The Relationship between the S&P 500 Index and S&P 500 Index Futures Prices

Ira G. Kawaller, Paul D. Koch, and Timothy W. Koch

The Standard and Poor's 500 Index and the related index futures prices are influenced by their own histories, each other's movements, and current market information. This study explores the temporal relationship between these two important market indicators and measures the change in this relationship as futures expiration day approaches.

The advent of markets for stock index futures and options has profoundly changed the nature of trading on stock exchanges. These markets offer investors flexibility in altering the composition of their portfolios and in timing their transactions. Futures and options markets also provide opportunities to hedge the risks involved with holding diversified equity portfolios. As a consequence, significant portions of cash market equity transactions are now tied to futures and options market activity.

The effect of the stock index futures and options markets on traditional stock trading has aroused both the ire of critics and the acclaim of supporters. Critics allege that futures trading unduly influences the underlying equity markets, especially on days when futures contracts expire. For example, on various expiration days from 1984 to 1985, the stock markets closed with equity prices either rising or falling dramatically during the final hour of trading. The phenomenon of sharp price swings and the seeming relation to futures market activity has, especially in the wake of the October 19, 1987, stock market crash, prompted various suggestions for modifying the design of the contracts to lessen their impact on the market. (For a related discussion, see this issue's Book Review by Peter A. Abken on p. 36.)

Proponents of futures markets, on the other hand, do not view the final-day price swings as a problem, since the swings are generally temporary and nonsystematic. In fact, proponents argue that such markets provide an important price discovery function and offer an alternative marketplace for adjusting equity exposure. The term price discovery function refers to the ability to use a certain market indicator—in this case, stock index futures—to forecast upcoming changes in the prices of securities. For the price discovery function to be most helpful, though, an investor must be able to determine when a change in the futures market will be reflected in the underlying market.

This article addresses some basic questions that have a fundamental bearing on the debate between the critics and advocates of futures markets. Do intraday movements in the index futures price provide predictive information...
about subsequent movements in the index, or do movements in the index presage futures price changes? Is the price relationship different on expiration days and the days leading up to expiration?

Analysis of the Standard and Poor's (S&P) 500 futures and the S&P 500 index can help answer these questions. This article shows that lags exist not only between movements in index futures prices and subsequent movements in the index, but also between the index and subsequent index futures prices, though these lags are not symmetrical. The index lags behind the index futures price by up to 45 minutes, but the index futures price tends to trail the index only briefly. Examination of the lagged relationships on expiration days and the days prior to them indicates that the relationships are remarkably stable, implying that neither expiration day volatility nor the climate preceding these days interferes with the price discovery function that index futures seem to offer.

An Overview of the S&P 500 Index and Index Futures

The S&P 500 stock index represents the market value of all outstanding common shares of 500 firms selected by Standard and Poor's. Prior to April 6, 1988, this group always consisted of 400 industrials, 40 financial institutions, 40 utilities, and 20 transportation firms. Though all of the shares are not traded on the New York Stock Exchange (NYSE), the cumulative market value equals approximately 80 percent of the aggregate value of NYSE-listed stocks. The index changes whenever the price and thus the cumulative market value of any underlying stock changes.

An S&P 500 futures contract represents the purchase or sale of a hypothetical basket of the 500 stocks underlying the S&P 500 index, set in a proportion consistent with the weights set by the index, with a market value equal to the futures price times a multiplier of 500. The futures price should be tied to the cost of investing in and carrying an S&P 500 look-alike basket of stocks until the expiration of the index future. The cost of carry incorporates transactions fees, taxes, and the expense of financing the investment, minus the dividends derived from the basket of stocks and any additional reinvestment income.

As a requirement for gaining access to the market, traders must post an initial margin deposit or collateral equal to a fraction of the futures contract market value (price x 500). Futures prices change intermittently throughout each trading day, and at day's end traders must cover any losses when prices move against
them. Alternatively, they may withdraw any profit in excess of their initial margin requirement should prices move favorably. During the period from which data for this study were drawn, contracts expired on the third Fridays of March, June, September, and December, with the futures contracts marked to the closing index value at 4:15 p.m., Eastern time.³

**Basic Functions of Stock Index Futures**

Stock index futures typically serve three functions: trading, hedging, and arbitrage. First, traders can take speculative positions in futures to take advantage of anticipated broad market price movements. Second, hedging, which involves the purchase or sale of index futures in anticipation of an intended cash market trade, compensates for adverse price moves in the cash market, and thus reduces aggregate risk. Simple hedges typically involve the purchase (sale) of an asset in the cash market and sale (purchase) of futures contracts on the same asset. As long as the cash-futures spread remains the same and the costs of effecting and financing the transaction are covered, gains (losses) on the cash market purchase are countered by losses (gains) on the future. The investor thus may mitigate the risk of loss and the possibility of gain on the cash market purchase.

