The Effect of the "Triple Witching Hour" on Stock Market Volatility

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This paper investigates the "Triple Witching Hour"—the four times during the year when stock options, stock index options, and stock index futures simultaneously expire—to determine whether these periods are characterized by excessive volatility in the stock market.

The term "triple witching hour" can conjure up images of broomsticks and brew, perhaps the scene from Shakespeare's *Macbeth* in which a trio of witches recite incantations around a boiling cauldron. For stock traders, though, the term represents something far more frightening. To them the "triple witching hour" refers to the four times each year when stock index futures, stock index options, and options on individual stocks expire simultaneously. Typically on triple witching hour days, large blocks of stock change hands as hedgers, arbitrageurs, and speculators seek to maximize returns or minimize losses as they settle the contracts entered into previously.

Analysts have alleged that the triple witching hour is a time of great volatility and wide price swings in the stock market. In mid-1987 the Chicago Mercantile Exchange and the New York Futures Exchange were so moved by the concern over triple witching hour volatility that they changed the rules governing the expiration of index futures and options. Trading in most index futures contracts and some index options now ends one day earlier, with expiration effectively taking place at the open of trading on the expiration day instead of at the close. The impact of triple witching hours and expiration days in general, though, extends far beyond the matter of whether the pattern of stock trading is atypical on certain days of the year. Of interest also is the fact that many of the new features that distinguish modern financial markets from markets of the past are integral to the triple witching hour phenomenon. These new features include futures and options trading, computerized trading, program trading of large blocks of stocks, and index arbitrage. Examination of triple witching hour days offers the opportunity to explore the impact of these innovations.

By looking at triple witching hour days in general, some insight can also be gained into fundamental questions about financial markets. To what extent does the mechanism of exchange—the market itself—affect asset prices? Are stocks rendered riskier merely by the existence of option contracts that are, in effect, "side bets" on stock performance? Why should the popularity of financial instruments that simply reallocate claims on firms' earnings change the inherent risk profile of the market itself?

Information about triple witching hour days can also be used to test widely held views about financial asset prices. For example, the efficient market hypothesis holds that stock prices continuously reflect all available information and that prices change only when new information

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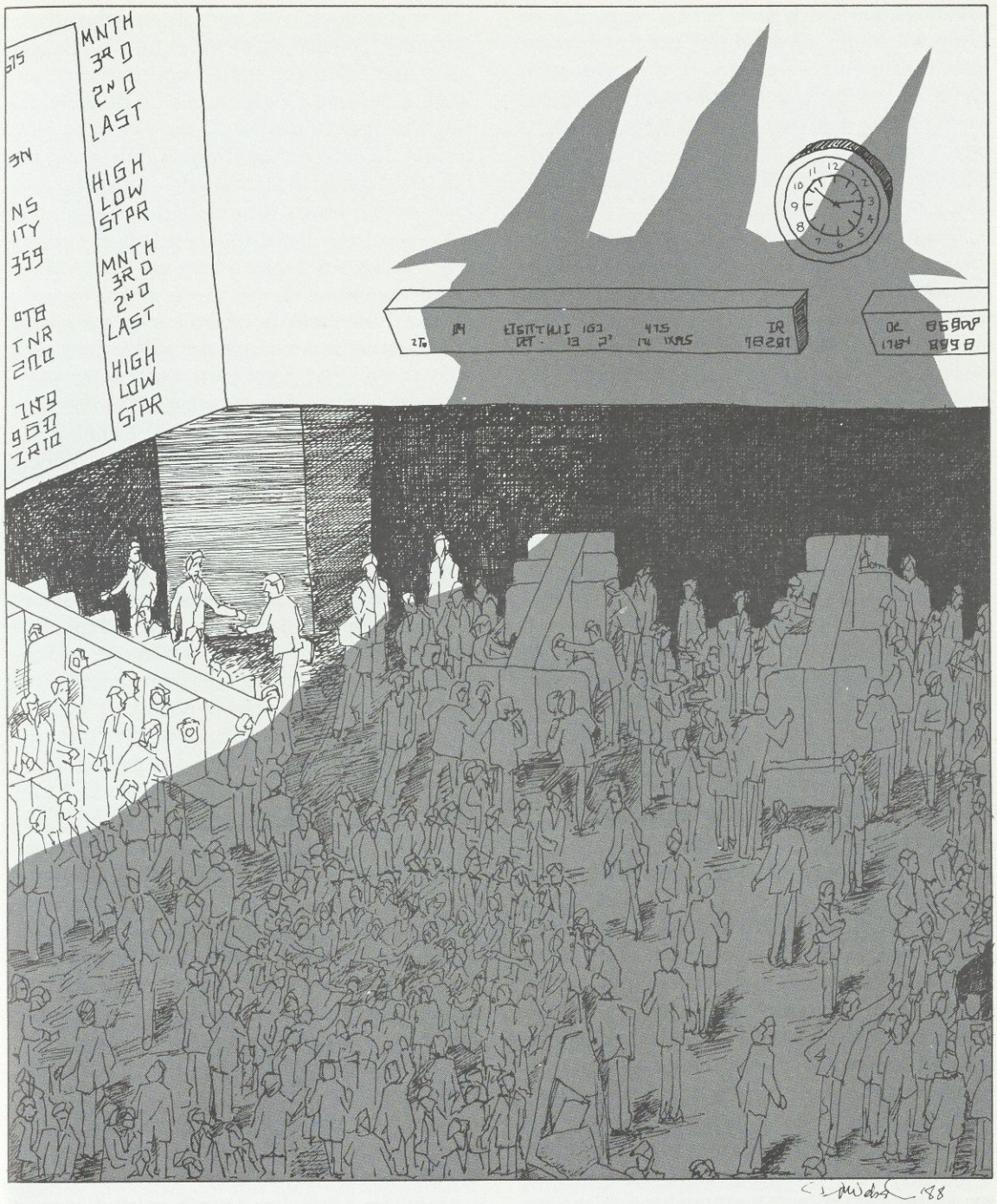


becomes available. Thus, when stock prices swing sharply, analysts must wonder if certain information is driving the movement or whether the mechanism of trade itself is precipitating the price swing.

Yet another branch of theory—option and futures pricing—hinges on the notion that these derivative instruments are "redundant." That is, an investment in options or futures can be perfectly mimicked with investment strategies involving only stocks and bonds. If in fact futures and options are redundant investment vehicles and markets had previously been efficient, the price behavior of stocks should be the same now as before the advent of the new markets. Consequently, price behavior across triple

witching hour days should not be unusual since triple witching hours did not exist before the new instruments were created. If, on the other hand, prices do behave differently on triple witching hour days than on other days, either the new assets are not truly redundant, markets previously were not efficient, or markets currently are not efficient.

