

Has Programmed Trading Made Stock Prices More Volatile?

G. J. Santoni

If there must be madness, something may be said for having it on a heroic scale.

— John Kenneth Galbraith, *The Great Crash*, p. 69.

MANY people believe that stock prices have become considerably more volatile in recent years. Typical descriptions have characterized stock market behavior as “careening through” trading ranges, subject to “wild gyrations,” and the product of “unexpected insanity.”¹

The presumed source of the volatility is a trading strategy called “programmed trading.”² This strategy, which essentially involves trading on small and short-lived price differences for the same group of stocks in the spot, futures and options markets, is not new. The introduction of stock *index* futures around 1982 and the application of computer techniques to monitor price differences and trigger trades between markets, however, are novel. These two innovations have reduced the cost of transacting among the markets, which has resulted in increased trading activity. The increased activity, the size of the trades made by individual players and the behavior of stock prices on days when stock index futures and options contracts

mature (triple witching days) have led many observers to conclude that this trading strategy has increased stock price volatility.³

The alleged increase in volatility has led both to closer scrutiny by the Securities and Exchange Commission and to calls for legislative action.⁴ In response to these concerns, the Chicago Mercantile Exchange voted recently to impose a 12-point daily price change limit on its Standard and Poor’s 500 stock index futures contract and to move the expiration of the contract from the close to the opening of trading on quarterly expiration days. The latter was also adopted by the Chicago Board of Options Exchange for its Standard and Poor’s 500 stock index option.

This paper examines the principles of trading between the spot and futures markets for stocks and the

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¹See “Abreast of the Market” (1987) and Clark (1987). Other examples can be found in the *Wall Street Journal* on the following dates: January 16; January 20; January 23.

²See, for example, Stoll and Whaley (1987), Laderman and Frank (September 29, 1986); Laderman, et. al (April 7, 1986); Stoller (February 9, 1987) and McMurray (February 12, 1987).

³See, for example, Laderman, et. al. (April 7, 1986) who assert that “Program trading, by its very nature, causes wild swings in the markets. . .” p. 32; and “Program trading is a mixture of irony and mystery. It breeds volatility.” p. 33. “Triple witching” is a reference to the third Fridays of March, June, September and December. Stock index futures contracts and options on the futures expire on these days.

⁴See Laderman and Frank (September 29, 1986), p. 102. Stoller (February 9, 1987) not only attacks programmed trading but all speculative activity. Borrowing from John Kenneth Galbraith (1955), he notes that “Wall Street, in these matters, is like a lovely and accomplished woman who must wear black cotton stockings, heavy woolen underwear, and parade her knowledge as a cook because, unhappily, her supreme accomplishment is as a harlot.” p. 24.

Glossary of Terms

"Arb": Arbitrageur. A person who simultaneously buys and sells the same good in two different markets.

Basis: The difference between the price of a futures contract and the price of an equal quantity of the cash instrument.

Basis Point: 1/100 of one percent.

Bear Straddle: A spread in which the instrument with the nearby maturity is sold and a similar instrument with a more distant maturity is purchased.

Bull Straddle: A spread in which the instrument with the nearby maturity is purchased and a similar instrument with a more distant maturity is sold.

CBT: Chicago Board of Trade. This exchange trades the Major Market Index Futures (MMI).

Hot Money: The money (wealth) tied up in program trading accounts.

IMM: International Monetary Market. This Chicago exchange trades the Standard and Poor's 500 Index futures.

Interest Elasticity: A ratio of the percentage change in the price of a financial instrument to

the percentage change in the interest (discount) rate.

Unwind: To reverse an earlier transaction.

KCBT: Kansas City Board of Trade. The exchange trades the Value Line Index Futures.

NYFE: New York Futures Exchange. This exchange trades the New York Stock Exchange Index Futures.

Programmed trading: The use of computer programs to analyze and trigger trading between stock index futures contracts, options on the index and the basket of stocks contained in the index.

Spreading: The simultaneous purchase and sale of two similar financial instruments of different maturity.

The .01 Effect: Measures the change in the dollar value of an instrument that results from a change of one basis point in its yield. This depends on the interest elasticity of the instruments.

Triple Witching Hour: The time when options and futures on stock indexes expire. This happens on the third Fridays of March, June, September and December.

claim that stock prices have become more volatile since stock index futures were first introduced. In addition, the paper examines whether programmed trading has contributed to increased stock price volatility.

The paper focuses on stock index futures rather than options because the market for options has been less active than the market for futures so the concerns noted above have focused on the more active futures market.⁵

⁵See Belongia (1983) for a general discussion of options markets. Kawaller (1986), p. 1 and 3, gives a general description of options on financial futures. Black and Scholes (1973) present a formal analysis of option trading. Cinar (1987) discusses the effect of options on stock prices.

