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An Examination of Stock Market Return Volatility During Overnight and Intraday Periods, 1964–1989

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ABSTRACT

This paper examines the variance of hourly market returns during 1964–1989. Results indicate that return volatility falls from the opening hour until early afternoon and rises thereafter and is significantly greater for intraday versus overnight periods. Market variance is also shown to change significantly over time, rising after NASDAQ began in 1971, rising after trading in stock options began in 1973, falling after fixed commissions were eliminated in 1975, rising after trading in stock index futures was introduced in 1982, and falling after margin requirements for stock index futures became larger in 1988.

WOOD, MCINISH, AND ORD (1985), Harris (1986), and McInish and Wood (1989) examine intraday stock returns over brief periods and find that market volatility is high near the open and close of the trading day. Market volatility also has been found to be greater during trading versus nontrading periods (French and Roll (1986)) and during open-to-open versus close-to-close periods (Amihud and Mendelson (1987)).

This paper extends previous volatility studies by examining market variance on an hourly basis for the 1964–1989 period.[1] Tests of the stability and ordering of market volatility are performed (a) across intraday hours, (b) between trading and nontrading periods, and (c) between open-to-open and close-to-close periods. Market volatility is also examined between dates of important structural changes in financial markets, such as the introduction of NASDAQ (1971), standardized stock options (1973), negotiable commissions (1975), stock index futures (1982), and increased margin requirements for trading in stock index futures (1988).

The remainder of the paper is composed of three sections. Section I describes the data. Section II presents the hypotheses, methodology, and results. Section III summarizes the main findings of the paper.

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[1] Wood, McInish, and Ord (1985), Harris (1986), and McInish and Wood (1989) examine stock transactions data over September 1971–February 1972 and all of 1982, December 1981–January 1983, and 1980–1984, respectively. French and Roll (1986) examine close-to-close stock returns over 1963–1982, and Amihud and Mendelson (1987) use open-to-open and close-to-close returns over February 1982–February 1983.

I. The Data

Market volatility is assessed using returns computed from opening, closing, and intraday hourly values of the Dow Jones Industrial Average (DJIA) for January 1964–February 1989. Returns are computed as the natural logarithm of the DJIA value relative times 100 for various trading and nontrading periods for each day in the sample: (a) the overnight period from close of the previous trading day to open of the subsequent trading day (e.g., overnight-Monday is the period from close-Friday to open-Monday); (b) the intraday period from open to close; (c) the period from open of the previous trading day to open of the subsequent trading day; (d) the period from close of the previous trading day to close of the subsequent trading day; and (e) several hourly intraday periods (10:00 a.m.–11:00 a.m., 11:00 a.m.–12:00 p.m., etc.). The NYSE extended the market close from 3:30 to 4:00 p.m. on October 1, 1974 and changed the market open from 10:00 a.m. to 9:30 a.m. on September 1, 1985.

Days immediately following holidays are excluded from all analyses except for tests of holiday effects. Days on which the NYSE closed early or during which trading was halted are excluded from the analysis.[2]

II. The Methodology and Results

A. Sample Variances of Day-of-the-Week Returns

Table I presents the sample variances for the trading and nontrading periods described in Section I. Results are reported for six subperiods segmented using dates on which five major structural changes occurred in the financial markets: (a) the initiation of the NASDAQ trading system on February 1, 1971; (b) the advent of trading in standardized stock options on April 26, 1973; (c) the elimination of fixed commissions on May 1, 1975; (d) the introduction of stock index futures on February 16, 1982; and (e) the start of much larger margin requirements for trading in stock index futures on February 4, 1988 (ending on February 23, 1989).[3]

On average, the hourly variances reported in Table I follow a distinct U-shape, falling from the opening hour until early afternoon and rising thereafter.[4] (Also see Figure 1 for a plot of the intraday variances for the 1964–1989 period.) Table I also indicates that the return variance for the open-to-close period exceeds the

[2] Periods during which the market closed early are January 6, 1966–January 14, 1966, January 22, 1968–March 1, 1968, January 2, 1969–May 3, 1970, and October 23, 1987–November 4, 1987.

