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# TRIPLE-WITCHING HOUR, THE CHANGE IN EXPIRATION TIMING, AND STOCK MARKET REACTION

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## INTRODUCTION

Stock index futures and index options have been a remarkable success in futures and options markets. The first stock index futures contract, based on the Value Line Index, was launched on the Kansas City Board of Trade on February 24, 1982, while the first stock index option, based on the S&P 100 Index, was introduced on the Chicago Board Options Exchange on March 11, 1983. Stock index futures and options provide a unique advantage to trade or hedge broad market movements. The stock index futures contracts have grown rapidly since 1982, and their average daily dollar volume of trading surpassed that of the New York Stock Exchange before the stock market crash of October 19, 1987.

However, stock index futures and options have not been without controversy. In particular, the issue of "triple-witching hour" has received much negative attention in the financial media since the start of

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trade in index futures and index options. Triple-witching hour refers to the last hour of trading on the third Fridays of March, June, September, and December on which, until a regulatory change June 19, 1987, three witches—stock index futures, stock index options, and individual stock options—all expire. Huge order imbalances and frantic trading on the expiration days have been blamed for generating volatile stock price swings.<sup>1</sup>

Published research focuses on two possible causes for heavy trading activity on triple-witching Fridays: (1) the expiration of the stock options and the stock index futures and options; and (2) the program trading which accompanies the expiration of the stock index futures and options.

Stoll and Whaley (1987) examined program trading and expiration-day effects over the 1983–1985 period. They documented that trading volume and the volatility of price changes were extremely higher than normal in the last hour of trading on the triple-witching Fridays during 1984 and 1985. Thus, they concluded that the stock market as a whole is affected on expiration days.

Grossman (1988) examined the implications of program trading for stock and futures price volatility. He argued that synthesized securities as used in portfolio insurance strategies represent unrevealed trading plans and, therefore, unrevealed information which if disclosed would have some effect in reducing volatility. Gennotte and Leland (1990) argued that hedge programs such as portfolio insurance are generally believed to make stock markets more volatile. But can such programs lead to a market crash in which selling begets selling and prices plunge without stop? Can the function relating price to underlying information become discontinuous? Their analysis suggested that the answer is yes, that unobserved hedging strategies can destabilize a market, leading to greater volatility and ultimately to a crash.

Stoll (1988) examined trading links between futures and the stock market. In addition, he investigated whether modifications in trading procedures could alleviate market congestion and price effects observed on expiration days. His findings indicated that the price effects appear to be temporary technical effects due to order imbalances in the stock market late on the expiration day of index futures contracts. When many arbitrageurs liquidate arbitrage positions at the same time, large volume and noticeable price effects have been observed.

<sup>1</sup>*Fortune* (January 20, 1986, p. 110) stated that the triple-witching hour began to get a bad name on September 21, 1984, when the Dow Jones industrial average plunged 16.46 points or 1.32% in the final hour.

Edwards (1988a) examined whether the volatility of asset prices has increased over the period from 1973 to the present, and whether the introduction of financial futures is responsible for an increase in asset price volatility. He argued that if asset prices continually exhibit sharp volatility in very short periods of time, investors may lose confidence that prices are determined by information about economic fundamentals. Thus, financial futures as used in dynamic trading strategies may have negative welfare effects by increasing transaction costs and increasing required return on financial assets. However, based on his empirical results, Edwards (1988a) found no evidence that increasing asset price volatility has adverse effects on economic activity. Although Edwards (1988a) found some evidence of futures-induced short-run volatility on expiration days, he also found that it does not carry over to longer periods of time. Therefore, he argued that the recent volatility of stock and bond prices which extends over longer periods is unlikely attributable to anything associated with futures trading. It is more likely attributable to the increasing uncertainty generated by the existence of macroeconomic disequilibriums.

Edwards (1988b) tested the price volatility for all trading days over the period from June 1973–May 1987. He concluded that stock index futures trading did not destabilize the stock market. In particular, market volatility in the S&P 500 Index was lower in the 1982–1986 post-stock index futures period than it was in the pre-index futures period. Although he found that the stock market experienced higher volatility during 1986 and 1987, he argued that the bond market and other markets which are not related to stock index futures trading also experienced greater volatility.

Harris (1989) examined the volatility of S&P 500 stocks relative to a matched set of non-S&P 500 stocks. He observed no significant difference in the 1975–1983 pre-stock index futures and options period. In the 1984–1987 post-stock index futures and options period, S&P 500 stocks became relatively more volatile. Stoll and Whaley (1990) investigated price reversals on expiration days. In apparent disagreement with the Harris (1989) findings, they found that the price behavior of stocks which are associated with program trading is not different from stocks that are not.