STOCK INDEX FUTURES CONTRACTS

Trading in stock index futures contracts was first introduced by the Kansas City Board of Trade on February 24, 1982. In April of the same year, the Chicago Mercantile Exchange, began trading a futures contract based on the Standard and Poor's Index of 500 common stocks. The introduction of both contracts was successful. By the end of 1982, daily trading volume in the Standard and Poor's futures contract, the most successful of the two, was running at about 20,000 contracts.⁶

The success of the first two contracts induced other major exchanges to introduce similar instruments.

⁶See Schwarz, Hill and Schneeweis (1986), pp. 87-88.

Table 1
Stock Index Futures Contracts

Underlying Instrument	Exchange	Trading Hours	Contract Size	Months Traded	Price Quoted In	Minimum Fluctuation	Value of Minimum Fluctuation
Major Market Index	CBT	8:15-3:15	Index times \$250	monthly	Index points	.05	\$12.50
Value Line Index	KCBT	9:00-3:15	Index times \$500	3,6,9,12	Index points	.05	\$25.00
S and P 500 Index	IMM	9:00-3:15	Index times \$500	3,6,9,12	Index points	.05	\$25.00
New York Composite Index	NYFE	10:00-4:15	Index times \$500	3,6,9,12	Index points	.05	\$25.00

Underlying Instrument	Last Trading Day	Margins Initial ¹	Average Daily Volume ¹
Major Market Index	3rd Friday of contract month	\$4,500	18,000
Value Line Index	Last business day of contract month	\$6,500	4,000
S and P 500 Index	3rd Friday of contract month	\$6,000	60,000
New York Composite Index	3rd Friday of contract month	\$3,500	15,000

¹As of 1985.

The New York Futures Exchange, a unit of the New York Stock Exchange, began trading a futures contract based on the New York Stock Exchange Composite Index in September 1983. Most recently, in July 1984, the Chicago Board of Trade began trading a futures contract based on the Major Market Index.

The Standard and Poor's 500 futures contract, which has been adopted by institutional investors, has experienced the most success. For example, the estimated volume of trades in this contract was about 115,000 on April 14 of this year. The average daily trading volume of the S&P 500 contract has been running at about 4 to 5 times the daily trading volume in the contracts based on both the New York Stock Exchange and Major Market indexes and about 15 times the contract based on the Value Line Index.⁷

⁷In addition, the Chicago Mercantile Exchange is currently trading a futures contract based on 100 stocks in the Standard and Poor's 500 Index (the "Mini" S&P). Trading volume in this contract is very thin compared with those mentioned in the text.

Characteristics of the Contracts

A futures contract on a stock index is an agreement between a seller (short position) and buyer (long position) to a cash settlement based on the change in the stock index's value between the date the futures contract is entered by the two parties and some future date.⁸ Table 1 summarizes some of the details regarding each of the stock index futures contracts mentioned above (see the shaded insert on page 22 for a general discussion of futures).

Table 2 presents the trading ranges for futures contracts on the Standard and Poor's 500 Index (S&P Futures) on February 6, 1987. The delivery dates of the contracts traded were the third Fridays of March, June and September of 1987. Notice that open interest is

⁸See Schwarz, Hill and Schneeweis (1986), p. 9. Stock index futures differ from commodity futures in that settlement of the former is always by cash. Stock index futures contracts make no provision for physical delivery of the stocks that are included in the index.

Table 2
Trading Ranges for the Standard and Poor's 500 Futures Contract, February 6, 1987¹

S&P 500 Index (CME) \$500 times index						
Month	Open	High	Low	Settle	Change	Open interest
March	282.50	283.20	280.35	281.20	-1.15	104,412
June	284.10	284.80	281.90	282.80	-1.15	7,131
September	284.90	285.90	283.40	284.10	-1.10	226

Estimated volume 85,705

S&P 500 index for stocks traded in the spot market closed at 280.04

¹Wall Street Journal, February 9, 1987.

greatest in the March (nearby) contract. The market is relatively thin for the more distant contracts. The March contract opened at 282.50 and traded in the range of 283.20–280.35 during the day. It closed at 281.20. Since the value of the futures contract is \$500 times the index, the value of the March contract fluctuated between a high of \$141,600 and a low of \$140,175.

The value of the contract at the close was \$140,600 ($= \500×281.20) which represented a decline in its value of \$575 from its close at \$141,175 ($= \$500 \times 282.35$) on the previous day. Traders who maintained long positions in this contract from the close on February 5 through the close on February 6 lost \$575 ($= \500×1.15) per contract and this amount was deducted from their margin accounts at the close of business on the 6th. The reverse was true for traders who maintained short positions over the time interval.