This article reviews the current research into the triple witching hour phenomenon and investigates whether the market really is more volatile on triple witching hour days. This research also presents preliminary results of the effect of the new settlement procedures on market volatility.

The New Financial Instruments

Stock Index Futures and Index Arbitrage. In order to understand triple witching hour day activity, one should understand the mechanics of stock index futures and options. Stock index futures first traded in 1982. They originated on the same midwestern exchanges that traditionally traded commodity futures and options, and in many ways are similar to their agricultural precursors (see box on page 5).[1] Like a futures contract on coffee or corn, a stock index futures contract will return profits when the price of the underlying asset rises and create losses when the asset price falls.

A stock index futures contract is an instrument that allows an investor to participate in the stock market without ever actually purchasing stocks. Moreover, stock index futures enable investment in large diversified portfolios through a single transaction rather than the numerous transactions that are required to form a diversified stock portfolio. In this way, the investor can save substantially in commission expenses. Although stock index futures are derivative instruments, that is, instruments whose prices are contingent on the values of other assets, the daily transaction volume measured in dollars for stock index futures now exceeds that of actual stocks.[2]

The market for stock index futures created the opportunity for a new type of investment strategy, index arbitrage, which involves exploiting the difference between the value of an underlying stock index portfolio and the price of the corresponding stock index future. Theoretically that difference should never become very large. If, however, a gap opens up between the two, the opportunity for a nearly riskless profit results. To execute the strategy, one would buy the less expensive instrument—either the portfolio or the index future—and sell the more expensive one. If the future is less expensive, one should buy ("take a long position in") the future and sell ("short") the portfolio of actual stocks. If the stock portfolio is less expensive, arbitrage calls for a purchase of the stock portfolio and a short position in the future. (Commissions and the cost of borrowing the necessary funds must also be considered.) Either action ensures a certain profit because the two prices must converge by the time of expiration.

For example, suppose the Standard and Poor's (S&P) 500 index futures price were $300, but the actual Standard and Poor's 500 stock portfolio could be purchased for $250. Seeing this discrepancy, an arbitrageur would calculate whether the gap between the future and the spot prices were enough to cover commissions and the costs of borrowing necessary funds. If indeed the gap were large enough, the arbitrageur could buy the actual stocks and take a short position in the futures. If the price of the actual stocks fell by the expiration date, a loss would be incurred on the actual stock investment, but the profit on the futures investment would more than offset that loss. Suppose, on the other hand, stock prices rose. In that case money would be lost on the short futures position, but even more would be realized from the change in the price of the actual stocks. Again the investor would reap a guaranteed profit. No matter what happens to the price of stocks, the arbitrageur benefits.[3]

Eventually, the arbitrageur must "unwind" his position, that is, sell the stock portfolio and exit the futures contract. In order to retain the arbitrage revenue and clear a profit, unwinding must take place when the two prices are the same or closer together than when the arbitrage strategy was initiated. Convergence may occur before the contract expiration but must certainly occur at expiration—at the witching hour.

Unwinding must be done quickly so that the arbitrageur is not left holding only one risky part of the arbitrage portfolio without the offsetting

A Comparison of Commodity Futures and Stock Index Futures

A commodity future is a contract that obligates an agent either to buy or sell a given quantity of a commodity at a prespecified price on a certain date. For example, taking a "long" position in a coffee futures contract obligates the agent to buy a certain large quantity of coffee (37,500 pounds) when the contract expires. The party taking the "short" position is obligated to sell the commodity. The price is determined via bidding at the time the contract is initiated and is referred to as the *futures price*. Taking a long position in a coffee futures contract is very similar to buying coffee outright, except delivery and payment are postponed until the contract's expiration. Since the contract conveys ownership of coffee, albeit deferred, coffee futures prices should be strongly related to the current price of coffee (also known as the *spot price* or cash price of coffee). Moreover, as the expiration date approaches, owning coffee and "owning" a coffee futures contract become nearly the same thing, and so the spot price of coffee and the coffee futures price converge. At expiration, buying a coffee futures contract is the same as buying actual coffee; the futures price must equal the spot price at that time.

One might think of a stock index futures contract as a contract that obligates an agent either to buy or sell a large portfolio of stocks at a prespecified price upon expiration of the contract. This simplification helps one to understand what determines stock index futures prices and what causes those prices to change. If this simplification were accurate, a stock index future would be just like a coffee futures contract, with the exception that stocks would be bought and sold instead of coffee. In reality, though, stock futures differ from commodity futures in that a stock portfolio is never actually delivered. When the contract expires, the agents exchange money—that is, the contract "cash settles." If the spot price has risen on net during the life of the contract so that the spot price upon expiration is greater than the original futures price, the "short" party pays the "long" party the difference in cash.

For example, suppose you took a long position in a stock index futures contract when the futures price was $100. If, by expiration, the value of the underlying stock portfolio had risen to $120 you would receive cash payments totaling $20—the difference between $100 and $120—over the life of the contract. You would have made money because the stock index value rose above the level the futures price had been when you entered into the futures contract. The cash settlement is not made all at once at expiration, however. Rather, it is made in part at the end of each trading day on the basis of the change that transpired that day in the futures price. On the expiration day you receive or pay only the difference between the futures price from the previous day and the spot price at expiration. Thus, in the example in which the original futures price was $100 and the expiration spot price was $120, the long party would receive payments each day as the futures price rose and perhaps have to make payments to the short party on those days when the futures price fell. Over the life of the contract, though, the net transfer would total $20 paid by the short party to the long party.

half. To accomplish the speedy dispensing of their stock holdings, arbitrageurs often employ the Designated Order Turnaround system of the New York Stock Exchange, a computerized stock order routing system. Alternatively, arbitrageurs may place orders with exchange specialists to execute the orders at the moment the futures contract expires. In either case, index arbitrage requires large volumes of stock to be bought and sold quickly, with many of these transactions occurring on triple witching hour days.

Stock Options. If the unwinding of index arbitrage positions were the only unusual activity taking place on certain days, those days might be called witching hour days, not *triple* witching hour days. Yet stock options and stock index options expire on those days as well, which may generate additional volume. The owner of a stock option has the right, but not the obligation, to buy or sell a certain stock by a specified time and at a particular price. (See box on page 6 for a brief explanation of options.) The following possible scenario illustrates how option expirations can lead to increased stock trading activity.

A call option owner (someone who has bought the right to purchase a certain stock) exercises the option and demands that the option "writer" (the party who sold the option) sell a share of stock. The writer first buys the stock at the stock exchange and then, to fulfill the contractual agreement, sells it to the option owner at the

Options Demystified

An option is a contract that affords the buyer the right, but not the obligation, to buy or sell an asset for a prespecified price on or before some selected date. The prespecified price, which is written into the option contract, is called the *strike price* or *exercise price.* The selected date is the *expiration date,* the last date on which the option owner can choose to buy or sell the underlying asset. The option owner can choose not to exercise the option and thus forfeit the right to buy or sell the underlying asset. In that case the option expires unexercised.