Arbitrage is a third strategy served by stock index futures. It involves the simultaneous purchase and sale of stocks and futures and subsequently enables an investor to capture profits from realignments of relative prices following an apparent inconsistency in the index and the index futures price. When the index futures price moves outside the range determined by the cost of the look-alike basket and the cost of carry, arbitrage will tend to drive the futures price and the index toward their cost-of-carry relationship. If the actual futures price is higher than the cost of the look-alike basket and the cost of carry, the futures contract is overvalued, justifying the purchase of the look-alike basket of stocks and the simultaneous sale of the futures contract. If the futures price falls below the price of the look-alike portfolio plus the cost of carry, the futures contract is undervalued, and the reverse trade would be profitable. In both cases, the arbitrage transactions realign the futures price and the index.

Because physical delivery does not take place, the futures contract is said to be "settled in cash." Cash settlement is an important feature of stock index futures. An arbitrageur who has sold futures and bought the underlying basket of stocks does not deliver the basket of stocks to the investor who bought futures. Instead the arbitrageur must sell the basket of stocks. Any open futures positions are marked to the final settlement index calculation when the futures expire. Once the arbitrageur pays or receives the value of the price change from the prior day, the position is closed. A common practice for arbitrageurs, however, is to trade large blocks of stocks or whole portfolios at prices tied to closing prices on the futures expiration days. As a result, these large volumes of orders late in the day have tended, on some occasions, to create at least temporary imbalances in the cash equity markets.

**Movements in Futures Prices.** Numerous studies have explained the price relationship between stock index futures and the underlying stocks in terms of arbitrage behavior. Futures prices normally vary relative to stock prices within ranges that are not sufficient to trigger arbitrage. In fact, arbitrage opportunities are often not available. A number of scholars have attempted to identify and measure arbitrage trading boundaries.⁶ Their results indicate that the futures to cash price differential, referred to as the basis, should fall within boundaries determined by the cost of carry. Because market interest rates have historically exceeded the dividend rate on common stocks, the "fair value" or theoretical stock index futures price normally exceeds the stock index.⁷

Conventional wisdom among professional traders dictates that movements in the S&P 500 futures price affect market expectations of subsequent movements in cash prices. The futures price presumably embodies all available information regarding events that will affect cash prices. Purchase or sale of index futures requires one transaction, while purchase or sale of a look-alike portfolio generally involves 200 or more stocks and a minimum $5 million investment. Consequently, the index futures price is...
likely to respond to new information more quickly than cash market prices in general and, thus, more quickly than the S&P 500 index. This lag of the index behind the futures price results because the underlying stocks must be traded in order for the index to reflect a change in value. Since most index stocks do not trade each minute, the cash market responds to the new information with a lag. S&P 500 index movements may similarly convey information about subsequent price variation in the futures contract; however, the lag of the futures price behind the index is likely to be much shorter than the lag of the index behind the futures price.

If new information on the health of the economy is bullish, a trader has the choice of buying either S&P 500 futures or the underlying stocks. While the futures trade can be effected immediately with little up-front cash, actual stock purchases require a greater initial investment and may take longer to implement since they require a subsequent stock selection. This preference for index futures as a vehicle for speculative transactions explains why changes in futures prices may lead changes in stock prices and the S&P 500 index. Futures prices may thus provide an indicator of forthcoming cash prices, which follow when investors who are unwilling or unable to use futures incorporate the same information that led to changes in futures prices into their own cash market transactions.

Changes in the S&P 500 index can also lead changes in the futures price, if the value of the index conveys information that affects futures prices. Futures traders are likely to incorporate recent changes in the index in their pricing decisions. For example, if the index declines because investors are selling stocks connected with options trading, the decline may induce a change in sentiment that is reflected in subsequent futures prices.

Potential lead and lag patterns between index futures and the index are complicated by two more possible relationships: the futures and the index may move together as new information affects both index futures and cash market trades. Each measure may lead the other as market participants find clues about impending values of index futures and broad market movements in previous futures prices and broad cash market movements, respectively. Technical analysts, or chartists, rely heavily on patterns of relationships between past and future values of series such as the S&P 500. A summary of possible relationships between the S&P 500 index and S&P 500 futures prices is shown in Table I.