The Basis

In addition to the information about the futures contracts, table 2 also indicates that the Standard and Poor's 500 Index for stocks traded on the spot market (S&P Index) closed at 280.04 on February 6, 1987. Notice that this amount is different than the amounts recorded at the close for all three of the S&P Futures contracts. The difference between the values of the S&P Futures contracts and the S&P Index is called the *basis*; it can be measured in dollars or index points. For example, at the February 6 close, the basis for the March contract was about \$580 ($= \$500 [281.20 -$

$280.04]$ or 1.16 index points ($= 281.20 - 280.04$).⁹ The basis differs systematically across the three futures contracts; it is larger for more distant delivery months. The qualitative relationship between the prices of the S&P Index and the three S&P Futures contracts shown in table 2 is generally the one that is observed; that is, the value of the S&P Futures is larger than the S&P Index, and the difference increases for more distant contracts. A similar qualitative relationship exists between the other stock index futures contracts discussed above and their respective indexes.¹⁰

WHAT DETERMINES THE BASIS?

Whenever the basis deviates substantially from its equilibrium (or theoretical) value, profitable trading opportunities exist and arbitrageurs will attempt to capture them. Program trading is a method of discovering and exploiting these profit opportunities. Since the opportunities can arise when the equilibrium basis changes, it is important to understand how the equilibrium basis is determined and what things cause it to change.

⁹The basis is "about" \$580 because the New York Stock Exchange closes at 4:00 p.m. Eastern Standard Time while the International Monetary Market closes 15 minutes later at 3:15 p.m. Central Standard Time.

¹⁰The Value Line Index may represent an exception to this general statement because of the averaging method used to calculate it. See Modest and Sundaresan (1983), pp. 19–20.

Futures: A General Discussion

What is a Futures Contract?

A futures contract is an agreement between a seller and a buyer to trade some well-defined item (wheat, corn, Treasury bills) at some specified future date at a price agreed to now, but paid in the future at the time of delivery.

There are three prices that must be kept straight when discussing these contracts: the spot price, the forward price and the futures price. The spot price is the price of the item today for delivery today. The price of the item in the future for delivery then is called the forward price. The price of the item today for delivery in the future is called the futures price. The futures price is specified in the futures contract. Essentially, it is a prediction of the forward price at maturity of the contract.¹

The Relationship Between Spot and Futures Prices

The futures price of a commodity is equal to the spot price plus the cost of storage, insurance and foregone interest earnings associated with holding the good over the interval of the contract. A similar relationship exists between the spot and futures prices of financial instruments (like stock index futures). Since the storage and insurance costs of holding these financial instruments is very low, however, the spread between spot and futures prices is largely determined by the interest cost.²

It Pays To Be Right

Because futures markets typically are very active and are open to virtually anyone who can meet fairly modest capital requirement rules, futures prices represent an aggregate guess about the for-

ward price of the item. Of course, because it is a guess, it typically will be wrong.³ When the forward price that is realized is higher than the futures price that was agreed on, the buyer of the futures contract gains because he can purchase the item at the previously agreed upon futures price and immediately sell it at the higher current spot price. The seller of the futures contract loses because he must sell the item whose current spot price is higher than the price he previously agreed to sell at when he entered the futures contract. The reverse occurs when the forward price that is realized is less than the futures price that was agreed upon.

Some Common Criticisms of Futures Markets

It may appear that futures markets are simply a convenient form of gambling on forward prices. This has been a common criticism of futures markets along with the allegation that trading in futures increases price variation in the spot market.⁴ Speculative bets about price changes, however, are not unique to futures market trading. Economic decisions to buy or sell any storable good, by their nature, are speculative bets about the future course of the price. Furthermore, futures markets serve some valuable social functions such as allocating the consumption of storable goods over time as well as providing a means, through hedging, to reduce the risk of unexpected price changes.⁵

³While typically wrong, the futures price will not consistently under- or over-predict the forward price. That is, the futures price is an unbiased predictor. If this were not true, it would be possible for traders to profit by exploiting the bias which would quickly eliminate it. See Fama (1970).

⁴See Working (1977), p. 293; Cagan (1981), p. 178; and Green (1986), p. 80, for a discussion of these common criticisms of futures markets. This paper examines the second allegation for the case of stock index futures.

⁵For discussion of the social functions fulfilled by futures markets see Working (1977), pp. 25-31 and pp. 267-97; Alchian and Allen (1977), pp. 132-39; and Cagan (1981).

¹See, for example, Working (1977), pp. 25-31.

²See, for example, Schwarz, Hill and Schneeweis (1986), pp. 326-46; Figlewski (1984), pp. 658-60; Cornell and French (1983), pp. 2-4; and Modest and Sundaresan (1983), pp. 22-23.