The two types of options are call options and put options. *Call options* confer the right to buy assets; *put options* confer the right to sell. One can think of a call option as a deposit. Suppose a college fraternity is planning a party for the next homecoming. To assure an ample supply of root beer for its party, the fraternity members may wish to place a deposit at the local grocery store reserving the right to buy a crate of root beer for a given price on the day of the party. Here, the fraternity is buying an option, and the grocery store is writing the option. The underlying asset is the crate of root beer, and the cash amount to be paid upon delivery of the root beer is the strike price. The amount of money paid in advance to the grocery store is the option price. Should the fraternity members decide they do not want the root beer, they may wish to surrender the deposit, not buy the root beer, and let the option expire unexercised.

Suppose on the other hand that the price of root beer increases dramatically before the day of the party. Maybe an explosion disables the local bottling plant or a root beer tasters' convention is scheduled for the same day as the party. The agreement with the grocery store would thus become more valuable. The grocery store is bound to sell the root beer to the fraternity for the previously agreed-upon price even though the spot price of root beer has risen in the interim. The fraternity members may exercise the option, buy the root beer at the strike price, and thus enjoy their assets at a bargain price. Alternatively, they may choose to exercise the option, buy the root beer at the strike price, then sell the root beer on the open market for the new higher spot price and retain the profit.

Stock call options are very much like the root beer deposit in this example. The call option buyer has the right but not the obligation to buy a certain stock for the strike price before or on the expiration date. If the market price of the underlying stock rises above the strike price, the option owner can exercise the option, buying the stock for the strike price, and then sell the stock for the higher current market price. The seller of the option must have the necessary shares of stocks to sell to the option buyer. If he does not, he must first buy those shares.

strike price. The option owner then resells the stock to capture profit from the difference between the price stated in the option contract and the current market price. The option's expiration date is the deadline for these maneuvers. Consequently, the existence of stock call options may generate increased trading activity on those days.

A scenario involving stock put options may yield similar activity. The owner of a put option has the right to sell shares of stock at a previously agreed-upon price. If the stock price falls below the strike price, exercise of the option is profitable. If the put owner wishes to exercise the option on an expiration day but does not already own the necessary shares of stock, he must first buy the shares at the market price. He then can sell them for the higher strike price to the party that sold the put and pocket the profit. The put writer might then wish to close out his position and sell the newly acquired stock. Again, one earlier option transaction might, upon expiration, generate three separate stock transactions.

Options on individual stocks have been traded on U.S. exchanges since 1973. Stock options may follow different quarterly schedules, but in general they expire on the third Friday of the month. Four times a year this day coincides with the expiration of index futures and index options.

Stock Index Options. The third aspect of the triple witching hour involves the expiration of stock index options. Since their introduction in 1983, stock index options have made it possible to buy or sell options on entire stock indexes in addition to options on individual stocks. Stock index put options have proved attractive to hedgers who own large portfolios that are likely to rise and fall in value in concert with the market as a whole. By purchasing a stock index

put option, investors can protect against losses caused by a market-wide decline.[4] Index options are also popular among speculators who wish to profit from the vicissitudes of the stock market as a whole. By investing in stock index options rather than individual stock options, speculators and hedgers need not be concerned with the idiosyncratic risks associated with individual stocks since the value of a stock index option is based on the value of a large, diversified portfolio.

Unlike options on individual stocks, stock index options settle in cash. No stocks change hands when stock index options are exercised. The exercising party simply receives a cash payment from the option writer equal to the difference between the strike price and the current market value of the underlying index. Although exercisers of index options need not actually sell or buy stocks, such exercise might provoke the option writer, instead, to execute a stock transaction. An option writer is responsible for the difference between the current stock index value and the option strike price. If the stock market has gained or lost much value since the writing of the option, payment by the option writer can be substantial.

Call option writers often hold the underlying stocks in their portfolios so that, should the option be exercised, they can sell the stocks on the exchange in order to raise the funds needed to pay the call option owner.[5] At expiration one can expect any in-the-money options (options for which immediate exercise is profitable) to be exercised, sending some option writers scrambling to cover their positions, thereby promoting heavy stock trading on expiration days.

Stock Volatility Effect

The previous section of this article reviewed how stock index futures, stock options, and stock index options might bring about frenetic equity trading on days when each of these instruments expires. This increased trading activity could in turn exacerbate price volatility. A temporary mismatch between buy and sell orders will either send the price up or down as the price equilibrates supply and demand pressures. Only a small price change is necessary to close a slight gap between buy and sell orders, but a large price change may be necessary when the gap is wide. When trade orders suddenly flood the exchange, large gaps are more likely, and thus large price swings are more likely to occur. On triple witching hour days the full expiration effects of stock options, stock index options, and stock index futures bear on the markets at the same time. This simultaneity provides one reason to expect higher volatility on those days. Of course, even if triple witching hour days are more volatile than other days, other reasons for the phenomenon could exist.

Reviewing the Evidence. Notwithstanding the theoretical reasons for triple witching hour day volatility and the belief by market participants and business journalists that this volatility exists, the phenomenon is ultimately an empirical question and one that warrants close scrutiny of the facts. Several academic studies have addressed the volatility of the triple witching hour days. Some researchers have investigated component parts of the triple witching hour phenomenon, such as the effects of large transactions on prices, while others have probed the impact that the stock index futures market has had on underlying stock price movements.[6]

Among the recent research directly investigating triple witching hour days, the paper by Hans Stoll and Robert E. Whaley (1986a) is the most comprehensive. They looked for evidence of unusual volume and price effects on and around expiration days. Testing the period from May 1982 through December 1985, the researchers failed to find that stock index future expiration days exhibited higher volatility than nonexpiration days.[7] They did conclude, however, that from July 1983 through December 1985, the last hour of trading on triple witching hour days was a frenetic one, exhibiting far greater volume and volatility than the last hour of trading on nonexpiration days.

Stoll and Whaley's results were corroborated in a study by Franklin R. Edwards (1988). Edwards compared hour-by-hour price fluctuations on triple witching hour days with hour-by-hour fluctuations from nonexpiration days during the period from July 1983 through October 1986. Edwards too found that price volatility was significantly greater in the last hour of triple witching days than on ordinary days.