In an attempt to moderate stock market swings, the Commodity Futures Trading Commission, the Chicago Mercantile Exchange, and the New York Stock Exchange implemented a new procedure to stem abnormal price movements in the final hour of triple-witching Fridays. This change in expiration timing, which became effective on June

19, 1987, requires that S&P 500 Index and NYSE Composite Stock Index futures and index options contracts use Friday opening prices instead of closing prices for settlement. This change in expiration timing is aimed at curbing huge trading volume and price swings in the last trading hour of expiration days. However, critics argue that this new procedure may simply spread volatility of stock price at the last trading hour over the whole day.<sup>2</sup>

Recently, Stoll and Whaley (1991) analyzed the impact of the change in expiration timing of S&P 500 and NYSE futures contracts. They found that trading activity and price volatility of S&P 500 and NYSE futures contracts decreased at the market close in the post-expiration timing change period. On the other hand, trading volume and price reversals increased significantly at the market opening.

Using different methodologies and a longer sample period, this study extends the empirical findings by Stoll and Whaley (1991) to examine the quarterly Friday triple-witching hour effects on the stock market and the effectiveness of the change in expiration timing in limiting the volatility of stock price on triple-witching Fridays. In addition, an examination is made of whether the empirical finding for the change of expiration timing remains valid when applied to a comparison of the periods before and after the stock market crash on October 19, 1987.

## METHODOLOGY

### Testing the Triple-Witching Friday Effects

Inasmuch as there are requirements to complete commitments and unwind positions on triple-witching Fridays that do not exist on other non-triple-witching Fridays, it is expected that price volatility and trading volume would be significantly higher on triple-witching Fridays than on other Fridays. First, daily volume and return data for the S&P 500 Index, value-weighted NYSE Index, and equally-weighted NYSE Index are examined from June 1984 to December 1990 to test the following three hypotheses:<sup>3</sup>

*H1.* The stock return volatility on triple-witching Fridays is more than on other Fridays.

<sup>2</sup>*Business Week* (June 22, 1987, p. 126) reported that the chaos could last all day instead of just during the last hour on expiration date under the new rules of open settlement.

<sup>3</sup>Prior to June 1984, stock index futures and options contracts expired on different days during the contract month.

- H2. The mean return on triple-witching Friday is different from the mean return on other Fridays. The issue is whether the stock market performance is related to triple-witching expiration days. The intuition is that higher volatility might imply higher risk and therefore result in higher return commensurate with this higher risk.
- H3. The daily trading volume on triple-witching Fridays is higher than on other Fridays.

The  $t$ -test is used to examine the mean stock returns between different periods, while the  $F$ -test is used to examine stock return volatility between different periods. The  $t$ -statistic is used to test the equality of the means as:

$$t = [(\bar{X}_1 - \bar{X}_2) - (u_1 - u_2)]/[S_{\text{pooled}} * (1/n_1 + 1/n_2)^{1/2}]$$

where  $X_1$  and  $X_2$  are sample portfolio means and  $S_{\text{pooled}}$  is the pooled standard deviation as  $[(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2]/(n_1 + n_2 - 2)^{1/2}$ . The  $F$ -statistic is employed to examine the equality of the variances:  $F = S_1^2/S_2^2$ , where  $S_1^2/S_2^2$  is the ratio of the sample portfolio variances.

### Testing the Effects of the Change in Expiration Timing

Intuitively, after the June 19, 1987, change in expiration timing, one expects the volatility of the final trading hour to be split between the final hour and the first hour on triple-witching Friday. And it is expected that the attempt in the change of expiration timing to reduce volatility for the whole expiration day will be successful.

The following hypothesis is tested to examine the effect of the change in expiration timing:

- H4. The volatility of stock return on triple-witching Fridays after the change in expiration timing is less than before the change in expiration timing.

The volatility of stock price is measured by the following three methods:

1. The standard deviation of Thursday close-to-Friday close percentage daily price changes.
2. The implied volatility estimated from the Black and Scholes (1973) option pricing model. A methodology similar to Harvey and Whaley's

(1991) study is followed in which the implied volatility is calculated from the daily closing values for the closest at-the-money S&P 100 Index call options.<sup>4</sup> All of the call options are the closest at-the-money calls with one month, about 30 days, to expiration. Since the implied volatilities on each triple-witching Friday are calculated with the control of the same maturity—30 days—the maturity is not a problem.

3. The intraday standard deviation of the hour-by-hour Dow Jones Industrial Average.<sup>5</sup>

Hypothesis H4 is tested further using two separate sample periods, pre- and post-stock market crash to determine whether the stock market crash of 1987 has affected price volatility on triple-witching days. It would seem that if the crash introduced fears into program trading and portfolio strategies, one would expect less triple-witching activity after the crash. Also, trading rule changes may have restricted index arbitrage activities.