The equilibrium difference between the S&P Index and S&P Futures (the equilibrium basis) is related to the equilibrium differences between the spot and futures prices of each of the stocks in the Standard and Poor's Composite Index.¹¹ Consequently, understanding the basis for individual stocks is helpful in analyzing the basis for S&P Futures contracts.

The Cost of Carry

In equilibrium, the difference between the spot price of a stock and its expected price at some future date is determined by the cost of holding the stock (termed "carrying the stock forward") from the present to the future date. This is called "the cost of carry."

As mentioned above, the storage and insurance costs of carrying stock is very low. However, a person who purchases stock gives up the rate of return he would have received if he invested in the next best available alternative. Economists call this foregone rate of return the opportunity cost of the investment; finance analysts call it the cost of capital. Both agree that it is equal to the market rate of interest (return) adjusted for the systematic risk associated with holding the particular stock.¹²

In order to focus on one thing at a time, suppose the stock that is being carried forward pays no dividends and that the cost of capital is 12.5 percent per year.¹³ Assume that it is now March 20, 1987 and the trader wants a forecast of the stock's forward price on June 19 — 91 days from now. If the spot price of the stock on March 20th is \$50, the foregone income that could be earned by investing the \$50 at 12.5 percent for three months is $\$50 (1.125)^{.25} - \$50 = \$1.49$; this is the cost of carry. The March 20th spot price plus the cost of carry is a forecast of the stock's forward price on June 19 (91 days from now). In this example, the forecast of the stock's price on June 19th is $\$51.49 (= \$50.00 + \$1.49)$.

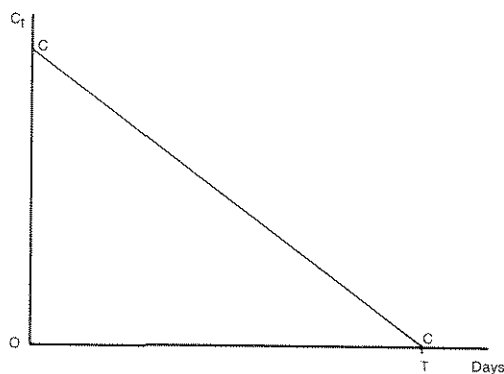
The Cost of Carry with Dividends

Computing the cost of carry is only slightly more complicated if the stock pays dividends. Suppose that the stock in the previous example is scheduled to pay a dividend of \$.50 on April 21, 1987. The dividend reduces the cost of carry by slightly more than \$.50 because the dividend paid on April 21 can be invested between April 21 and June 19. Consequently, the value of the dividend as of June 19 is slightly higher than \$.50.¹⁴ For the example considered, the cost of carry is $\$50 (1.125)^{.25} - \$.50 (1.125)^{.167} - \$50 = \$.98$. Notice that the dividend payment reduces both the cost of carry (from \$1.49 to \$.98) and the March 20th forecast of the stock's price on June 19th (from \$51.49 to \$50.98).

The Cost of Carry Is Lower for Nearby Delivery Dates

This discussion helps explain why the basis observed in table 2 is lower for futures contracts with nearby delivery dates. Because the holding period is shorter, the interest earnings foregone are less for nearby delivery dates. Similarly, as each contract approaches its delivery date, the cost of carrying the stock shrinks for the period remaining until delivery, other things the same; the cost of carry is zero on the delivery date. This is shown in figure 1. Figure 1 as-

Figure 1
The Cost of Carry



$$C_t = P_t(1+i)^{(T-t)} - D_{t+\alpha}(1+i)^{(T-t-\alpha)} - P_t$$

- Where: C_t = the cost of carry at t
- T = the delivery date
- i = the cost of capital
- P_t = the stock's spot price at t
- $D_{t+\alpha}$ = the expected dividend receipt α days from t

¹¹The discussion focuses on the Standard and Poor's index not only for convenience but also because the Standard and Poor's futures contract is the most widely traded; it accounts for about 75 percent of all trading in stock index futures. See, *Wall Street Journal* (March 2, 1987).

¹²See Brealey and Meyers (1984), p. 133. Systematic risk is given by β , which is a measurement of the sensitivity of the investment's return with respect to the market return. Roughly, β is the percentage change in the present value of the investment project divided by the percentage change in some market index of capital values such as the Standard and Poor's composite index *ibid.*, pp. 166-67. The cost of capital, i , is calculated as $i = \beta(i_m - i_f) + i_f$, where i_m and i_f are the market and risk free rates of return.

¹³See Cornell and French (1983), Modest and Sundaresan (1983) and Figlewski (1984) for a formal analysis of the cost of carry.

¹⁴This adjustment may seem trivial. When one is computing the basis for a stock portfolio that runs into the millions of dollars, as is the case for programmed trading, however, this adjustment can be very important. Notice that $.167 = 60/360$ where 60 is the number of days between the dividend receipt on April 21 and June 19.

sumes that the cost of capital (i) and the dividends (D) the stock is expected to pay are unchanged during the holding period.