Stoll and Whaley, as well as Edwards, arrived at their conclusions based on the statistical procedure known as an *F-test*, which compares stock prices in one sample with those from another sample. Based on assumptions of certain properties regarding the distribution of stock returns in both samples, the test determines the likelihood that stock prices were equally volatile in the two samples. One troubling feature of the F-test, however, is that it assumes that stock returns are normally distributed; that is, when plotted on a graph, the distribution would resemble a bell curve. However, an abundance of evidence shows that stock returns are not normally distributed but instead are characterized by sporadic extreme observations, either occasional huge losses or huge gains.[8] The recent stock market crash of October 1987 is a graphic reminder that the distribution of stock returns does not conform to a normal distribution. Consequently, the F-test, whose results are easily distorted by extreme occurrences, is not reliable for drawing inferences about underlying stock return distributions and thus for identifying trends that are likely to persist in the future.[9]

Market Volatility and the Triple Witching Hour: A New Perspective

The primary objective of the research presented in this article is to determine if the triple witching hour days in the period before 1987 were, in fact, characterized by unusually high volatility. Unlike past research, this effort uses a statistical procedure that does not require the assumption of normally distributed stock returns. Furthermore, the research presented here benefited from several more triple witching hour days than were available for earlier studies.

This article also includes an examination of the first five triple witching hour days since the 1987 rule change. A study of this data can help determine whether the new expiration procedures succeeded in reducing triple witching hour day volatility.

The tests used are distribution-free statistical tests, that is, they do not rely on the assumption of normally distributed stock returns. The test works as follows: if triple witching hour days are not unusual with regard to volatility, then any given triple witching hour day will just as likely fall in the top half as in the lower half of all days ranked according to volatility. This implication of the hypothesis is tested by ranking all days in the sample by volatility and simply counting how many triple witching hour days ranked in the top 50 percent and how many ranked in the bottom 50 percent. From the results of this tabulation, one can determine whether the hypothesis about equal volatility and the triple witching hour effect is reasonable.

The Data. This research examines the daily returns of the S&P 500 index from January 1983 through June 1988, the period over which stock index futures and index options have been traded. The returns are calculated as daily percent changes in closing prices. The volatility measure used was the absolute value of the daily stock return, which reflects the magnitude of each day's price swing.[10]

"If triple witching hour days are not unusual with regard to volatility, then any given triple witching hour day will just as likely fall in the top half as in the lower half of all days ranked according to volatility."

Prior to June 1984, stock index futures and stock index options expired on the third Thursday of the final month of the quarter. Consequently, the first five expiration days in the sample used here are Thursdays. Since that time all triple witching hour days have been the third Friday of the final month of the quarter.

Before June 1987, the close of trading on the expiration day marked the end of trading in and expiration of stock index futures and stock index options. Since then, with the change in rules, trading in most index futures contracts and some index options ends on the Thursday before the third Friday, but settlement and expiration take place on the next day.[11] The set-

tlement price for the index futures and options is a composite of the opening prices of the individual stocks in the index. In effect, the contracts governed by the new rule now expire at the opening of trading on Friday rather than at the close.

According to the Chicago Mercantile Exchange, the rationale for changing the expiration of stock index futures and options on stock index futures from the close of trading on Friday to the open was as follows: whereas arbitrageurs would previously unwind positions using market-on-close orders—to time their stock transactions exactly with the expiration of the futures or options—now they must place market-on-open orders. Although a specialist cannot delay the close of trading, he may delay the opening of trading in a particular stock if he observes a large imbalance between buy and sell market-on-open orders. With this extra time he can find parties willing to absorb some of the surplus orders. Thus, large price swings might no longer be necessary to equilibrate temporary surges in supply or demand.

"The two tests run on the 1983-87 data set clearly rejected the hypothesis that expiration days were equally likely to have above- as below-median price swings."

Also, because trading in options and futures now stops on the Thursday prior to expiration, some market participants may choose to unwind their positions on a day when they can still buy and sell futures or options. Therefore, the new expiration rules might have the effect of spreading both volume and volatility over two days, whereas they used to be concentrated on one.

Design of the Tests. This study tests first for higher-than-usual volatility of the S&P 500 on the expiration days between January 1983 and May 1987. The test is based on a comparison of the price swings on those days with the median price swing from all other days in the January 1983 to May 1987 sample.[12] Most of the expiration days in this sample, however, occurred on Fridays, and, as documented in Kenneth R. French's (1980) research, the day of the week bears on stock price behavior. Therefore, these expiration days were then compared specifically to the other Fridays in the sample. These two tests yield similar results.

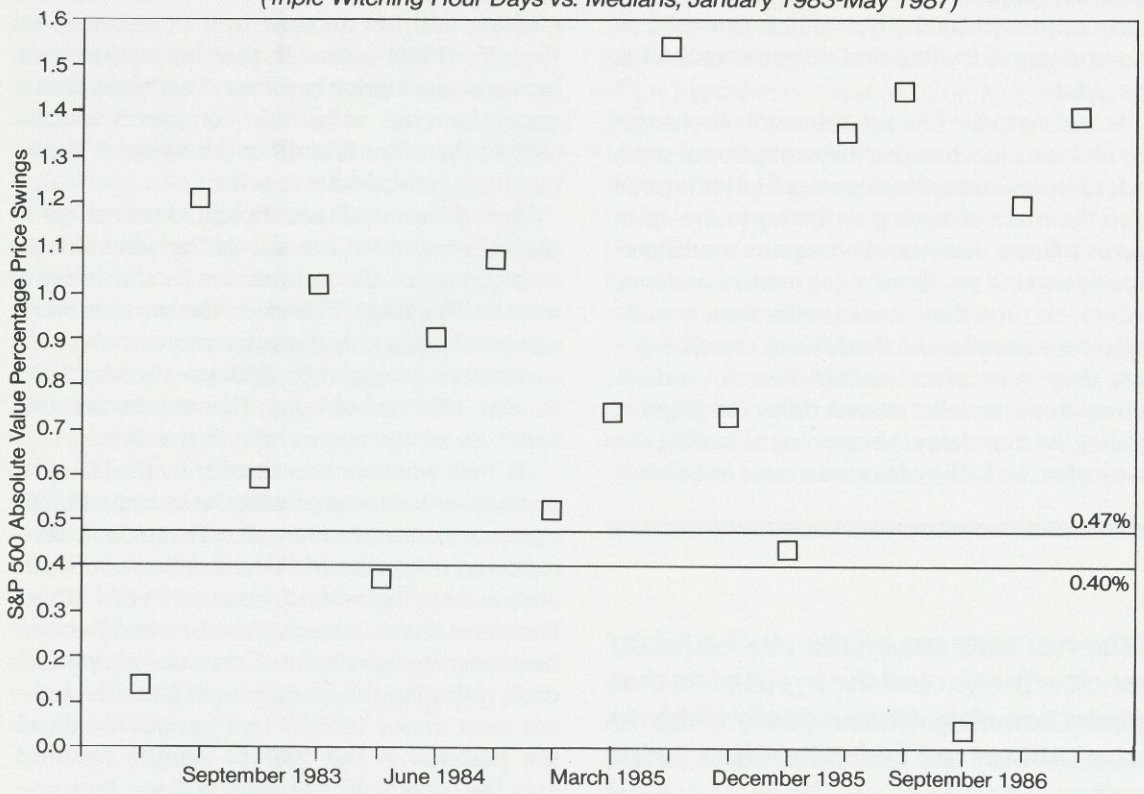
Even the second test, though, does not completely control for the day-of-the-week effect, since some of the expirations in the sample were on Thursdays. Therefore, the two tests were repeated using only the subsample in which all expirations occurred on Fridays—the May 1984 to May 1987 subsample. The results are the same, as will be shown later in this article.