## EMPIRICAL RESULTS

### Volatility of Stock Returns on Expiration and Non-Expiration Fridays

Table I summarizes the close-to-close mean returns ( $\mu$ ) and standard deviations ( $\sigma$ ) of close-to-close stock returns of all three indexes for all Fridays, triple-witching Fridays, and Fridays excluding triple-witching Fridays over the period June 1984–December 1990.

Evidence by Stoll and Whaley (1987) showed S&P 500 Index volatility to be higher on expiration days. Specifically, they found that the standard deviation of non-expiration Friday S&P 500 Index returns is 0.769% while the standard deviation of the triple-witching Fridays is 0.827% over the sample period May 1983–December 1985. Findings of the present article are not consistent with Stoll and Whaley's (1987) empirical results. The volatility (measured by the standard deviation of

<sup>4</sup>Harvey and Whaley (1991) pointed out that S&P 100 index market is the most actively traded index option in the world. Thus, the nearby at-the-money S&P 100 Index call options with one month to maturity are chosen to estimate the implied volatility on each expiration day. The risk-free interest rate is measured by the three-month Treasury bill rate on each expiration Friday. The data for S&P 100 Index calls and 3-month Treasury bill rates are collected from the *Wall Street Journal*. The annual dividend yield is assumed to be 4% over the sample period.

<sup>5</sup>The intraday data of the Dow Jones Industrial Average Index are collected from the *Wall Street Journal*. The data include the following observations, open, 10 AM, 11 AM, 12 noon, 1 PM, 2 PM, 3 PM, and close on each day.

**TABLE I**  
Average Daily Percentage Returns and Standard  
Deviations for Fridays: June 1984–December 1990

|                                                                  |          | Value-Weighted<br>NYSE Index<br>(%) | Equally-Weighted<br>NYSE Index<br>(%) | S&P 500<br>Index<br>(%) |
|------------------------------------------------------------------|----------|-------------------------------------|---------------------------------------|-------------------------|
| All Fridays<br>(333 obs.)                                        | <i>u</i> | 0.0981                              | 0.1773                                | 0.0979                  |
|                                                                  | <i>s</i> | 0.9682                              | 0.7562                                | 1.0818                  |
| Triple-witching<br>Fridays<br>(27 obs.)                          | <i>u</i> | 0.1526                              | 0.1628                                | 0.2069                  |
|                                                                  | <i>s</i> | 0.8173                              | 0.6339                                | 1.0254                  |
| Fridays<br>excluding<br>triple-witching<br>Fridays<br>(306 obs.) | <i>u</i> | 0.0933                              | 0.1783                                | 0.0883                  |
|                                                                  | <i>s</i> | 0.9814                              | 0.7670                                | 1.0878                  |

Note: *u* denotes close-to-close mean return.

*s* denotes the standard deviation of close-to-close stock returns.

close-to-close stock returns) of triple-witching Fridays is less than the volatility of other Fridays for either the NYSE Indexes (value-weighted and equally-weighted) or the S&P 500 Index over the period June 1984–December 1990. In particular, the standard deviations of the Value-Weighted and Equally-Weighted NYSE close-to-close Indexes for triple-witching Fridays are 0.8173% and 0.6339%, respectively, which appear far less than the standard deviations of other Fridays, 0.9814% and 0.7670%, respectively, but the difference of standard deviations between expiration Fridays and non-expiration Fridays for any of the indexes are not enough to be significant using the *F*-statistic at the 5% confidence level.

The increasing volatility of non-triple-witching Fridays, especially, after the change of expiration timing, is attributed to greater volatility surrounding the stock market crash in 1987 and the mini-stock market crash in 1989. In effect, there are four non-triple-witching Fridays with abnormal percentage price changes.<sup>6</sup>

In addition, the close-to-close mean returns for triple-witching Fridays appear substantially higher than other Fridays for both the Value-Weighted NYSE Index and the S&P 500 Index. In particular, the mean return of triple-witching Fridays for the S&P 500 Index is 0.2069% which appears much higher than the mean return of

<sup>6</sup>These four non-triple-witching Fridays include 10/16/87, 10/30/87, 1/8/88, and 10/13/89 with daily S&P 500 rates of return -5.16%, 2.87%, -6.77%, and -6.13%, respectively.

other Fridays, 0.0883%, a difference of 0.1186%. However, this finding fails to reject the hypothesis of no difference of the returns between triple-witching Fridays and non-expiration Fridays at the 5% significance level. Therefore, these empirical results refute the contention frequently reported in the financial press that triple-witching Fridays are characterized by higher than normal price volatility. In addition, the findings demonstrate no statistical effect of volatility on mean return on triple-witching Fridays.