The Cost of Carry Is Uncertain

Since expected dividends can change during the holding period, the cost of carry is not known with certainty. The only thing known with certainty is that the cost of carry will be zero on the day the futures contract is scheduled for delivery.

A change in the expected dividend will cause the line showing the cost of carry in figure 1 to rotate through the point labeled T. An increase in D causes the cost of carry to rotate downward, while a decrease in D causes the cost of carry to rotate upward.¹⁵

The Cost of Carry and the Basis

The expected cost of carry and the basis are closely related.¹⁶ To illustrate this for a simple case, suppose for a moment that the S&P Index contains only one share of stock. Suppose that the March 20th spot price of the share is \$50 (the level of the index is 50) and that

the expected cost of carry is \$1.50 per share for the next three months (from March 20th to June 19th). If the current price of the S&P Futures contract dated for June delivery is \$52.00, the \$2.00 basis (= \$52.00 - \$50.00) exceeds the \$1.50 expected cost of carry. The arbitrageur will sell (go short in) June futures at a price of \$52.00 per contract and buy (go long in) spot shares of the stock at \$50.00. He does this because he expects the price of the June futures to fall to \$51.50 (the spot price plus the expected cost of carry). At that price, he can cover his futures position (by purchasing a June futures) at a cost of \$51.50 per contract. His gain is \$.50 per contract — the difference between the sale price of the futures contract (\$52.00) and the cost of covering the contract (\$51.50).¹⁷

The arbitrageur's long, spot position serves to hedge his short, futures position against unexpected changes in the price of the stock. For example, suppose both the June futures price and the spot price rise by \$3.00 immediately after the arbitrageur sells the futures and buys the stock spot. The June futures price rises to \$55.00 per contract and the spot price increases to \$53.00 per share. After the price change, the basis (\$2.00 = \$55.00 - \$53.00) still exceeds the expected cost of carry (\$1.50) by \$.50 so the arbitrageur expects the price of the June futures to fall to \$54.50 per contract.¹⁸ At that price he will cover his short position at a loss of \$2.50 per contract (= \$52.00 - \$54.50). This loss, however, is more than offset by his \$3.00 per share gain (= \$53.00 - \$50.00) on his spot position. His net gain is \$.50 (= \$3.00 - \$2.50) — the same as in the previous case. By hedging in the spot market, the arbitrageur protects the expected gain from unexpected changes in the price of the stock.

On the other hand, suppose the price of the June futures is \$51.00. In this case, the \$1.00 basis (= \$51.00 - \$50.00) is less than the \$1.50 expected cost of carry. The arbitrageur will short the stock and go long in the June futures. The arbitrageur expects the price of the June futures to rise to \$51.50 per share. At that price, he will sell his June futures contract at a gain of \$.50 per contract (= \$51.50 - \$51.00). Again, his short spot position hedges his expected gain against unexpected changes in the price of the stock. Since virtually any-

¹⁵The cost of carry generally will vary with changes in the cost of capital, i . Whether a direct or indirect relationship exists, however, is problematic. To see this, let

$$(1) E(t)P(T) = F(t) = P(t)e^{(i-\delta)(T-t)}$$

$$(2) P(t) = \frac{E(t)\pi}{i}$$

$$(3) B(t) = F(t) - P(t).$$

where

$E(t)P(T)$ = The period t expectation of the forward price at T .

$F(t)$ = The futures price in period t of a contract dated for delivery at T .

$P(t)$ = The spot price in period t .

i = The cost of capital.

δ = The expected dividend rate.

$E(t)\pi$ = The period t expectation of the perpetual stream of profits (π) assumed to be of constant amount in each period.

$B(t)$ = The basis in period t .

Substitution gives

$$B(t) = \frac{E(t)\pi}{i} [e^{(i-\delta)(T-t)} - 1]$$

$$\frac{\partial B(t)}{\partial i} = -\frac{E(t)\pi}{i^2} [\quad] + \frac{E(t)\pi}{i} (T-t)e^{(i-\delta)(T-t)}$$

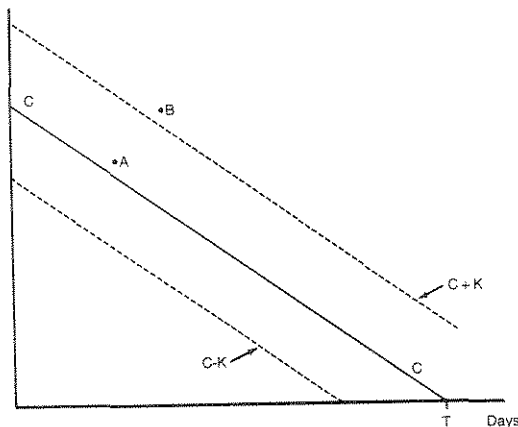
$$\frac{\partial B(t)}{\partial i} = P(t) \{ e^{(i-\delta)(T-t)} [(T-t) - 1/i] + 1/i \} > 0.$$

¹⁶See, for example, Cornell and French (1983), pp. 2-3. The example assumes that the equilibrium spot price is given so that the futures price adjusts to the cost of carry. In fact, spot and futures prices are determined simultaneously.