[3] The initial margin requirement on the Major Market Index (MMI) just before October 19, 1987 was $4500 per contract. The margin requirement was increased in increments in the days following October 19. Starting on February 4, 1988, the margin requirement became $15,000 per contract, where it stayed until February 23, 1989 (when it dropped to $6000). Bride Maloney of the Chicago Board of Trade Records Center is gratefully acknowledged for providing us with the MMI data.

[4] Since the NYSE closed at 3:30 prior to October 1974, the 3:00–close variance for all of the Pre-Nasdaq and Nasdaq periods and for much of the Options period is only a thirty-minute variance, while the 3:00–close variance for the Commissions, Futures, and Margin subperiods is for a full hour, 3:00–4:00. So the apparent "decline" in the hourly market variance from 2:00–3:00 to 3:00–close for the first three subperiods is misleading.

Table I

Variances for the Returns on the Dow Jones Industrial Average for Trading and Nontrading Periods, 1964–1989

Returns are calculated as the natural logarithm of the DJIA value relative times 100. The sample period is segmented according to structural changes in financial markets: (1) pre-Nasdaq, the sample period before NASDAQ was initiated, 1/1/64–1/31/71; (2) Nasdaq, the period after NASDAQ began and before trading in standardized option contracts began, 2/1/71–4/25/73; (3) Options, the period after trading in options began and before fixed commissions were eliminated, 4/26/73–4/30/75; (4) Commissions, the period after fixed commissions were eliminated and before trading in stock index futures began, 5/1/75–2/15/82; (5) Futures, the period after trading in stock index futures began and before margin requirements for such trading became large, 2/16/82–2/3/88; and (6) Margin, the period after margin requirements for trading in stock index futures became large, 2/4/88–2/22/89. Before October 1974, the NYSE closed at 3:30 and subsequently at 4:00. For the Pre-Nasdaq and Nasdaq periods and for much of the Options period, the 3:00–close return variance is a 30-minute variance only. The 3:00–close variances for the Commissions, Futures, and Margin periods are 60-minute variances. Holiday variances (column 7) are reported from returns for trading days immediately following holidays. The 1964–1989 sample period (column 8) spans the period January 1, 1964–February 23, 1989. Days on which the market closed early are excluded. Except for column 7, trading days immediately following holidays are excluded. The number of days, for each subperiod, over which the variances are computed is presented in the last row of the table.

Measurement Period	Pre-Nasdaq (1)	Nasdaq (2)	Options (3)	Commissions (4)	Futures (5)	Margin (6)	Holidays (7)	1964–1989 (8)
10:00–11:00	.0693	.0946	.2039	.0815	.1477	.1031	.1196	.1092
11:00–12:00	.0558	.0613	.1901	.0714	.1310	.0782	.0640	.0925
12:00–1:00	.0347	.0330	.1001	.0434	.1020	.0595	.0388	.0612
1:00–2:00	.0302	.0271	.1296	.0490	.0974	.0539	.0429	.0631
2:00–3:00	.0408	.0430	.2031	.0911	.1536	.0955	.0625	.1010
3:00–close	.0319	.0253	.1323	.1293	.3603	.1914	.0992	.1593
close-to-open	.0812	.1214	.3427	.1363	.4557	.1544	.2868	.2229
open-to-close	.3320	.3481	1.2670	.5841	1.0658	.6750	.7330	.6896
close-to-close	.4251	.4651	1.7786	.7119	1.5660	.9355	1.0047	.9426
open-to-open	.5726	.6110	2.2247	1.0259	1.4758	.8773	.7965	1.0946
Number of days	1294	543	493	1652	1448	256	228	5687

