Full Sample	726	-0.055	0.740	-1.98	
Discount	340	-0.296	0.689	-7.91**	-8.67
Premium	386	0.158	0.719	4.31**	(718)

a. The full sample is divided into two groups: where the futures price trades at a discount relative to the CCM, and whre it trades at a premium.

b. Two-tail test of the null hypothesis that the mean is equal to zero, where *, ** denotes significance at the 5%, 1% leveles, respectively.

c. Two-tail test of the null hypothesis that the mean of the futures discount sample is equal to the mean of the futures premium sample, where ** denotes significance at a 1% level. The degrees of freedom are in parentheses.

d. Two-tail test of the null hypothesis that the mean of the daily spot index returns is equal to the mean of the daily futures returns cannot be rejected at a 5% significance level, except where the futures trade at a discount:

	t-statistics	d.f.
Full Sample	0.44	1432
Discount	-2.17*	672
Premium	-1.58	763

TABLE XVI

ANALYSIS OF TRADING ACTIVITY ASSOCIATED WITH FUTURES MISPRICING

Description	Number of Observations	Mean	Median	Standard Deviation	Equal Means t-stat.[c]
Total Volume (All S&P 500 Futures Contracts):					
Full Sample	726	62,180	60,362	19,820	
Discount [a]	340	64,755	63,576	19,577	3.31**
Premium[a]	386	59,911	57,348	19,780	(714)
Contract Volume (Near Term Futures Contracts):					
Full Sample	726	54,291	53,932	20,861	
Discount	340	57,139	57,671	20,590	3.48**
Premium	386	51,783	51,686	20,801	(714)
Total Open-Interest (All S&P 500 Futures Contracts):					
Full Sample	726	66,606	60,522	32,202	
Discount	340	75,225	66,889	34,373	6.90**
Premium	386	59,014	55,142	28,090	(655)
Contract Open-Interest (Near Term Futures Contracts):					
Full Sample	726	54,299	51,770	26,877	
Discount	340	62,877	57,371	31,356	8.22**
Premium	386	46,744	43,577	19,297	(549)

a. The full sample is divided into two groups: where the futures price trades at a discount relative to the CCM, and where it trades at a premium.

b. Two-tail test of the null hypothesis that the mean of the futures discount sample is equal to the mean of the futures premium sample, where ** denotes significance at a 1% level. The degrees of freedom are in parentheses.

TABLE XVII

STATISTICAL ANALYSIS OF BASIS

Description	Number of Observations	Mean[a]	Standard Deviation	Min.	Max.
Daily Basis (B_t)[b] (B_t=$F_{t,n}$-S_t)	726	1.037 (24.59)**	1.137	-1.76	5.06
Positive Basis[c] (Sample P)	619	1.297 (31.79)**	1.015	0.01	5.06
Negative Basis[c] (Sample N)	107	-0.462 (-11.32)**	0.422	-1.76	0.00
Daily Change in Basis[d]	726	-0.055 (-1.98)*	0.740	-4.54	4.61

a. The t-statistics are in parentheses, which are two-tailed test of the null hypothesis that the mean is equal to zero, where *, ** denotes significance, at the 5%, 1% levels, respectively.

b. The 726 observations can be divided into two groups: where the basis is positive, called Sample P, and where the basis is negative, called Sample N. The latter includes four observations where the basis is zero other than on expiration date.

c. The two-tail test of the null hypothesis that the mean of the positive basis is equal to the mean of the negative basis can be rejected at a 1% significance level, because the t-value is 30.5 with 362 degrees of freedom.

d. This is defined as B_t-B_t-1. The statistical runs test shows that the null hypopthesis that the daily changes in basis is random distributed around zero can be rejected at a 1% significance level (443 observed runs versus 362 expected runs).