¹⁷The arbitrageur always has the alternative of holding the stock until the June delivery date of the futures contract at which time the stock is sold and the proceeds are used to settle the futures contract. Since the arbitrageurs' investment in the stock is expected to be \$51.50 per share as of the settlement date (= \$50.00 + \$1.50), expected profits are \$.50 per share.

¹⁸In fact, if the interest rate does not change, the expected cost of carry will rise slightly because of the higher spot price.

Figure 2
The Cost of Carry and Transaction Costs



- A profitable trading opportunity exists when:
- 1) The basis is greater than the cost of carry plus transaction cost $(C + K)$
 - 2) The basis is less than the cost of carry minus transaction cost $(C - K)$

Where:
 C = the cost of carry
 K = transaction cost

one can take advantage of these trading opportunities, large deviations of the basis from the cost of carry do not persist.

Small differences between the basis and cost of carry may persist, however, if the transactions cost of making the appropriate trades is greater than the expected gain. In terms of figure 1, transaction costs can be represented by bands around the line representing the cost of carry. This is shown in figure 2. The vertical distance between the solid line and the dashed lines represent the transaction cost. If the basis deviates from the cost of carry but remains within the bands (as represented by point A, for example), no profitable arbitrage trading is possible. If the basis moves outside the bands (to point B, for example), arbitrageurs will exploit the profitable trading opportunities caused by this large discrepancy. The trading will continue until the basis has been driven back within the bands.

TRADING STOCK INDEX FUTURES

The analysis discussed above is directly applicable to trading among the stocks that make up the S&P Index and the S&P Futures contract. Rather than one stock, however, the S&P Index represents a basket of 500 stocks. The S&P Index multiplied by \$500 is analo-

gous to the spot price of the stock in the previous discussion and the S&P Futures multiplied by \$500 minus the S&P Index multiplied by \$500 is the basis.¹⁹ In principle, the cost of carry is calculated the same way as for an individual stock. There are two important practical differences, however.

First, because the S&P Index represents a well-diversified basket of stocks, it typically is assumed that the risk of unanticipated changes in the value of this basket is roughly equal to the market's risk. Consequently, the cost of capital for the S&P Index is the market rate of return.²⁰

A second important practical difference is that the trader must track the dividend policies of 500 companies and the dates on which the shares trade ex-dividend in order to compute the cost of carry. These calculations must be made quickly and accurately because profitable trading opportunities that result from differences between the basis and cost of carry persist only for a short time.

Because both the monitoring and transaction costs increase with the number of companies included in the arbitrage portfolio, traders do not track all 500 stocks in the S&P Index. Instead, they identify a subset of the 500 stocks whose combined value has closely followed the value of the index in the past.²¹ Thus traders accept some additional risk because the values of their narrower portfolios are unlikely to move precisely with the S&P Index. The added risk is accepted to reduce the expense of tracking the cost of carry for the broader portfolio.

Of course, computer programs are another way to reduce the expense of calculating and continuously updating the cost of carry as new information becomes available. "Program trading" refers to computer programs that compute the cost of carry and signal profitable trading opportunities. Programmed trading is a less costly (more efficient) method of exploiting profitable trading opportunities between the spot and futures markets.

INDEX FUTURES AND THE VOLATILITY OF STOCK PRICES

Various commentators have alleged that trading between the stock index futures market and the spot

¹⁹Recall that the value of an S&P Futures contract is \$500 times the index. See table 1.

²⁰That is, β is assumed to equal 1 so that $i = \beta(i_m - i_f) + i_f = i_m$.

²¹See Schwarz, Hill and Schneeweis (1986), p. 91.

Table 3

A Comparison of Percentage Changes in the Standard and Poor's 500 Index Pre- and Post-April 1982

Panel A: Means and Standard Deviations of % Δ S&P 500 Index

Period	Pre-April 1982		Post-April 1982		Differences in Means	Ratio of Variances
	Mean	Standard Deviation	Mean	Standard Deviation		
Weekly ¹	.130	1.68	.306	1.74	.176	1.07
Daily ²	.004	.95	.069	.88	.065	1.17

Panel B: Means and Standard Deviations of % Δ S&P 500 Index: Settlement vs. Nonsettlement Days

Period	Settlement Days		Nonsettlement Days		Differences in Means	Ratio of Variances
	Mean	Standard Deviation	Mean	Standard Deviation		
Daily ³	.150	.97	.069	.88	.081	1.21

where: % Δ S&P 500 Index = $\Delta \ln(\text{S\&P 500 Index}) / 100$

¹The data begins on the first week of January 1975 and ends on the last week of December 1986; it excludes data from April 1982.