<table>
<thead>
<tr>
<th>Possible Effects of Movements</th>
<th>Movement in the S&amp;P 500 Index</th>
<th>Movement in S&amp;P 500 Index Futures Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>May be affected by</td>
<td>may affect</td>
<td>may affect</td>
</tr>
<tr>
<td>• prior index levels</td>
<td>• upcoming index levels</td>
<td>• prior futures prices</td>
</tr>
<tr>
<td>• current futures prices</td>
<td>• upcoming futures prices</td>
<td>• current index levels</td>
</tr>
<tr>
<td>• prior futures prices</td>
<td></td>
<td>• prior index levels</td>
</tr>
<tr>
<td>• other market information</td>
<td></td>
<td>• other market information</td>
</tr>
</tbody>
</table>

Tests of the Intraday Relationship between S&P 500 Futures and the S&P 500 Index

A complex set of potential relationships could exist between S&P 500 futures and the S&P 500 index prices. Movements in each are thought to be influenced by the past and current movements of both as well as by other market information. The study reported on in this article tried to gauge the magnitude and variability of the relationships between the index and the futures by estimating distributed lags between the two prices. Distributed lags employ a method of weighting past data to determine their effects on the data under study.
The pattern of lags between index futures and the index may not be constant over time. While shifting patterns are conceivable throughout the life of the futures contract, the focus of interest on expiration day effects begs the question of whether these temporal relationships show any differentiation on those days. On expiration days, the traders’ need to close positions may generate market imbalances that could conceivably overwhelm the mechanism by which new information influences index futures and cash market prices. An expiration-day breakdown in this mechanism would diminish the benefits of the index futures market—at least on expiration day—as a medium for discovery.

The data are minute-by-minute prices of index futures contracts and the S&P 500 index on all trading days in 1984 and 1985. The Chicago Mercantile Exchange provided the data.\(^\text{10}\) Pairing the reported index with the last index futures price quoted during the minute that the index appeared yielded 360 pairs of index and futures observations each day (six-hour trading day x 60 observations per hour). To judge whether the index futures-index relationship changes as the expiration day approaches, lags were estimated for six trading days in each quarter beginning in the second quarter of 1984 and ending with the last quarter of 1985.\(^\text{11}\) The days are 88, 60, 30, and 14 days prior to expiration, 1 day prior to expiration, and expiration day. These days were chosen to represent the approach of expiration and the effect of this approach on the index futures-index relationship.

The nature and extent of the lead/lag relationships between index futures prices and the index were measured using a number of analyses. First, a time series analysis was performed to study the movements of futures prices relative to prior futures prices. Next, the same method of analysis gauged movement of the S&P 500 index based on past index performance. These time series analyses studied the minute-to-minute changes in both the index and the futures prices. The next step in the analysis was to construct a model to describe the dynamic intraday price relationships between the index and the futures prices. In this model, index movements depend on their own past movements, current and past movements in the futures price, and other relevant market information (see Table 1). Likewise, futures price movements are modeled to depend on their own past movements, current and past movements in the index, and other relevant market information.\(^\text{12}\)

Consistent evidence on both the form of the lag relationships and their stability over time emerges from these tests: first, the contemporaneous relationship between futures prices and the index is quite strong—dwarfing the lagged relationships. In fact, the futures and index move almost in lock step. Second, lags between index futures prices and the index are not symmetrical. The index lags behind the index futures price by up to 45 minutes, while the futures price lags behind the index only briefly if at all. This result supports the contention that index futures do, in fact, serve a price discovery function. Third, the lagged relationships do not appreciably change as expiration day approaches or on expiration day itself.

Different patterns of lagged relationships between S&P 500 futures and the S&P 500 index are given in Chart 1. It shows the distributed lag coefficients for two days in the fourth quarter of 1984; results for other days in this contract period, as well as days in other contract periods, are quite similar. Typically, the first coefficient, which describes the contemporaneous relationship, is the greatest, or one of the greatest, on each day. In the panels showing lags from futures to the index, relatively large and statistically significant coefficients show up with lags as long as 45 minutes. Panels showing lags from the index to futures typically show the one-minute lag as the largest coefficient and the only one that is significant. These results parallel evidence garnered from earlier time-series analyses.\(^\text{13}\)

Chart 1 also shows quite similar patterns in the distributed lag coefficients 88 days prior to expiration day and on expiration day. Coefficients showing the lead from futures to the index continue to be mostly positive even on expiration day. They are significant or nearly significant through 20 to 30 minutes on each day, though the lag appears somewhat less on expiration day. Other quarters record quite similar patterns.
Implications

Evidence uncovered in the tests of lagged relationships between S&P 500 index futures prices and the S&P 500 index points to the usefulness of the futures as a predictor of broad equity market movements measured by the index. The S&P 500 futures price and underlying index evidently respond to market information simultaneously, and the index shows lags of up to 45 minutes behind the futures. Importantly, the magnitudes of the contemporaneous effects on different days are consistently much larger than the lagged effects. Thus, though the price discovery function has been demonstrated, the indications of forthcoming cash market changes provided by past futures prices are not sufficient to provide an exploitable trading strategy.