To test whether the results in the sample period were associated with the introduction of options on index futures, all of these tests were repeated using data from the four years immediately prior to their introduction, 1979-82.[13] Third Fridays in March, June, September, and December were designated as "pseudo-expiration" days, following the same rule in force throughout most of our 1983-87 test period. If indeed the patterns in the 1983-87 sample resulted from the introduction of index options, then one would expect to find no similar pattern in the 1979-82 period.

In the period since the 1987 rule change, the triple witching hour is in effect spread out over two days, a Thursday and the following Friday. If a volatility effect is present, it may be on one day or the other, or perhaps spread out over the two days. Consequently, for this recent sample, expiration Fridays were compared to all other Fridays, expiration Thursdays were compared to all other Thursdays, and the two-day price swings that transpired over expiration Thursday-Friday clusters were compared to those price swings that transpired over all other Thursday-Friday clusters.

Results. The two tests run on the 1983-87 data set clearly rejected the hypothesis that expiration days were equally likely to have above- as below-median price swings. These results are presented in Table 1. Chart 1 shows the price swings for each of the 17 expiration days during those years; the median price swing for all other days and the median price swing for all other Fridays are represented by the top and bottom

Chart 1.
S&P 500 Daily Percentage Price Swings
(Triple Witching Hour Days vs. Medians, January 1983-May 1987)



The horizontal lines represent median price swings for the period January 1983-May 1987. The top line shows the median for all days during this period; the bottom line shows the median for Fridays. A box above the median represents a greater-than-usual price swing for that triple witching hour day. A box below the median indicates a lower-than-usual price swing for that day. A box between the medians for the different samples represents a lower-than-usual price swing relative to all days in the sample but a greater-than-usual price swing for Fridays during the sample period. Thus, this chart shows that on triple witching hour days between March 1983 and March 1987, price swings in the S&P 500 index were typically greater than on Fridays and on all days in general.

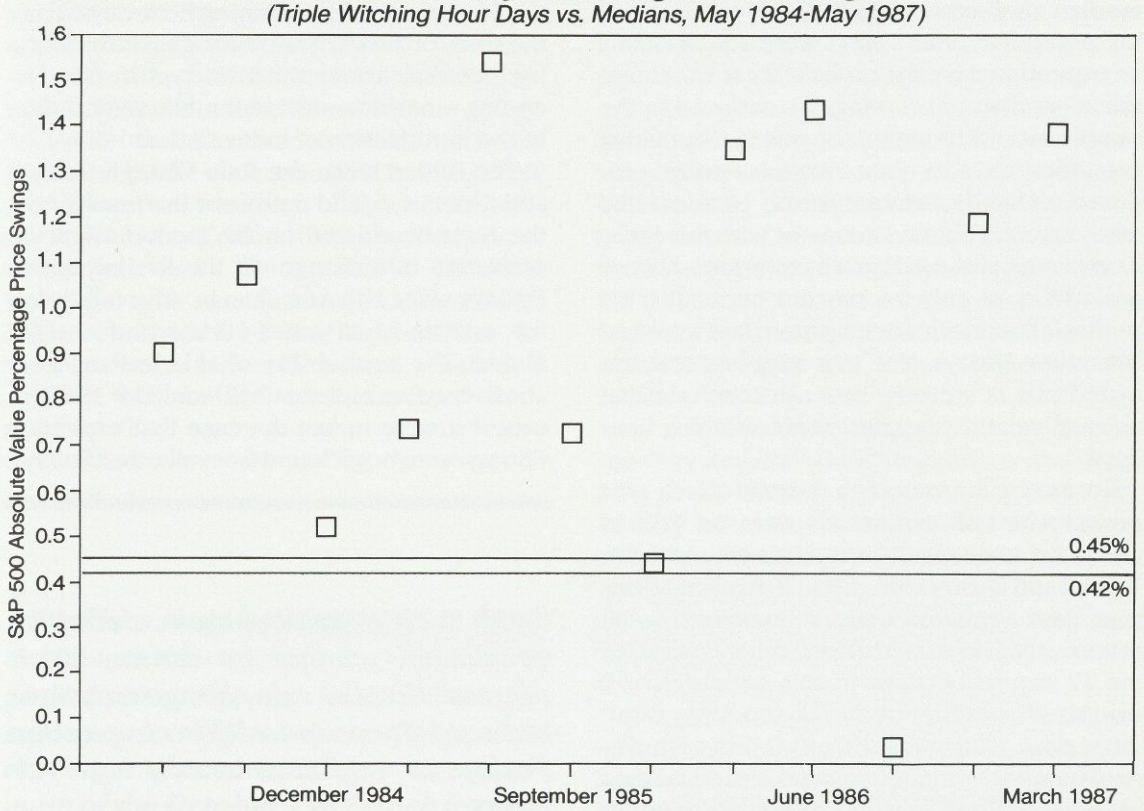
Table 1.
Test of S&P 500 Index Volatility on Triple Witching Hour Days
(January 1983-May 1987)

Test	Sample Size	Below-Median Price Swings	Above-Median Price Swings	Probability* (Percent)
Expiration days vs. all other days	17	4	13	2.5
Expiration days vs. nonexpiration Fridays	17	3	14	0.6

**Probability of the occurrence of at least the indicated number of above-median price swings under the assumption that expiration days are as likely to exhibit above- as below-median price swings.*

Source: Figures in all tables and charts were calculated at the Federal Reserve Bank of Atlanta from data obtained from Data Resources, Inc., Lexington, Mass.

Chart 2.
S&P 500 Daily Percentage Price Swings
(Triple Witching Hour Days vs. Medians, May 1984-May 1987)



The horizontal lines represent median price swings for the period May 1984-May 1987. The top line shows the median for all days during this period; the bottom line shows the median for Fridays. This chart demonstrates that even after controlling for a "day-of- the-week" effect, the daily percentage price swings on triple witching hour days were greater than usual for other days in the period May 1984-May 1987.