TABLE XVIII

REGRESSION RESULTS OF BASIS

Dependent Variable	Constant Coefficient[a]	Slope Coefficient[a]	Indendent Variable	R^2	D.W.[b]
Daily Basis	-0.085 (-0.66)	0.036 (11.77)**	Maturity	16.0%	2.43
Daily Basis-Positive (Sample P)	0.175 (1.49)	0.034 (12.24)**	Maturity	19.4%	2.40
Daily Change in Basis	-0.016 (-0.30)	-0.001 (-0.80)	Maturity	0	2.83
Daily Change in Basis	-0.065 (-2.59)**	0.320 (11.53)**	Daily returns on futures	15.5%	2.73

a. The t-statistics are in parentheses, which are two-tailed test of the null hypothesis that the coefficient estimate is equal to zero, where ** denotes significance at the 1% level. There are 726 observations, except for Sample P which has 619 observations.

b. These results are corrected for autocorrelation using the Cochrane-Orcutt iterative least squares techniques. They were also tested for heteroskedasticity, by regressing the residuals against days to maturity (independent variable) and found no linear relationship.

TABLE XIX

DAY-OF-THE-WEEK EFFECT IN SPOT, FUTURES AND BASIS

	MON.	TUES.	WED.	THUR.	FRI.	F-stat.[b]
Observations[a]	132	130	145	147	135	-
Daily Returns on Spot Index (Grand Mean = 0.069%):						
Mean	-0.042	0.133	0.042	0.114	-0.094	1.01
t-statistic[c]	(-0.59)	(1.88)	(0.62)	(1.70)	(1.35)	
Net Mean[a]	-0.110	0.065	-0.027	0.045	0.025	
t-statistic[c]	(-1.57)	(0.91)	(-0.40)	(0.67)	(0.36)	
Daily Returns on Futures (Grand Mean = 0.056%):						
Mean	0.084	0.124	-0.020	0.106	-0.010	0.76
t-statistic	(1.07)	(1.57)	(-0.27)	(1.43)	(-0.12)	
Net Mean	0.028	0.068	-0.076	0.050	0.065	
t-statistic	(0.35)	(0.86)	(-1.02)	(0.67)	(0.84)	
Daily Changes in Basis (Grand Mean = -0.041%):						
Mean	0.156	-0.009	-0.111	-0.023	-0.211	4.69**
t-statistic	(2.47)*	(-0.14)	(-1.83)	(-0.83)	(-3.37)**	
Net Mean	0.197	0.032	-0.069	0.018	-0.170	
t-statistic	(3.12)**	(0.50)	(-1.15)	(0.31)	(-2.71)**	

a. There are 689 observations because all holidays and the following trading days are excluded from this sample. Thus, all the data are "normal" one-day and weekend returns. The mean of all 689 observations is the grand mean. The net mean for each of the five days is the daily mean minus the grand mean.

b. The F-statistic is to test the null hypothesis that all the coefficients are equal in the regression $R_t = a_1 D1 + a_2 D2 + a_3 D3 + a_4 D4 + a_5 D5 + e_t$, where R_t is the daily return and D1 to D5 are day-of-the-week dummy variables. The daily change in basis is the only case where the daily changes are statistically different from each other at a 1% significance level, denoted with **.

c. The t-statistics are two-tail test of the null hypothesis that the mean (net mean) is equal to zero, where *, ** denotes significance at the 5%, 1% levels, respectively.

TABLE XX

CONTRACT VOLUME AND OPEN-INTEREST: DAY-OF-THE-WEEK EFFECT

	MON.	TUES.	WED.	THUR.	FRI.	F-stat.[c]
Observations[a]	132	130	145	147	135	-
Near Term Futures Contract Volume (Grand Mean = 54.416):						
Net Mean[a]	-2679	3879	3438	-282	-4498	4.31**
t-statistic[d]	(-1.49)	(2.14)*	(2.00)*	(-0.16)	(-2.53)**	
Near Term Futures Contract Open-Interest (Grand Mean = 54,240):						
Net Mean[b]	848	127	-403	-766	307	0.07
t-statistic[d]	(0.36)	(0.05)	(-0.17)	(-0.34)	(0.12)	

a. The net mean for each of the five days is the daily mean minus the grand mean. The latter is based on 689 observations (refer to (a) in Table IX), with a mean of 54,416 contracts and standard deviation of 20,838. A contract represents $500 times the current market value fo the S&P 500 index.