Consistency in the lagged relationships over the days approaching expiration day and on expiration day also indicates that the pattern of lags between futures and the index is not disturbed by the closing out of arbitrage positions. This consistency implies that index futures trading continues to make its contribution to price discovery, even on expiration days that transpired without market activity restrictions.
Chart 1. 
Sample Distributed Lags for the 
S&P 500 Index and S&P 500 Index Futures Prices

Chart 1 shows the relationship between minute-to-minute movements in the S&P 500 futures price and the S&P 500 index. The top graph in each set shows how past minute-to-minute movements in the futures price affect current movements in the index, and the bottom figure shows how past movements in the index affect current movements in the futures price.

The vertical axis in each figure represents the magnitude of the minute-to-minute impacts of each value on the other. The horizontal axis charts the number of minute-to-minute lags incorporated into the model. For example, for \( k = 1 \) minute lag, the value plotted in the top graph shows the impact of the futures price change one minute earlier on the current index value. At the number '20' on the horizontal axis, the effect on the current index value of the futures price 20 minutes earlier is plotted.

When the vertical lines within the graph fall between the two dotted horizontal lines, the magnitude of the distributed lag coefficient is less than twice its standard error, and thus is not statistically significant. When the vertical lines within the graph fall outside the dotted lines, the magnitude of the distributed lag coefficient is more than twice its standard error, and, thus, is statistically significant.

When the vertical lines are concentrated in the positive portion of the figure (above 0.0), most of the lagged impacts of one price on the other are positive, that is, increases in one price are then followed by increases in the other price.

When the vertical lines are concentrated in the negative portion of the figure (below 0.0), most of the lagged impacts of one price on the other are negative, that is, increases in one price are then followed by decreases in the other price.
The term "triple witching hour" was used to describe this trading period because the Chicago Mercantile Exchange’s (CME) S&P 500 futures, the Chicago Board of Trade Options Exchange’s (CBOE) S&P 100 options, and contracts on individual stock options all expired on the third Fridays of March, June, September, and December. After March 1987, the final day of trading for S&P 500 futures was moved to the day prior.

The U.S. Securities and Exchange Commission, the Government Accounting Office, and the executive branch (the Brady Commission), as well as various exchange and private research groups, are currently studying the relation of price swings to futures market activity.

These results do not explain expiration day swings, nor do they suggest that such swings are desirable.

Standard and Poor’s has recently announced that the composition of the S&P 500 will now be flexible.

Since this study, the final settlement procedures for S&P 500 futures have changed. Contracts currently expire one business day prior to the third Friday of the contract month, with the final settlement price based on a special calculation of the Friday opening prices for each of the 500 stocks. Upon expiration, one final cash adjustment is made to reflect the last day’s gains or losses.

Cornell and French (1983a, b); Figlewski (1984a, b); Modest and Sundaresan (1983); and Stoll and Whaley (1986).

The theoretical upper and lower bounds are discussed extensively in the literature. For example, see Stoll and Whaley (1986): 8-10, or Kawaller (1987): 447-49.

New information could affect a subset of index stocks disproportionately relative to the entire stock market. In such cases, not all index stocks must be traded each minute for the index to adjust completely and quickly to new information.

In options trading, an investor purchases the right to buy or sell a given security at a fixed strike price before a specific date in the future. If the investor does not exercise this right before the date in the contract, the option expires and the option buyer forfeits the money.

At the time of this study, the index was available only each minute. Since then, index quotations have been calculated and disseminated at about 15-second intervals.

Prior to the June 1984 contract, S&P 500 futures expired on Thursdays. This article’s sample is restricted to the last three contracts in 1984 and all contracts that expired in 1985. Also note that futures trade for 15 minutes after the stock markets close. Quotes from these 15 minutes are not considered in this analysis. Finally, since September 30, 1985, quotes are available beginning at 8:30 a.m., but the analysis is restricted to the six hours (360 observations) from 9:01 a.m. and 3:00 p.m. so that the results can be compared across quarters.

In the context of this model, zero restrictions are tested on the distributed lag coefficients, allowing, alternately, the contemporaneous coefficient and the coefficient at lag one minute to remain unconstrained. See Kawaller, Koch, and Koch (1987) for details.

The tests with no restrictions on the contemporaneous and first coefficients also confirm the longer lags from the futures to the index and the very short lag from the index to the futures.
Bibliography


__________. Roundtable on Index Arbitrage, July 9, 1986c.