Table 2.
Test of S&P 500 Index Volatility on Triple Witching Hour Days
(May 1984-May 1987)

Test	Sample Size	Below-Median Price Swings	Above-Median Price Swings	Probability* (Percent)
Expiration days vs. all other days	12	2	10	1.9
Expiration days vs. nonexpiration Fridays	12	1	11	0.3

**Probability of the occurrence of at least the indicated number of above-median price swings under the assumption that expiration days are as likely to exhibit above- as below-median price swings.*

horizontal lines, respectively. Thirteen of the 17 expiration days had price swings above the median of all other days. If above-median and below-median price swings were equally likely on expiration days, the probability of 13 or more above-median price swings, as occurred in the sample, would be only 2.5 percent. Comparing expiration days to nonexpiration Fridays produced a slightly stronger result, 14 above the median and 3 below. Outcomes with this many or more above-median observations have a probability of only 0.6 percent under the hypothesis that triple witching hour days were just like other Fridays. The test suggests that the hypothesis is unlikely; one can conclude that unusual volatility typified triple witching hour days.

Restricting the sample to the post-March 1984 period when all expirations were on Fridays yields the same results, which are presented in Table 2 and illustrated in Chart 2. Triple witching hour days appeared unusual compared to all other trading days, as well as to other Fridays. Of the 12 expiration days in this subperiod, 10 exhibited volatility above the median of all other days. Outcomes with 10 or more above-median price swings out of a possible 12 would have just a 1.9 percent chance of occurring under the hypothesis of no unusual volatility on triple witching hour days. The second test produced an even stronger result: 11 of the 12 days fell above the median for other Fridays. The probability of this result occurring under the hypothesis of no unusual volatility on triple witching hour days is only 0.3 percent. One can thus conclude that triple witching hour days were more volatile than ordinary Fridays and more volatile compared to all other trading days as well.

These results showed a marked contrast to similar tests run on the 1979-82 data. "Pseudo-triple witching hour" days were created for this presample by examining the third Friday of the final month of the quarter. If something were unusual about these days of the year, apart from being triple witching hour days after 1982, similar patterns of volatility would also be expected in this earlier period. As shown in Table 3 and Chart 3, these expectations were not fulfilled. Exactly half of the pseudo-triple witching hour days, eight of the sixteen, fell above the median of all other days' volatility, and, similarly, eight fell above the median of other Fridays. This result is likely when nothing is unusual about the 16 pseudo-triple witching hour days. Thus, the study of the 1979-82 data suggests that nothing peculiar about third Fridays in quarter-ending months was evident in the period prior to the introduction of index options.

The Period since the Rule Change. Table 4 and Charts 4, 5, and 6 present the results from the tests conducted on the period since the expiration rule change. Of the five expiration Fridays since the rule change, four fell *below* the median of all other Fridays and one fell above. The probability of this few or fewer above-median observations would be 18.8 percent if it were in fact the case that expiration Fridays were no different from all other Fridays.

"With such a small sample, definitive conclusions cannot be drawn, but it appears that the rule change may have reduced the propensity for expiration Fridays to exhibit unusually high volatility."

With such a small sample, definitive conclusions cannot be drawn, but it appears that the rule change may have reduced the propensity for expiration Fridays to exhibit unusually high volatility. Prior to the rule change, ten Fridays fell above the median and only two below, whereas since the rule change only one has fallen above the median and four have fallen below.

The purpose of examining Thursdays and Thursday-Friday clusters is to test the possibility that the rule change simply shifted volatility to the Thursday preceding expiration or perhaps spread the excess volatility across two days. The test of Thursday volatility, however, could not confirm or reject this possibility. Of the five Thursdays preceding expiration Fridays, three fell above the median for all other Thursdays, and two fell below. No conclusions

can be drawn from this result, and more observations are needed in order to determine whether these Thursdays are now more or less volatile than ordinary Thursdays.

On the other hand, the test of Thursday-Friday clusters does provide evidence against the notion that the excessive volatility is still generated by the expirations but is now simply spread out over two days. All five of the expiration Thursday-Friday cluster two-day price swings fell below the median of all other Thursday-Friday clusters, which indicates that expiration Thursday-Friday clusters are not likely to display higher-than-usual volatility; if anything, they are likely to display lower-than-usual volatility. Again, though, one must exercise caution when interpreting these results.

"[T]raders may have practiced extra caution and restraint in this early period under the new rule while waiting to see its effects. Also, curbs placed on computerized trading in the aftermath of the October 1987 stock market crash could have contributed to the apparent reduction in volatility. . . ."

The sample size of five observations is small, and a different pattern quite possibly will emerge with time. Moreover, traders may have practiced extra caution and restraint in this early period under the new rule while waiting to see its effects. Also, curbs placed on computerized trading in the aftermath of the October 1987 stock market crash could have contributed to the apparent reduction in volatility on triple witching hour days.

Conclusion

This study of the volatility on triple witching hour days finds that before the rule change, volatility on those days was likely to be greater than the volatility of ordinary trading days. In other words, the change in stock market prices over the course of a triple witching hour day was likely to be greater than the price changes experienced over most ordinary days.

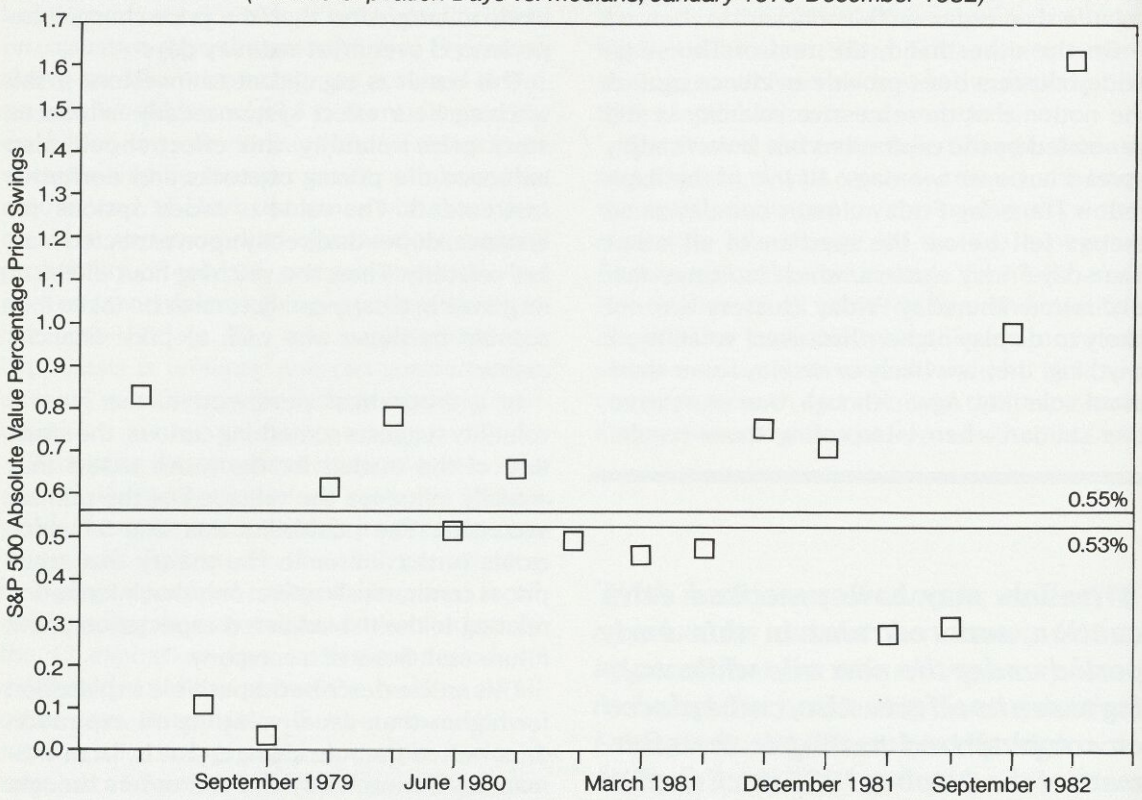
This result is significant to investors. If the witching hour effect systematically influences stock price volatility, this effect should also influence the pricing of stocks and derivative instruments. The value of index options, for instance, depends directly upon expected market volatility. Thus, the witching hour effect, or its possible disappearance, must be taken into account by those who wish to price financial assets.