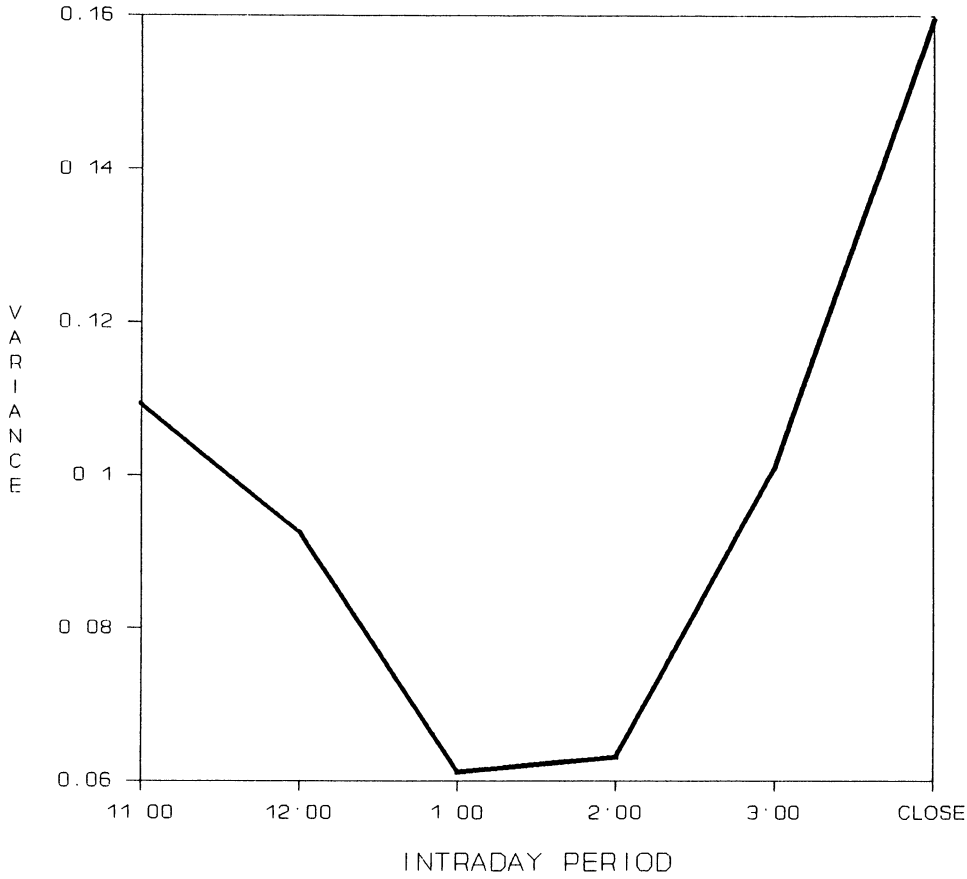

Figure 1. Intraday variances, 1964–1989. Market return variances for six intraday periods from 10:00–11:00 a.m. through 3:00–close are plotted. Returns are calculated as the natural logarithm of the Dow Jones Industrial Average value relative times 100. The sample period spans January 1, 1964–February 22, 1989 (5687 trading days). Days on which the NYSE closed early or during which trading was suspended are excluded. Trading days immediately following holidays also are excluded.

return variance for the close-to-open period by a factor of 2.34 (for the Futures period) to 4.37 (for the Margin period). Variance is higher for open-to-open returns versus close-to-close returns during the Pre-Nasdaq period through the Commissions period and is lower for open-to-open returns versus close-to-close returns during the Futures and Margin periods.[5]

B. Tests for Homoskedasticity Across Trading and Nontrading Periods

To test the equality of variances more formally, the null hypothesis that the variances for the J hourly intraday periods are equal (homoskedastic) is examined, H_1: $\sigma_1^2 = \sigma_2^2 = \cdots = \sigma_J^2$. Tests are performed across the five (six) intraday hourly

[5] If October 1987 is deleted from the analysis, the open-to-open return variance (1.2589) exceeds the close-to-close return variance (0.9793) during the Futures period.

periods starting at 10:00 a.m. and ending at 3:00 p.m. (4:00 p.m.) for the first (last) three subperiods. Equality of variance tests are also performed between overnight (close-to-open) and intraday (open-to-close) periods, H_2: $\sigma_O^2 = \sigma_I^2$, and between open-to-open and close-to-close periods, H_3: $\sigma_P^2 = \sigma_C^2$. Results are reported for each subperiod.