Panel A of Table II reports the means and standard deviations of NYSE daily trading volume and the daily trading volume without time

**TABLE II**  
Panel A. Average Daily Trading Volume and Standard  
Deviation on the NYSE: June 1984–December 1990

|                                                       | <i>Statistic</i> | <i>Trading Volume<br/>(Million Shares)</i> | <i>Trading Volume<br/>Without Time Trend<br/>(Million Shares)</i> |
|-------------------------------------------------------|------------------|--------------------------------------------|-------------------------------------------------------------------|
| Whole period                                          |                  |                                            |                                                                   |
| All Fridays 13th                                      | <i>u</i>         | 150.93                                     | 110.78                                                            |
| (333 obs.)                                            | <i>s</i>         | 49.04                                      | 43.23                                                             |
| Triple-witching                                       |                  |                                            |                                                                   |
| Fridays                                               | <i>u</i>         | 196.20                                     | 155.99                                                            |
| (27 obs.)                                             | <i>s</i>         | 61.84                                      | 48.30                                                             |
| Fridays excluding triple-witching                     |                  |                                            |                                                                   |
| Fridays                                               | <i>u</i>         | 146.94                                     | 106.79                                                            |
| (306 obs.)                                            | <i>s</i>         | 45.76                                      | 40.48                                                             |
| Before the change of expiration-day settlement timing |                  |                                            |                                                                   |
| Triple-witching                                       |                  |                                            |                                                                   |
| Fridays                                               | <i>u</i>         | 149.21                                     | 131.52                                                            |
| (12 obs.)                                             | <i>s</i>         | 53.30                                      | 44.27                                                             |
| Fridays excluding triple-witching                     |                  |                                            |                                                                   |
| Fridays                                               | <i>u</i>         | 124.15                                     | 105.70                                                            |
| (140 obs.)                                            | <i>s</i>         | 41.69                                      | 36.48                                                             |
| After the change of expiration-day settlement timing  |                  |                                            |                                                                   |
| Triple-witching                                       |                  |                                            |                                                                   |
| Fridays                                               | <i>u</i>         | 233.79                                     | 175.57                                                            |
| (15 obs.)                                             | <i>s</i>         | 38.26                                      | 43.23                                                             |
| Fridays excluding triple-witching                     |                  |                                            |                                                                   |
| Fridays                                               | <i>u</i>         | 166.15                                     | 107.72                                                            |
| (166 obs.)                                            | <i>s</i>         | 39.93                                      | 43.65                                                             |

*u* denotes the mean of daily trading volume on the NYSE.

*s* denotes the standard deviation of daily trading volume on the NYSE.

TABLE II (Continued)

Panel B. Testing for Equality of the Standard Deviation of the Trading Volume between Various Periods: June 1984–December 1990

|                                                                                                                                             | Trading<br>Volume | Trading Volume without<br>Time Trend |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------|
| A. Triple-witching Fridays: Before versus after the change of expiration timing (June 1987)                                                 |                   |                                      |
| F-statistic                                                                                                                                 | 1.94              | 1.05                                 |
| B. Triple-witching Fridays versus Fridays excluding triple-witching Fridays before the change of expiration timing (June 1984–May 1987)     |                   |                                      |
| F-statistic                                                                                                                                 | 1.63              | 1.47                                 |
| C. Triple-witching Fridays versus Fridays excluding triple-witching Fridays after the change of expiration timing (June 1987–December 1990) |                   |                                      |
| F-statistic                                                                                                                                 | 0.92              | 0.98                                 |
| D. Triple-witching Fridays versus Fridays excluding triple-witching Fridays for the whole sample period (June 1984–December 1990)           |                   |                                      |
| F-statistic                                                                                                                                 | 1.83              | 1.42                                 |

Critical value:

$$F_{1-0.05, 12-1, 15-1} = 2.57$$

$$F_{1-0.05, 12-1, 140-1} = 2.00$$

$$F_{1-0.05, 15-1, 166-1} = 1.90$$

$$F_{1-0.05, 27-1, 306-1} = 1.90$$

Panel C. Testing for Equality of the Average Trading Volume between Various Periods: June 1984–December 1990

|                                                                                                                                             | Trading<br>Volume | Trading Volume without<br>Time Trend |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------|
| A. Triple-witching Fridays: Before versus after the change of expiration timing (June 1987)                                                 |                   |                                      |
| t-statistic                                                                                                                                 | 4.80              | 2.60                                 |
| B. Triple-witching Fridays versus Fridays excluding triple-witching Fridays before the change of expiration timing (June 1984–May 1987)     |                   |                                      |
| t-statistic                                                                                                                                 | 1.95              | 2.31                                 |
| C. Triple-witching Fridays versus Fridays excluding triple-witching Fridays after the change of expiration timing (June 1987–December 1990) |                   |                                      |
| t-statistic                                                                                                                                 | 6.30              | 5.77                                 |
| D. Triple-witching Fridays versus Fridays excluding triple-witching Fridays for the whole sample period (June 1984–December 1990)           |                   |                                      |
| t-statistic                                                                                                                                 | 5.02              | 5.91                                 |