In a theoretical perspective, the greater volatility suggests something curious: the structure of the market for derivative assets may actually influence the valuation of the primary securities. The possibility that this influence exists runs counter to the theory that stock prices continuously reflect only that information relating to the risk-adjusted expectation of the future cash flows of a company.

This article described a possible explanation for higher-than-usual volatility on expiration days before the rule change, that is, large mismatches between buy and sell orders brought on by the flood of orders submitted by agents covering or settling positions. Another possibility is that with higher volume on expiration days, more new information was brought to the market—information that could have pushed prices one way or the other. Yet, these explanations are only possibilities. Though this research sheds little light on the true cause of the volatility, the study does clarify just what the empirical effect of the triple witching hour was before the rule change.

Finally, the early evidence suggests that since the rule change, expiration Fridays are no longer likely to exhibit higher-than-usual volatility, and expiration Thursday-Friday clusters are likely to exhibit less volatility than other Thursday-Friday clusters. Nonetheless, because of the limited amount of information available since the rule change and other potentially influential events during this period, this result is tentative; the newly emerging evidence could still contradict this result. For now observers must wait to see whether the triple witching effect is still a reality or a thing of the past.

Chart 3.
S&P 500 Daily Percentage Price Swings
(Pseudo-expiration Days vs. Medians, January 1979-December 1982)



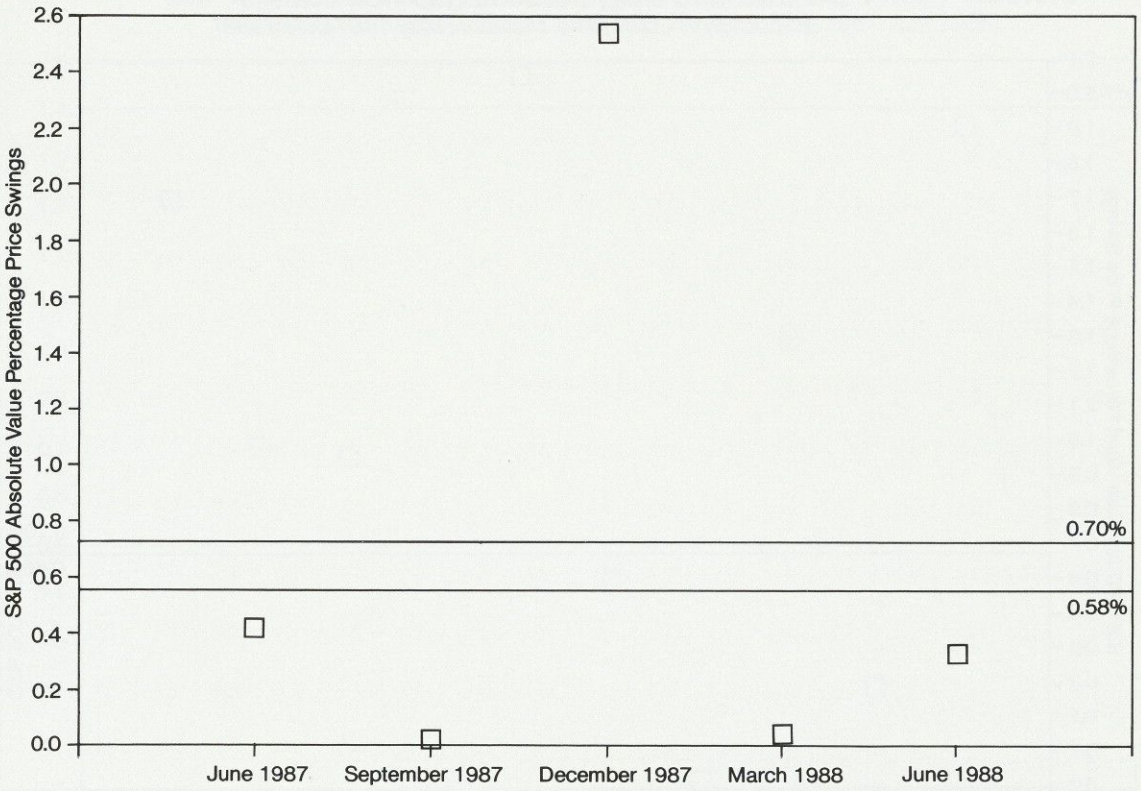
The horizontal lines represent median price swings for the period January 1979-December 1982. The top line shows the median for all days during this period; the bottom line shows the median for all Fridays. Since the boxes representing triple witching hour day price swings are distributed fairly evenly above and below the lines, this chart indicates that before the introduction of options on index futures, pseudo-expiration days were not likely to be more volatile than typical days.

Table 3.
Test of S&P 500 Index Volatility on Pseudo-expiration Days
(January 1979-December 1982)

Test	Sample Size	Below-Median Price Swings	Above-Median Price Swings	Probability* (Percent)
Pseudo-expiration days vs. all other days	16	8	8	59.8
Pseudo-expiration days vs. other Fridays	16	8	8	59.8

**Probability of the occurrence of at least the indicated number of above-median price swings under the assumption that expiration days are equally likely to exhibit above- as below-median price swings.*

Chart 4.
S&P 500 Daily Percentage Price Swings
(Expiration Fridays vs. Medians, May 1987-July 1988)