Hypotheses H_1, H_2, and H_3 are examined with the Brown-Forsythe (1974) modified Levene (1960) test statistic,

$$F = \left[\sum_{j=1}^{J} n_j(\bar{D}\cdot_j - \bar{D}\cdot\cdot)^2 / \sum_{j=1}^{J} \sum_{i=1}^{n_j} (D_{ij} - \bar{D}\cdot_j)^2 \right] [(N - J)/(J - 1)], \tag{1}$$

where $D_{ij} = |R_{ij} - M\cdot_j|$; R_{ij} is the return for day i, intraday period j (for example, for H_1, $j = 1, 2, \cdot\cdot, J$, where $J = 5$ or 6); $M\cdot_j$ is the sample median return for period j computed over the n_j days included in the test; $D\cdot_j = \Sigma_{i=1}^{nj} D_{ij}/n_j$ is the mean absolute deviation (from the median) for period j; and $D\cdot\cdot = \Sigma_{j=1}^{J} \Sigma_{i=1}^{nj} D_{ij}/N$ is the grand mean ($N = \Sigma_{j=1}^{J} n_j$). The statistic in (1) is distributed $F_{J-1,\, N-J}$ under the null hypothesis.[6]

The F-statistics for tests of H_1, H_2, and H_3 are reported in Table II (F_1, F_2, and F_3, respectively). The critical value at the five percent level for F_1 equals 2.37 (2.21) for the first (last) three subperiods. The critical value for F_2 and F_3 equals 3.84. The first two hypotheses are rejected at the five percent level in each subperiod, indicating that market return variance is not constant across the intraday period and is larger when the stock market is open than when it is closed. Hypothesis H_3 is rejected at the five percent level for the Pre-Nasdaq, Options, Commissions (and Futures) periods, indicating that, during these periods, market return variance is larger (smaller) for open-to-open versus close-to-close periods. No significant differences in the variance of open-to-open and close-to-close returns are found at the five percent level for the Nasdaq and Margin subperiods.

To better identify the typical intradaily pattern in market volatility, the D_{ij} can be ranked and examined for each day in the sample. Patterns in the D_{ij} ranks will be examined over two parts of the day, from the 10:00–11:00 hour through the 1:00–2:00 hour and from the 1:00–2:00 hour through the closing hour, respectively. The sample is now segmented into two periods, (a) days when the market closed at 3:30 p.m. (before October 1974, $n = 2188$) and (b) days when the market closed at 4:00 p.m. (after September 1974, $n = 3499$). For the first (second) subperiod, there are five (six) intraday hourly periods starting with the 10:00–11:00 hour and ending with the 2:00–3:00 (3:00–4:00) hour. For the first

[6] Tests of normality of the data (not reported) indicate that overnight, intraday, hourly intraday, close-to-close, and open-to-open period returns are not normally distributed. Conover, Johnson, and Johnson (1981) compare over fifty methods for testing homogeneity of variance and find that the modified Levene (1960) test is among the most powerful and is robust regarding departure of the underlying data from normality. They also examine the small sample properties of the modified Levene test. The authors conduct simulations using, among other distributions, examples in which pseudo-random numbers are generated from a leptokurtic distribution (i.e., similar to stock returns). For their small samples (ranging from 5 to 20 observations), the modified Levene test is found to be the most powerful when the null is false and is found to have the most controlled nominal rejection rates when the null is true.

Table II

Modified Levene Statistics for Tests of the Equality of Variance Across Trading and Nontrading Periods, 1964–1989

The sample period is segmented according to structural changes in financial markets: (1) Pre-Nasdaq, 1/1/64–1/31/71; (2) Nasdaq, 2/1/71–4/25/73; (3) Options, 4/26/73–4/30/75; (4) Commissions, 5/1/75–2/15/82; (5) Futures, 2/16/82–2/3/88; and (6) Margin, 2/4/88–2/22/89. Modified Levene F-statistics for tests of equality of variance are reported for each period. F_1 is used to test the equality of hourly intraday variances (H_1), F_2 is used to test the equality of close-to-open and open-to-close variance (H_2), and F_3 is used to test the equality of close-to-close and open-to-open variance (H_3). The critical value at the five (one) percent level for F_1 equals 2.37 (3.32) for the first three subperiods and equals 2.21 (3.02) for the last three subperiods and the Holidays period. The critical value at the five (one) percent level for F_2 and F_3 equals 3.84 (6.63). The number of days over which each test is performed is presented in the last row of the table.