Two tails *t*-value with 25 d.f. at 5% significance level:  $t = 2.06$ . Two tails *t*-value with 150 d.f. or more at 5% significance level:  $t = 1.96$ .

trend (measured in million shares) for all Fridays, triple-witching Fridays, and other Fridays in the period June 1984–December 1990. The average daily trading volume of 196.20 million shares on triple-witching Fridays is substantially higher than the 146.94 million shares on non-triple-witching Fridays. Table II also separates data before the change in expiration timing from data after the change in expiration timing, and it can be observed that the difference in triple-witching and non-triple-witching Friday volumes increases greatly. Before the change in expiration timing, the average witching volume of 149.21 million shares exceeds average non-witching volume of 124.15 million shares by 20.2%. After the change, the average witching volume of 233.79 million shares exceeds the average non-witching volume of 166.15 million shares by 40.7%. The findings in Panel B of Table II for standard deviations of trading volume do not indicate significantly different volatility of trading volume on witching Fridays either before or after the change in expiration timing. In fact, it is shown in Table II that the difference between the standard deviation for volume of trading after the change in expiration timing is less than before the change.

To remove the potential problem of time trend from the trading volume series, the trading volume is regressed against the time trend as follows:

$$\text{Trading volume} = \alpha + \beta t + \epsilon$$

where  $t$  is the time trend. The coefficient of the time trend is highly significant at the 1% level. Thus, the time trend from the series of trading volume is removed as follows:

Trading volume without time trend = trading volume  $- \beta * t$ . Table II displays that before the change in expiration timing, the percentage difference between the average witching trading volume without time trend (131.52 million shares) and the average non-witching volume without time trend (105.70 million shares) is 24.4%. After the change, the difference of the average witching volume without the time trend (175.57 million shares) and the average non-witching volume without time trend (107.72 million shares) is 63.0%. That is, removing the time trend from the trading volume, the percentage difference in triple-witching and non-triple-witching Friday trading volumes increases after the change of expiration timing. Whether the increasing difference between trading volume on triple-witching Fridays and non-triple-witching Fridays is due to program trading or other factors is an open question for further investigation.

Panel B of Table II presents the tests of equality of the standard deviations of the trading volume for various time periods. The results indicate no significant differences for the standard deviations of the trading volume between triple-witching Fridays and other Fridays, or between triple-witching Fridays before and after the change of expiration timing. The trading volume statistics are reported in Panel C of Table II, which show that the average trading volume after the change of expiration timing is significantly greater than before the change of expiration timing. In addition, the average trading volume on triple-witching Fridays is also significantly greater than on other Fridays. The results are valid even when the time trend is removed in the trading volume.

Interestingly, Tables I and II demonstrate substantially higher trading volume and lower return volatility on triple-witching Fridays relative to other Fridays. This finding is inconsistent with the characteristic that higher trading volume is generally accompanied with higher return volatility. However, the abnormally higher trading volume on triple-witching Fridays is due to expiration of the stock index futures and options rather than the announcement of any new information. In addition, the return volatility is insignificantly different between triple-witching Fridays and other Fridays. Increased trading volume on triple-witching Fridays may not affect volatility of returns one way or the other.

### **The Impact of the Change in Expiration Timing on the Volatility of Stock Prices**

An article in *Business Week* stated that under the new regulation the chaos could be increased rather than decreased, while Stoll and Whaley (1990) claim that concern about expiration day effects has diminished since the move of the settlement from the Friday closing to the Friday opening.<sup>7</sup> However, no evidence was provided to support either view.

Table III shows that the close-to-close mean returns and standard deviations of close-to-close stock returns for the value-weighted NYSE Index and the S&P 500 Index on the triple-witching Fridays after the change in expiration timing exceed the mean return and standard deviation before the change in expiration timing. But these differences of the standard deviations and the mean returns, as reported in Panel A and Panel B of Table IV, respectively, are not statistically different

<sup>7</sup>See footnote 3 for details.