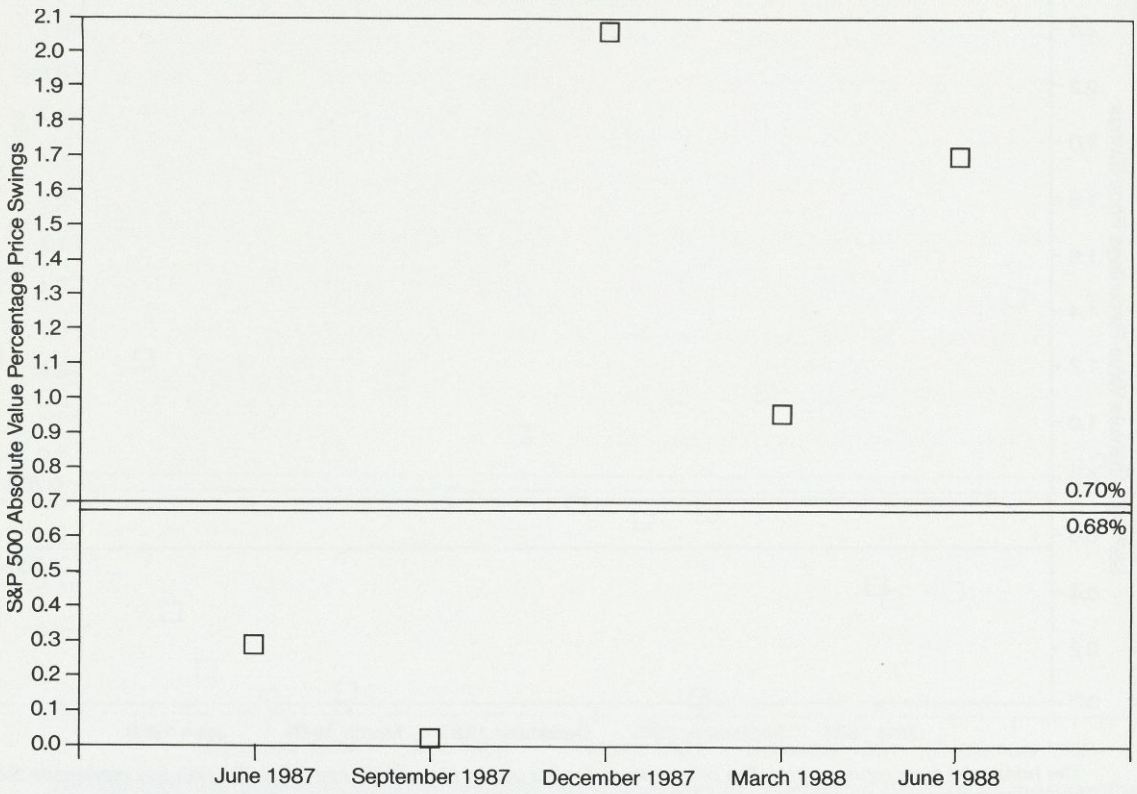
The horizontal lines represent median price swings for the period May 1987-July 1988. The top line represents the median for all days during this period; the bottom line represents the median for Fridays. This chart shows that since the rule change which moved the end of trading on most index futures contracts and some index options to one day earlier, the propensity for expiration Fridays to exhibit greater-than-usual price swings may have been reduced.

Table 4.
Test of S&P 500 Index Volatility on Expiration Days since the 1987 Rule Change

Test	Sample Size	Below-Median Price Swings	Above-Median Price Swings	Probability* (Percent)
Expiration Fridays vs. all other Fridays	5	4	1	18.7
Expiration Thursdays vs. all other Thursdays	5	2	3	50.0
Expiration Thursday-Friday clusters vs. all other Thursday-Friday clusters	5	5	0	3.1

**Probabilities listed for the first and third tests are the probability of the occurrence of at least the indicated number of below-median price swings under the assumption that expiration days are as likely to exhibit above- as below-median price swings. The probability listed for the second test is the probability of the occurrence of at least the indicated number of above-median price swings under the assumption that expiration days are as likely to exhibit above- as below-median price swings.*

Chart 5.
S&P 500 Daily Percentage Price Swings
(Expiration Thursdays vs. Medians, May 1987-July 1988)



The horizontal lines represent median percentage price swings for the period May 1987-July 1988, after the rule change. The top line represents the median for all days during this period; the bottom line represents the median for all Thursdays. Since the boxes in this chart show no distinct pattern, and since the sample on which the chart is based is such a small one, these results are not conclusive regarding price swings on expiration Thursdays since the rule change.

Chart 6.
S&P 500 Percentage Price Swings over Thursday-Friday Clusters

(Expiration Thursday-Friday Clusters vs. Medians, May 1987-July 1988)

The horizontal line represents the median price swing for Thursday-Friday clusters during the May 1987-July 1988 period. Since all the boxes fall below the line indicating typical price swings for Thursday-Friday clusters, the results of this test appear to indicate that expiration Thursday-Friday clusters are not likely to display greater-than-usual price swings. If anything, they are likely to exhibit lower-than-usual price swings. The sample to this date is small, though, and another pattern may emerge over time.

Notes

[1]The U.S. Commodity Futures Trading Commission (CFTC), which oversees agricultural commodity trading, also oversees trading in stock index futures and options on stock index futures.

[2]Galberson (1987).

[3]Stock index arbitrage is not practical for the small or even moderately sized investor. Execution of the strategy with the S&P 500 stocks requires a $25 million position in stocks (Stoll and Whaley, 1986b).

[4]Suppose a pension fund includes a stock portfolio similar in composition to the S&P 500, and the fund manager must ensure that the fund maintains a value above a certain level, $10,000 for example. One way to achieve this security is through the purchase of S&P 500 put options with combined strike prices totaling $10,000. Should the value of the stock portfolio fall below $10,000, the puts can be exercised, earning for the fund a cash payment equal to the shortfall between the current market value of the stocks and the $10,000.

[5]A position in a stock index future can serve the same purpose.

[6]See, for example, Kraus and Stoll (1972); Kawaller, Koch, and Koch (1988); Edwards (1988); Finnerty and Park (1987); or U.S. Congress (1985).

[7]Their sample of nonexpiration days included only Thursdays from the years when stock index futures expired on Thursdays, and Fridays from the years when expirations were on Fridays. In this way, they controlled for possible day-of-the-week effects.

[8]See Fama (1965), Mandelbrot (1963), and Blattberg (1974).

[9]The F-test is still a useful device, however, primarily for summarizing comparisons of stock return volatilities from different samples.

[10]In a nonparametric test like the one employed in this study, using absolute values of returns gives the same result as squared returns. Note also that the expectation of the squared return equals the stock return variance, should that variance exist.

[11]The instruments that are now governed by the new procedures are S&P 500 futures, options on S&P 500 futures, some S&P 500 index options, New York Stock Exchange (NYSE) Composite Index futures, and options on NYSE Composite Index futures. The old rules still govern some S&P 500 index options, S&P 100 index options, Major Market Index futures and options, and Value Line Index futures and options.

[12]May 5, 1987, was chosen as the terminal date for the pre-rule change period since it is halfway between the expiration of the March 1987 contract, the last to expire under the old rules, and the June 1987 contract, the first to expire under the new rules.

[13]A four-year sample is roughly the same size as the previously described test samples.

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