b. The net mean for each of the five days is the daily mean minus the grand mean. The latter is based on 689 observations resulting in a mean of 54,240 contracts and standard deviation of 26,977.

c. The F-statistic is to test the null hypothesis that all the coefficients are equal in the regression $C_t = a_1 D1 + a_2 D2 + a_3 D3 + a_4 D4 + a_5 D5 + e_t$, where Ct is the daily volume (open-interest) and D1 to D5 are day-of-the-week dummy variables. The daily volume is statistically different from each other at a 1% significance level, denoted with **.

d. The t-statistics are two-tail test of the null hypothesis that the net mean is equal to zero, where *, ** denotes significance at the 5%, 1% levels, respectively.

TABLE XXI

STATISTICAL ANALYSIS OF POSITIVE AND NEGATIVE BASIS

Description	Number of Observations	Mean	Standard Deviation	t-stat.[b]	Equal Means t-stat.[c]
Daily Returns on Spot Index[d]:					
Full Sample	726	-0.054	0.813	1.80	
Sample P[a]	619	0.116	0.780	3.70**	4.47**
Sample N[a]	107	-0.302	0.911	-3.43**	(134)
Daily Returns on Futures[d]:					
Full Sample	726	0.034	0.910	1.01	
Sample P	619	0.131	0.856	3.81**	6.36**
Sample N	107	-0.527	1.009	-5.40**	(133)
Daily Change in Basis:					
Full Sample	726	-0.055	0.740	-1.98*	
Sample P	619	0.023	0.726	0.80	7.53**
Sample N	107	-0.504	0.658	-7.92**	(154)

a. The full sample is divided into two groups: where the basis is positive, called Sample P, and for the negative basis, called Sample N. The latter group includes four observations where the basis is zero other than on expiration days.

b. Two-tail test of the null hypothesis that the mean is equal to zero, where *, ** denotes significance at the 5%, 1% levels, respectively.

c. Two-tail test of the null hypothesis that the mean of Sample P is equal to the mean of Sample N, where ** denotes significance at a 1% level. The degrees of freedom are shown in parentheses.

d. The two-tailed test of the null hypothesis that the mean of the daily spot index returns is equal to the mean of the dialy futures returns cannot be rejected at a 5% significance level:

	t-statistics	d.f.
Full Sample	0.44	1432
Sample P	-0.33	1225
Sample N	1.71	209

TABLE XXII

CONTRACT VOLUME AND OPEN-INTEREST ASSOCIATED WITH POSITIVE ANE NEGATIVE BASIS

Description	Number of Observations	Mean	Standard Deviation	Equal Means t-stat.[b]
Total Volume (All S&P 500 Futures Contracts):				
Full Sample	726	62,180	19,819	
Sample P[a]	619	60,642	19,204	-4.79**
Sample N[a]	107	71,073	21,047	(138)
Contract Volume (Near Term Futures Contracts):				
Full Sample	726	54,291	20,861	
Sample P	619	54,792	20,009	1.33
Sample N	107	51,392	25,143	(130)
Total Open-Interest (All S&P 500 Futures Contracts):				
Full Sample	726	66,606	32,202	
Sample P	619	62,184	29,836	-8.67**
Sample N	107	92,198	33,582	(136)
Contract Open-Interest (Near Term Futures Contracts):				
Full Sample	726	54,299	26,877	
Sample P	619	52,045	24,450	-4.33**
Sample N	107	67,342	35,049	(124)

a. Refer to Table XI for the division of the full sample into Sample P and Sample N.

b. Two-tail test of the null hypothesis that the mean of Sample P is equal to the mean of Sample N, where ** denotes significance at a 1% level. The degrees of freedom are in parentheses.