**TABLE III**  
Average Daily Percentage Returns and Standard  
Deviations for Fridays: June 1984–December 1990

|                                                                                   |          | <i>Value-Weighted<br/>NYSE Index<br/>(%)</i> | <i>Equally-Weighted<br/>NYSE Index<br/>(%)</i> | <i>S&amp;P 500<br/>Index<br/>(%)</i> |
|-----------------------------------------------------------------------------------|----------|----------------------------------------------|------------------------------------------------|--------------------------------------|
| <b>A. Before the change<br/>of expiration timing<br/>(June 1984–May 1987)</b>     |          |                                              |                                                |                                      |
| Triple-witching                                                                   |          |                                              |                                                |                                      |
| Fridays                                                                           | <i>u</i> | 0.0684                                       | 0.2392                                         | 0.0536                               |
| (12 obs.)                                                                         | <i>s</i> | 0.7959                                       | 0.5231                                         | 1.0927                               |
| Fridays excluding<br>triple-witching                                              |          |                                              |                                                |                                      |
| Fridays                                                                           | <i>u</i> | 0.1259                                       | 0.2241                                         | 0.1108                               |
| (140 obs.)                                                                        | <i>s</i> | 0.7160                                       | 0.5564                                         | 0.7832                               |
| <b>B. After the change<br/>of expiration timing<br/>(June 1987–December 1990)</b> |          |                                              |                                                |                                      |
| Triple-witching                                                                   |          |                                              |                                                |                                      |
| Fridays                                                                           | <i>u</i> | 0.2201                                       | 0.1016                                         | 0.3295                               |
| (15 obs.)                                                                         | <i>s</i> | 0.8555                                       | 0.7226                                         | 0.9891                               |
| Fridays excluding<br>triple-witching                                              |          |                                              |                                                |                                      |
| Fridays                                                                           | <i>u</i> | 0.0656                                       | 0.1397                                         | 0.0726                               |
| (166 obs.)                                                                        | <i>s</i> | 1.1602                                       | 0.9074                                         | 1.2920                               |
| <b>C. Before the Market crash<br/>(June 1984–September 1987)</b>                  |          |                                              |                                                |                                      |
| Triple-witching                                                                   |          |                                              |                                                |                                      |
| Fridays                                                                           | <i>u</i> | 0.0798                                       | 0.2315                                         | 0.0743                               |
| (14 obs.)                                                                         | <i>s</i> | 0.7369                                       | 0.4837                                         | 1.0102                               |
| <b>D. After the Market crash<br/>(October 1987–December 1990)</b>                 |          |                                              |                                                |                                      |
| Triple-witching                                                                   |          |                                              |                                                |                                      |
| Fridays                                                                           | <i>u</i> | 0.2310                                       | 0.0888                                         | 0.3497                               |
| (13 obs.)                                                                         | <i>s</i> | 0.9199                                       | 0.7782                                         | 1.0630                               |

Note: *u* denotes close-to-close mean return.

*s* denotes the standard deviation of close-to-close stock returns.

from zero at the 5% significance level for any of the three indexes. Therefore, this study concludes that the change in expiration timing on expiration days does not reduce volatility (measured by the standard deviation of the close-to-close stock returns) and mean returns on triple-witching Fridays.

In Panel A of Table V, the average implied volatility for S&P 100 Index call options before the change in expiration timing (18.47%) is slightly lower than after the change in expiration timing (19.43%). The

TABLE IV

Panel A. Testing for Equality of the Volatility (Standard Deviations of Close-to-Close Daily Returns) between Various Periods: June 1984–December 1990

|                                                                                             | <i>Value-Weighted<br/>NYSE Index</i> | <i>Equally-Weighted<br/>NYSE Index</i> | <i>S&amp;P 500<br/>Index</i> |
|---------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------------|------------------------------|
| A. Triple-witching Fridays: Before versus after the change of expiration timing (June 1987) |                                      |                                        |                              |
| <i>F</i> -statistic                                                                         | 0.87                                 | 0.52                                   | 1.22                         |
| B. Triple-witching Fridays: Before versus after Market crash (October 1987)                 |                                      |                                        |                              |
| <i>F</i> -statistic                                                                         | 0.64                                 | 0.62                                   | 0.95                         |

Critical value:

$F_{1-0.05, 12-1, 15-1} = 2.57$

$F_{1-0.05, 14-1, 13-1} = 2.66$

Panel B. Testing for Equality of the Close-to-Close Mean Returns between Various Periods: June 1984–December 1990

|                                                                                             | <i>Value-Weighted<br/>NYSE Index</i> | <i>Equally-Weighted<br/>NYSE Index</i> | <i>S&amp;P 500<br/>Index</i> |
|---------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------------|------------------------------|
| A. Triple-witching Fridays: Before versus after the change of expiration timing (June 1987) |                                      |                                        |                              |
| <i>t</i> -statistic                                                                         | -0.47                                | 0.55                                   | -0.69                        |
| B. Triple-witching Fridays: Before versus after Market crash (October 1987)                 |                                      |                                        |                              |
| <i>t</i> -statistic                                                                         | -0.47                                | 0.55                                   | -0.69                        |

Two tails *t*-value with 25 d.f. at 5% significance level:  $t = 2.060$ .

difference of the average implied volatility is not statistically significant at the 5% level.

In addition, in Panel A of Table V, the average of the standard deviation of the percentage change of the hour-by-hour Dow Jones Industrial Average Index before the change in expiration timing (0.3257%) is greater than the average of the standard deviation after the change in expiration timing (0.2854%). However, the difference of the standard deviation is statistically insignificant at the 5% level.