²The data begins on 1/2/80 and ends on 12/31/86; it excludes data from April 1982.

³The data begins on 5/1/82 and ends on 12/31/86.

*Statistically significant at the 5 percent level.

market for stocks has increased the volatility of stock prices. This criticism has a long history.²² Our analysis, however, does not imply that stock prices will exhibit greater volatility as a result of this trading. Rather, it suggests that such trading results in a closer correspondence between prices in the spot and futures markets. Since there is no reason to suspect, *a priori*, that this trading increases the volatility of prices in the spot market, we must rely on the data to help answer this question.²³

The following analysis addresses three key questions: 1) Has stock price variability increased since stock index futures began trading early in 1982? 2) Are stock prices more variable on days when futures contracts are scheduled for delivery (triple witching days)? 3) Is stock price variability related to trading activity in stock index futures?

²²See Working (1977), pp. 267-97.

²³*Ibid.*, p. 295.

Percentage Changes In the S&P 500: Pre- and Post-April 1982

The Standard and Poor's futures contract began trading on April 21, 1982. This is the most active contract and accounts for about 75 percent of all trading in stock index futures.²⁴

Table 3 compares the period before and after April 1982 using weekly and daily percentage changes in the Standard and Poor's 500 Index. Percentage differences are employed to control for the general increase in the level of the index from 1975 through 1986.²⁵

Panel A of table 3 examines the mean and standard deviation of weekly and daily percentage changes in

²⁴See, *Wall Street Journal* (March 2, 1987).

²⁵The index rose from an average level of 86.18 in 1975 to an average level of 236.34 in 1986. A one-point change in the index represented a much larger percentage change in 1975 (about 1.2 percent) than a one-point change in 1986 (about .4 percent).

the index. As indicated, the mean of the weekly percentage change in the index prior to April 1982 was .130 percent. After April 1982, the mean rose to .306 percent, an increase of .176 percentage points in the later period. In the case of the daily data, the mean of the daily percentage change increased by .065 percentage points in the later period. Neither increase is statistically significant at conventional confidence levels (t-scores are 1.30 and 1.39, respectively). The differences in the means before and after April 1982 could easily have been produced by chance variation in the data.

Comparing the means, however, masks much of the *variation* in the data, because increases in the index are offset by decreases when the mean is computed. The standard deviation is a better indicator of variation because it measures the spread in the data around the mean.²⁶ For example, the standard deviation of the weekly data before April 1982 is 1.68. If these percentage changes in the index are normally distributed, about 67 percent of the weekly observations fall within the range of $.13 \pm 1.68$ (or -1.56 percent to 1.80 percent). The standard deviation of the weekly data after April 1982 is 1.74 which is about the same as for the earlier period. In fact, the two are not significantly different in a statistical sense (the ratio of the variances = 1.07). A similar conclusion holds for the daily data. In this case, the standard deviation is somewhat smaller in the more recent period, but is not significantly smaller in a statistical sense.²⁷

Panel B of table 3 compares variation in the index on days when S&P 500 Futures contracts mature (settlement days) to variation on all other days (nonsettlement days) for the post-April-1982 period. In the case of settlement days, the data are percentage changes in the S&P 500 Index from the close on the day before a settlement day to the close on the settlement day. For nonsettlement days, the data are percentage changes in the daily closing value of the index excluding the changes on settlements days. As indicated in panel B, the mean percentage change is larger on settlement than on nonsettlement days; but the difference between the two is not statistically significant at conventional confidence levels (t-score = .36). Similarly, the

standard deviation is larger on settlement days (.97 vs. .88), but is not significantly larger in a statistical sense (the ratio of the variances = 1.21). Thus, the data in table 3 suggest that the share prices of companies included in the S&P Index did not become statistically more variable on average after the S&P Futures contract began trading nor were they more variable on settlement (triple witching) days.

Intra-Day Variation: Pre- and Post-April 1982

The above data measures price variation from day-to-day. Some commentators have expressed concern about intra-day movements in stock prices. The data in panel A of table 4 examine one measure of the intra-day price spread in the S&P Index for pre- and post-April 1982 data: the difference between the daily high and low of the index divided by the close and multiplied by 100.²⁸

Panel A indicates that the mean intra-day spread was 2.03 percent before April 1982 and 1.38 percent after. The difference, $-.65$ percent, is statistically significant (t-score = 17.29) and indicates that the intra-day percentage spread declined after April 1982.