TABLE XXIII

ANALYSIS OF FINANCING COST AND CUMULATIVE DIVIDENDS

Description	Number of Observations	Mean	Standard Deviation	Equal Means t-stat.[b]
Financing Cost with Federal Funds[c]:				
Full Sample	726	1.928	1.160	
Sample P[a]	619	2.031	1.148	6.24**
Sample N[a]	107	1.334	1.050	(153)
Financing Cost with Treasury Bills[d]:				
Full Sample	726	1.756	1.088	
Sample P	619	1.854	1.082	6.51**
Sample N	107	1.194	0.946	(158)
Cumulative Value of Dividends[e]:				
Full Sample	726	0.940	0.543	
Sample P	619	0.979	0.530	4.46**
Sample N	107	0.716	0.568	(139)
Net Financing Cost with Federal Funds[f]:				
Full Sample	726	0.988	0.640	
Sample P	619	1.052	0.642	8.02**
Sample N	107	0.619	0.491	(175)
Net Financing Cost with Treasury Bills[f]:				
Full Sample	726	0.816	0.571	
Sample P	619	0.874	0.578	8.98**
Sample N	107	0.478	0.388	(198)

a. Refer to Table XI for the division of the full sample into Sample P and Sample N.

b. Two-tail test of the null hypothesis that the mean of Sample P is equal to the mean of Sample N, where ** denotes significance at a 1% level. The degrees of freedom are shown in parentheses.

c. This is based on the Cost of Carry Model (CCM) and it is the financing cost element based on the overnight federal funds rate: $S_t\,(1 + f_{t,n})^{n-t} - S_t$.

d. This is based on the CCM and it is the financing cost element based on the Treasury bill yield:

$$S_t(1 + r_{t,n})^{n-t} - S_t.$$

TABLE XXIII (continued)

e. This is based on the CCM and it is the cumulative value of future dividends with reinvestment at the Treasury bill yield to expiration date:

$$\sum_{t=1}^{n} DPS_{t,x,n}(1 + r_{x,n})^{n-x}$$

f. This is based on the CCM and it is the financing cost element (based on federal funds rate and Treasury bill yield, respectively) minus the cumulative dividends, which results in the net financing cost.

TABLE XXIV

SIMULATION BASED ON CUMULATIVE DIVIDENDS

Week Number[a]	Number of Observations	Percentage Increase in Cumulative Dividends[b] Federal Funds	Treasury Bills
1	18	885%	865%
2	19	308	289
3	10	138	118
4	8	204	180
5	3	172	154
6	5	199	170
7	4	130	108
8	12	137	116
9	11	126	108
10	5	119	102
11	4	116	97
12	4	109	91
13	4	94	73
Mean	107	296%	276%
Mean (exclude Week 1)	89	177%	157%

a. These are the numbei of weeks to expiration of the contracts, where Week 1 is the expiration week.

b. Cumulative dividends, as described in note (e) to Table XXIII, will have to increase by these percentages from their present level so that the negative net financing cost is equal to the negative value fo the basis. The results are reported using the federal funds rate and the Treasury bill yield.

TABLE XXV

REGRESSION RESULTS OF POSITIVE AND NEGATIVE BASIS

Dependent Variable[a]	Constant Coefficient	Slope Coefficient[b]	Independent Variable[a]	R^2	D.W.[c]
Positive Basis (Sample P)	0.422 (4.01)**	0.834 (11.01)**	Net Financing With Fed Funds	16.3%	2.32
Negative Basis (Sample N)	-0.472 (-7.14)**	0.016 (0.19)	Net Financing With Fed Funds	0	1.28
Positive Basis (Sample P)	0.294 (3.11)**	1.142 (13.98**	Net Financing With T-Bills	24.1%	2.31
Negative Basis (Sample N)	-0.488 (-7.50)**	0.055 (0.52)	Net Financing With T-Bills	0	1.28

a. The 726 observations are divided into two groups: positive basis (619 observations) and negative basis (107 observations). They are regressed against the net financing costs element of the Cost of Carry Model (CCM), using the federal funds rate and Treasury bill yield, respectively.

b. The t-statistics are in parentheses and are two-tailed tests of the null hypothesis that the coefficient estimate is equal to zero, where ** denotes significance at the 1% level.

c. The Durbin-Watson test shows positive autocorrelation in all four cases. No correction is effected for the negative bases since the R^2 is equal to zero, revealing no linear relationship. For the positive basis, the autocorrelation is corrected using the Cochrance-Orcutt iterative least squares techniques. They were also tested for heteroskedasticity by regression the residuals against days to maturity (independent variable) and found no linear relationship.

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