F-Statistics	Pre-Nasdaq (1)	Nasdaq (2)	Options (3)	Commissions (4)	Futures (5)	Margin (6)	Holidays (7)
F_1	44.65**	45.53**	15.93**	80.69**	53.12**	17.05**	9.73**
F_2	332.98**	160.58**	175.10**	684.46**	204.80**	70.82**	44.97**
F_3	12.68**	3.66	4.78*	46.00**	4.36*	0.03	1.90
Number of days	1294	543	493	2358	1448	256	228

** The F-statistic is significant at the one percent level.

* The F-statistic is significant at the five percent level.

part of the day, the ranks, defined as r_{i1} through r_{i4}, range from 1 for the smallest D_{ij} to 4 for the largest D_{ij}. For the second part of the day, r_{ij} ranges from 1 to 2 (3) for days in the first (second) subperiod. The number of possible orderings is 48 (4!2!) and 144 (4!3!) for the first and second subperiods, respectively. Under the null hypothesis of random ordering of the r_{ij}, the mean frequency equals 45.6 (2188/48) for each cell in the first subperiod and equals 24.3 (3499/144) for each cell in the second subperiod.

The number of days with intradaily volatility rankings that fall from the opening hour through the 1:00–2:00 hour and that rise thereafter (4, 3, 2, 1; 1, 2 for the first subperiod and 4, 3, 2, 1; 1, 2, 3 for the second subperiod) equals 142 (98) for the first (second) subperiod. Both numbers are more than three standard deviations ($s_1 = 29.9$ and $s_2 = 16.8$) from their respective means under the null hypothesis of random ordering. In fact, of the 48 possible orderings in the first subperiod, only two other cells have observed frequencies that are more than two standard deviations from the mean: (a) 3, 4, 2, 1; 1, 2, ($n = 131$) and (b) 4, 2, 3, 1; 1, 2 ($n = 122$), both of which closely resemble the proposed 4, 3, 2, 1; 1, 2 ordering. A similar result is found for the second subperiod.

Application of the ordered hypothesis test developed by Page (1963) indicates that the null hypothesis of random ordering of the r_{ij} from the 10:00–11:00 hour to the 1:00–2:00 hour is rejected at the five percent level in favor of the alternative that the r_{ij} fall from the 10:00–11:00 hour to the 1:00–2:00 hour for both subperiods. Similarly, the null hypothesis of random ordering of the r_{ij} from the 1:00–2:00 hour to the closing hour is rejected at the five percent level in favor of the alternative that the r_{ij} rise from 1:00–2:00 through the closing hour for both subperiods.[7]

C. Tests of Homoskedasticity Across Subperiods

Although a U-shaped within-day pattern for market volatility is found within each subperiod, the level of volatility is not the same across subperiods. In particular, the market variance during the Options period and, to a lesser extent, the Futures period exceeds the market variance of the other periods. To examine the stability of the market variance more formally, the null hypothesis that the variance (for any trading or nontrading period j) is constant across the six