Panel B examines whether the post-April 1982 intra-day price spreads have been unusually large on triple witching days.²⁹ The data indicates that the mean intra-day percentage spread is slightly larger on triple witching days than on nonsettlement days (1.56 vs. 1.38); the difference, however, is not statistically significant at conventional confidence levels (using the pooled variances, the t-score = 1.48).

To summarize, the data in table 4 indicate that there was a statistically significant decline in the intra-day percentage price spread in the post-April 1982 period. There was no statistically discernible difference, however, between the spreads on triple witching days vs. other post-April-1982 trading days.

Price Variation and Trading Activity in S&P Futures

The data in table 5 help assess whether stock price variability is related to trading activity in S&P Futures contracts. The data are correlation coefficients for daily trading volume in S&P Futures contracts (V) and

²⁶See Wonnacott and Wonnacott (1977), pp. 24–25.

²⁷In addition, both the mean absolute deviation (MAD) and mean absolute value (MAV) of the weekly and daily percentage changes in the index were examined for the two periods. Like the standard deviation, these measure variation and, for this data, each measure tells a similar story. As in the case of the standard deviation, both the MAD and MAV are slightly higher for the weekly data (about 2 percent higher) and slightly lower for daily data (about 11 percent lower) in the post-April 1982 period.

²⁸Scaling the difference between the high and low by the daily low rather than the close produces virtually identical results.

²⁹See, for example, Stoller, and Laderman and Frank (September 29, 1986), pp. 96–97.

Table 4
A Comparison of Intra-Day Price Spreads

Panel A: Means Pre- and Post-April 1982

	Pre-April 1982	Post-April 1982	Differences in Means
	Mean	Mean	
Intra-Day Price Spread ¹	2.03	1.38	-.65*

Panel B: Means on Settlement and Nonsettlement Days: Post-April 1982

	Settlement Days	Nonsettlement Days	Differences in Means
	Mean	Mean	
Intra-Day Price Spread ²	1.56	1.38	.18

$$\text{Intra-Day Price Spread} = [(H-L)/C]100$$

where: H = the daily high of the S&P Index
 L = the daily low of the S&P Index
 C = the daily close of the S&P Index

¹The data begins on 1/2/80 and ends on 12/31/86; it excludes data from April 1982.

²The data begins on 5/1/82 and ends on 12/31/86.

*Statistically significant at the 5 percent level.

several measures of price variation in the S&P Index: the daily percentage change in the S&P Index (\dot{P}), the absolute value of the daily percentage change in the S&P Index ($A\dot{P}$) and the intra-day percentage price spread (S). Respectively, these correlations indicate whether the volume of trades in S&P Futures generally is associated with an increase or decrease in the S&P Index, larger or smaller changes (either up or down) in the S&P Index, and larger or smaller intra-day price spreads.

An examination of table 5 indicates that the coefficient of correlation for V and \dot{P} is not significantly different from zero in a statistical sense. The same holds in the case of V and $A\dot{P}$. This data suggests that neither the direction nor the magnitude of changes in the S&P Index are associated with trading volume in the S&P Futures market. The coefficient of correlation for V and S, however, is negative and significantly different from zero in a statistical sense; larger trading volume in S&P Futures contracts generally was associated with smaller intra-day price spreads. The table 5 data are not consistent with the claim that trading activity in S&P Futures was associated with increased variation in the S&P Index.

CONCLUSION

Numerous commentators have claimed that stock prices have been more variable since stock index futures contracts began trading. The alleged increase in volatility led to both closer scrutiny of the market by the Securities and Exchange Commission and calls for legislative action. The presumed increase in stock price volatility has been attributed to programmed trading — the practice of trading between the spot and futures markets for stocks. While this trading strategy is not new, the introduction of stock index futures contracts around 1982 and the application of computer programming techniques to trigger trades between the markets are novel.

This paper discusses the theory that underlies programmed trading and examines various measures of stock price variation. The results of the analysis are *not* consistent with the claim that trading activity in the S&P Futures contract is associated with increased price variation in the spot market for stocks.

While closer scrutiny and regulation of trading in stock index futures markets may be justified on other grounds, the evidence presented here suggests that

Table 5
Correlations Between Volume and Measures of Variation in the S&P Index (Daily data: May 1982–December 1986)

	Daily Volume ¹
Percentage Change in the S&P Index	-.006
Absolute Value of the Percentage Change in the S&P Index	.049
The Intra-Day Price Spread	-.286*

¹Total daily volume for all delivery months.

*Statistically significant at the 5 percent level.

regulation based on the proposition that it has increased price volatility in the spot market would be misdirected.

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