These empirical results of the volatility calculated by the standard deviation of close-to-close stock returns, the average implied volatility, and the average intraday volatility of Dow Jones Hour-by-Hour Index indicate that the volatility before and after the change of expiration timing is not significantly different. The large discrepancies between implied volatilities and intraday volatilities are of interest. Implied

**TABLE V**  
 Panel A. Alternative Estimators of Volatility: June 1984–December 1990

|                                                                          | <i>Average Implied<br/>Volatility of<br/>S&amp;P 100 Index<br/>Call Options</i> | <i>Average Intra-day<br/>Volatility of Dow<br/>Jones Hour-by-Hour<br/>Index</i> |
|--------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| A. Before the change<br>of expiration timing<br>(June 1984–May 1987)     |                                                                                 |                                                                                 |
| Triple-witching                                                          |                                                                                 |                                                                                 |
| Fridays (12 obs.)                                                        | 0.1847                                                                          | 0.3257                                                                          |
| B. After the change<br>of expiration timing<br>(June 1987–December 1990) |                                                                                 |                                                                                 |
| Triple-witching                                                          |                                                                                 |                                                                                 |
| Fridays (15 obs.)                                                        | 0.1943                                                                          | 0.2854                                                                          |
| C. Before the market crash<br>(June 1984–September 1987)                 |                                                                                 |                                                                                 |
| Triple-witching                                                          |                                                                                 |                                                                                 |
| Fridays (14 obs.)                                                        | 0.1846                                                                          | 0.3129                                                                          |
| D. After the market crash<br>(October 1987–December 1990)                |                                                                                 |                                                                                 |
| Triple-witching                                                          |                                                                                 |                                                                                 |
| Fridays (13 obs.)                                                        | 0.1958                                                                          | 0.2904                                                                          |

Note: The implied volatility estimated from the Black and Scholes option pricing model. The nearby at-the-money S&P 100 Index calls with 1 month to maturity and the 3-month Treasury bill rates on each expiration Fridays are used to estimate implied volatility.

Panel B. Testing for Equality of the Volatility between  
 Various Periods: June 1984–December 1990

|                                                                                                | <i>Average Implied<br/>Volatility of<br/>S&amp;P 100 Index<br/>Call Options</i> | <i>Average Intra-day<br/>Volatility of Dow<br/>Jones Hour-by-Hour<br/>Index</i> |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| A. Triple-witching Fridays: Before versus after the change of<br>expiration timing (June 1987) |                                                                                 |                                                                                 |
| F-statistic                                                                                    | 1.11                                                                            | 1.30                                                                            |
| B. Triple-witching Fridays: Before versus after market crash<br>(October 1987)                 |                                                                                 |                                                                                 |
| F-statistic                                                                                    | 1.13                                                                            | 1.16                                                                            |

Critical value:

$F_{1-0.05, 12-1, 15-1} = 2.57$

$F_{1-0.05, 14-1, 13-1} = 2.66$

volatilities are superior predictors of actual future volatilities than historically estimated volatilities. However, intraday volatility is also calculated based on current price changes rather than historical price changes. Whether implied volatilities are superior predictors of actual future volatilities than intraday volatilities deserves further research.

Table VI reports the volatility of the hour-by-hour Dow Jones Industrial Average Index percentage change from the market open to the market close.<sup>8</sup> Interestingly, the volatility from 3:00 PM to the market close at 4:00 PM EST decreases substantially from 0.9449% before the change of expiration timing to 0.3040% after the change of expiration timing. On the other hand, the volatility from the market open

**TABLE VI**  
Intraday Volatility on Triple-Witching Fridays: June 1984–December 1990

|                                                                                         | <i>From:<br/>To:</i> | <i>Open<br/>10:00</i> | <i>10:00<br/>11:00</i> | <i>11:00<br/>12:00</i> | <i>12:00<br/>1:00</i> | <i>1:00<br/>2:00</i> | <i>2:00<br/>3:00</i> | <i>3:00<br/>Close</i> |
|-----------------------------------------------------------------------------------------|----------------------|-----------------------|------------------------|------------------------|-----------------------|----------------------|----------------------|-----------------------|
| A. Before the<br>change of<br>expiration timing<br>(June 1984–May<br>1987: 12 obs.)     |                      | 0.1512                | 0.2338                 | 0.2143                 | 0.2369                | 0.1635               | 0.3359               | 0.9449                |
| B. After the<br>change of<br>expiration timing<br>(June 1987–December<br>1990: 15 obs.) |                      | 0.3196                | 0.3038                 | 0.1644                 | 0.1872                | 0.3437               | 0.3753               | 0.3040                |
| C. Before the<br>Market crash<br>(June 1984–September<br>1987: 14 obs.)                 |                      | 0.1341                | 0.2301                 | 0.2038                 | 0.2356                | 0.1774               | 0.3342               | 0.8750                |
| D. After the<br>Market crash<br>(December 1987–December<br>1990: 13 obs.)               |                      | 0.3438                | 0.3195                 | 0.1653                 | 0.1777                | 0.3586               | 0.4003               | 0.2675                |

Volatility is the standard deviation of percentage changes in the Dow Jones Industrial Average Hour-by-Hour Index.  
Source: The *Wall Street Journal*.