[7] The Page (1963) ordered test statistic is $L = \Sigma_{i=1}^{n} \Sigma_{j=1}^{J} h_{ij} r_{ij}$, where h_{ij} is the rank under the alternative hypothesis for D_{ij} (e.g., for the first part of the day, $J = 4$ and $h_{i1} = 4$, $h_{i2} = 3$, $h_{i3} = 2$, and $h_{i4} = 1$). Thus, the Page test uses the hypothesized ranks (h_{ij}) and the observed ranks (r_{ij}) to produce a statistic that, for any day i, obtains its maximum value when h_{ij} and r_{ij} are equal (e.g., for tests on the first part of the day, $\Sigma_{j=1}^{4} h_{ij} r_{ij} = 30$) and obtains its minimum value when h_{ij} and r_{ij} are inversely related (e.g., $\Sigma_{j=1}^{4} h_{ij} r_{ij} = 20$). Critical values for the exact distribution of L are provided by Page (1963). Properties of the Page test are discussed in Hollander and Wolfe (1973), p. 147, and in Manoukian (1986), p. 296. Boersma, DeJonge, and Stellwagon (1964) perform simulations for sample sizes of 5, 10, and 15 and for J equal to 3, 4, and 5 showing that the Page test is extremely powerful, especially if an a priori ordering is believed to exist. The test was also performed on the six market system subperiods. In each subperiod, the null hypothesis of random ordering r_{ij} was rejected at the five percent level in favor of the ordered alternative that market volatility falls from the 10:00–11:00 hour through the 1:00–2:00 hour. Similarly, the null hypothesis of random ordering of the r_{ij} from the 1:00–2:00 hour through the closing hour was rejected at the five percent level in favor of the alternative that market volatility rises from the 1:00–2:00 hour through the closing hour.

Table III

Modified Levene Statistics for Tests of the Equality of Variance Across Subperiods, 1964–1989

The sample period is segmented according to structural changes in financial markets: (1) pre-Nasdaq, 1/1/64–1/31/71; (2) Nasdaq, 2/1/71–4/25/73; (3) Options, 4/26/73–4/30/75; (4) Commissions, 5/1/75–2/15/82; (5) Futures, 2/16/82–2/3/88; and (6) Margin, 2/4/88–2/22/89. Modified Levene F-statistics are reported for tests of the equality of variance across the six subperiods (F_4), between Pre-Nasdaq and Nasdaq periods (F_5), between Nasdaq and Options periods (F_6), between Options and Commissions periods (F_7), between Commissions and Futures periods (F_8), between Futures and Margin periods (F_9), and between trading days after holidays and trading days excluding days after holidays (F_{10}). The critical value at the five (one) percent level for F_4 is 2.21 (3.02) and for F_5–F_{10} is 3.84 (6.63). The number of days over which each test is performed is presented in the last row of the table.

Measurement Period	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
close-to-open	37.50**	3.50	103.28**	110.54**	12.72**	0.73	3.00
open-to-close	68.47**	4.96*	169.58**	118.50**	12.73**	2.30	1.03
close-to-close	62.18**	5.81*	173.92**	163.85**	13.60**	0.91	1.39
open-to-open	71.06**	2.40	167.27**	111.54**	2.10	4.77*	6.08*

** The F-statistic is significant at the one percent level.

* The F-statistic is significant at the five percent level.

subperiods ($i = 1, 2, \cdots, 6$) is tested: H_4: $\sigma^2_{1j} = \sigma^2_{2j} = \sigma^2_{3j} = \sigma^2_{4j} = \sigma^2_{5j} = \sigma^2_{6j}$ (e.g., $i = 1$ for the Pre-Nasdaq period, etc.). Additional tests for incremental change in market variance between adjacent subperiods are performed: H_5: $\sigma^2_{1j} = \sigma^2_{2j}$ (pre-Nasdaq vs. Nasdaq), H_6: $\sigma^2_{2j} = \sigma^2_{3j}$ (Nasdaq vs. Options), H_7: $\sigma^2_{3j} = \sigma^2_{4j}$ (Options vs. Commissions), H_8: $\sigma^2_{4j} = \sigma^2_{5j}$ (Commissions vs. Futures), and H_9: $\sigma^2_{5j} = \sigma^2_{6j}$ (Futures vs. Margin). The critical value at the five percent level for F_4 is 2.21 and for F_5–F_9 is 3.84.

Table III presents the F-statistics (F_4–F_9) derived from the modified Levene test for hypotheses H_4–H_9, for close-to-open, open-to-close, close-to-close, and open-to-open periods. Equality of variance across the six subperiods is always rejected at the five percent level (see F_4). Return variance increases significantly at the five percent level during the Nasdaq period using either open-to-close or close-to-close returns (see F_5). Return variability, again, increases significantly during the Options period (see F_6) and, then, decreases significantly during the Commissions period (see F_7). Market return variance rises significantly during the Futures period (see F_8) for all but open-to-open periods. Finally, the open-to-open return variance falls significantly during the Margin period (see F_9).[8]

D. The Influence of Holidays

Variances of returns for trading days following immediately after holidays are reported in column 7 of Table I. The data indicate that the hourly intraday variances for days following holidays also are U-shaped. Test statistics, applied to the holiday data, for hypotheses H_1–H_3 are presented in column 7 of Table II. H_1 and H_2 are rejected at the five percent level, indicating that, for days following holidays, hourly intraday variances are unequal and variance is higher intraday than overnight.[9] No significant difference between the variance of close-to-close and open-to-open returns is found at the five percent level for days following holidays.

Tests of equality of variance are also performed between trading days following holidays (period 7) and all trading days excluding days following holidays (period 8), H_{10}: $\sigma^2_{7j} = \sigma^2_{8j}$. F-statistics for tests of H_{10} are presented in the last column of Table III for close-to-open, open-to-close, close-to-close (e.g., close-to-close for a Tuesday following a Monday holiday is the period from close-Friday to close-Tuesday, etc.), and open-to-open returns (e.g., open-to-open for a Tuesday following a Monday holiday is the period from open-Friday to open-Tuesday,

[8] Causality should not be inferred from these results. For example, the rise in volatility following the initiation of trading in options and in stock index futures does not imply that these events caused the rise in volatility. Market pressures for the introduction of these derivative securities could have occurred in anticipation of increased market volatility predicated on forecasts, say, of increased interest rate variance. See Skinner (1989) for a study of individual stock return volatility following the introduction of trading in call options. Additional testing indicates that market volatility is significantly higher at the five percent level (a) during Commissions versus Nasdaq periods and (b) during Options versus Futures periods, using open-to-close, close-to-close, or open-to-open returns, and (c) during Commissions versus Margin periods using open-to-open returns only.

[9] The Page (1963) ordered hypothesis test was also performed on the D_{ij} for all days following holidays. The null hypotheses of random ordering over the 10:00–2:00 and 1:00–closing hours were rejected at the five percent level in favor of the alternatives that hourly market volatility falls from the opening through the 1:00–2:00 hour and rises thereafter.

etc.). H_{10} is rejected at the five percent level using open-to-open returns only. Thus, the variance of open-to-open returns is significantly less for trading days that follow holidays versus trading days that do not follow holidays.

Interestingly, the median open-to-open return for trading days following holidays (.250) exceeds the median open-to-open return for days not following holidays (.018) by a factor of fourteen even though the open-to-open return variance is lower for trading days following holidays. These results can be compared with those of Ariel (1987), who finds that the mean close-to-close return for trading days prior to holidays exceeds the mean return for all other trading days also by a factor of fourteen even though the close-to-close return variance is lower for trading days prior to holidays.[10]

III. Conclusions

This paper examines the stability of the variance of returns on the Dow Jones Industrial Average for the period 1964–1989. Equality of variance tests are performed across hourly intraday returns, between close-to-open and open-to-close returns, and between open-to-open and close-to-close returns. Return volatility between dates of major changes in market microstructure is also investigated.

Results indicate that hourly intraday return variances are heterogeneous and ordered, falling from the opening hour until the early afternoon and rising thereafter. Results also indicate that market volatility is significantly higher during intraday versus overnight periods. These findings are not influenced by divisions of the sample period into different market systems. Market return variance is shown to be significantly higher for open-to-open versus close-to-close periods during the pre-Nasdaq, Options, and Commissions periods but is shown to be significantly lower for open-to-open versus close-to-close periods during the Futures period.

Market return variance is shown to change significantly across different market systems, rising after NASDAQ began in 1971, rising after trading in standardized options began in 1973, falling after commissions became negotiable in 1975, rising after trading in stock index futures began in 1982, and falling after margin requirements for trading in stock index futures became larger in 1988.

[10] In contrast, Harris (1986) finds that mean returns for close-to-close, close-to-open, and open-to-close periods are significantly less for Mondays than for other days of the week. Thus, open-to-open returns for days following holidays behave differently from returns for close-to-close, close-to-open, and open-to-close periods for days following weekends.

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