<sup>8</sup>For the period June 1984 through September 1985, the 10:00 AM index was not reported by the *Wall Street Journal*. Thus, the volatility from 9:30 AM (open) to 10:00 AM and from 10:00 AM to 11:00 AM is estimated for the period from December 1985 to December 1990.

at 9:30 EST to 10:00 AM doubles after the change of the expiration timing. The results clearly indicate that the change of expiration shifts volatility from the last hour of the triple-witching Fridays to the first half hour of the triple-witching Friday. The volatility from 1:00 PM to 2:00 PM also increases from 0.1635% to 0.3437%. Overall, the change of the expiration timing for settlement of the S&P 500 Index and NYSE Composite Stock Index futures from the last hour to the market open seems to be effective in reducing the volatility near the market close on the triple-witching hour.

### **The Effect of the Stock Market Crash on the Volatility of Stock Returns and Average Returns**

The 27 quarterly expirations are separated further into two subperiods, pre- and post-stock market crash on October 19, 1987. In Table III, the standard deviations for all three indexes after the stock market crash appear higher than before. The mean returns of the value-weighted NYSE Index and the S&P 500 Index on triple-witching Fridays after the stock market crash appear substantially higher than they were before. However, the statistical tests reported in Panel A and Panel B of Table IV indicate no significant differences for the standard deviations and mean returns before and after the stock market crash at the 5% significance level.

The volatility estimated by two alternative methods as reported in Table V shows no significant difference of the volatility on triple-witching Fridays before and after the stock market crash. What roles do new trading rules play in these volatility figures?

The "circuit breaker" rules impose one-hour and two-hour trading halts in all markets when the Dow Jones Industrial Average declines 250 points and 400 points, respectively, from the previous trading day's closing index. This type of restrictive circuit breaker has been in effect since October 20, 1988, but it has never been used since the stock market crash in 1987. A less restrictive version of the circuit breaker rule (rule 88) was implemented by the NYSE July 23, 1990. It limits index arbitrage orders to be of a sell-plus (buy-minus) nature when the Dow moves down (up) 50 points from the previous trading day's close. In addition, the NYSE has adopted a trading restriction, the 5-minute "sidecar", since October 19, 1988. When S&P 500 futures prices fall 12 points from the previous trading day's close, Direct Order Turnaround (DOT) orders are held in a sidecar for five minutes before

the orders can be observed by the specialist and then executed.<sup>9</sup> Neither the circuit breaker nor the sidecar has been used on the triple-witching Fridays since 1988. Therefore, the circuit breakers have no effect on the empirical results of this study.

## CONCLUSIONS

This study examines the trading volume and price effects on triple-witching Fridays compared with non-triple-witching Fridays, and the impacts of the change in expiration timing of 1987 and the stock market crash of 1987. The major findings are:

1. For the close-to-close stock returns on triple-witching Fridays and non-triple-witching Fridays, the differences of mean return and standard deviation for the entire period from June 1984–December 1990 are statistically insignificant. There is no evidence that the trading of futures and options on stock indexes has destabilized the stock market on triple-witching Fridays. The empirical results are not consistent with the speculation that expirations of stock index futures, index options, and stock options result in increased volatility in the stock market as measured by the standard deviation of close-to-close percentage price change on triple-witching day.
2. The average trading volume on the NYSE was 20.2% higher on triple-witching Fridays than on non-triple-witching Fridays for the period before the change in expiration timing, and climbed to 40.7% higher for the period after the change in expiration timing.
3. Two methods are used to estimate return volatility: (a) The implied volatility of S&P 100 index call options estimated from the Black and Scholes (1973) option pricing model. (b) The average of the intraday standard deviations of hour-by-hour Dow Jones Industrial Average Index. The volatility measured by these alternatives is not significantly different before and after the change in expiration timing for settlement on triple-witching Fridays. The most striking finding is that the change in the expiration time of the S&P 500 Index and the NYSE Composite Index futures contracts to ease stock market volatility seems to be

<sup>9</sup>McMillan (1992) and Kuhn, Kuserk, and Locke (1992) provide very interesting studies for the impact of circuit breakers on the volatility of stock index futures during "mini market crash" of 1989.

effective based on the findings for the hour-by-hour Dow Jones Industrial Average Index.

Finally, this study finds the stock market crash of 1987 has not affected the price volatility on triple-witching Fridays.

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