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# The Intraday Interdependence Structure Between U.S. and Japanese Equity Markets

*Kent G. Becker*
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*Alan L. Tucker*

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August 1990

# The Intraday Interdependence Structure Between U.S. and Japanese Equity Markets

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The Intraday Interdependence Structure
Between U.S. and Japanese Equity Markets

Abstract

Contrary to the efficient market hypothesis, previous researchers document significant correlation between lagged U.S. close to close stock market returns and current open to close Japanese stock market returns. We find that the significant correlation is limited to the first hour of Japanese trading, with subsequent hourly returns independent of lagged U.S. returns. This evidence suggests that the documented significant correlation is attributable to a sticky Japanese opening value associated with the use of nonsynchronous index data. However, anomalous intraday volatility patterns are documented.

# The Intraday Interdependence Structure Between U.S. and Japanese Equity Markets

## 1. Introduction

Employing opening and closing index data, Kato [19] and Becker, Finnerty and Gupta [3, BFG hereafter] report that the U.S. equity market has a strong influence on the Japanese equity market while the opposite does not hold. With data for the Nikkei 225 and Dow Jones Industrial Average from 1980 through 1987, Kato finds that the correlation between lagged U.S. returns and current Japanese overnight returns is .536.[1] In contrast, the effect of the Japanese market on U.S. overnight returns is low, exhibiting a correlation of just .10 percent. The current open to close Japanese returns are also positively correlated with lagged U.S. changes, with the correlation between lagged U.S. close to close returns and current open to close Japanese returns equal to .255. With data for the Nikkei 225 and Standard and Poor's 500 (SP500) from October 1985 through December 1988, BFG find that lagged U.S. returns explain approximately seven percent of the fluctuations of current open to close Japanese returns, excluding the crash month of October 1987. The same lagged U.S. returns account for approximately 17 percent of the fluctuations of Japanese overnight returns. U.S. filters are able to select profitable trading days in Japan with great regularity. However, high trading costs in Japan prevent arbitrageurs from profiting from a strategy based on following the U.S. market. In contrast, the Japanese market has little influence on the U.S. market, accounting for only one percent of the changes of U.S. open to close returns.

# The Intraday Interdependence Structure Between U.S. and Japanese Equity Markets

## 1. Introduction

Employing opening and closing index data, Kato [19] and Becker, Finnerty and Gupta [3, BFG hereafter] report that the U.S. equity market has a strong influence on the Japanese equity market while the opposite does not hold. With data for the Nikkei 225 and Dow Jones Industrial Average from 1980 through 1987, Kato finds that the correlation between lagged U.S. returns and current Japanese overnight returns is .536.[1] In contrast, the effect of the Japanese market on U.S. overnight returns is low, exhibiting a correlation of just .10 percent. The current open to close Japanese returns are also positively correlated with lagged U.S. changes, with the correlation between lagged U.S. close to close returns and current open to close Japanese returns equal to .255. With data for the Nikkei 225 and Standard and Poor's 500 (SP500) from October 1985 through December 1988, BFG find that lagged U.S. returns explain approximately seven percent of the fluctuations of current open to close Japanese returns, excluding the crash month of October 1987. The same lagged U.S. returns account for approximately 17 percent of the fluctuations of Japanese overnight returns. U.S. filters are able to select profitable trading days in Japan with great regularity. However, high trading costs in Japan prevent arbitrageurs from profiting from a strategy based on following the U.S. market. In contrast, the Japanese market has little influence on the U.S. market, accounting for only one percent of the changes of U.S. open to close returns.

In addition, there is no relation between the performance of the Japanese market and overnight returns in the U.S.

These results have efficiency implications because the correlation between open to close returns should be equal to zero for these two markets. If markets are efficient, information about the open to close performance in one market (for example, the U.S. return in period t-1) will be fully reflected in the opening price in the other market (Japan in period t). Since information flows randomly into the market, subsequent price changes should be random and open to close returns in Japan will be uncorrelated with lagged U.S. returns. Although it does not appear possible to profit from following the U.S., the high correlation documented between current Japanese open to close returns and lagged U.S. returns implies that the Japanese opening price does not fully reflect available information about lagged U.S. returns.

However, a mitigating factor may be found in the use of non-synchronous index data to study correlation structures. The opening Nikkei 225 value is obtained at 9:01 a.m. (Tokyo). Many of the index's component stocks may not have traded by then, meaning that their previous closing prices are used. This would cause a sticky opening index value that does not differ substantially from the previous close. If this is the case, the effect of lagged U.S. returns on overnight Japanese returns would be underestimated and, more importantly, the reported effect on the subsequent Japanese open to close returns would be overestimated.

This paper investigates the effects of information on price movements in one country (U.S. or Japan) on the intraday returns in the other. Using hourly prices for both markets, we are able to address a key question that Kato and BFG could not: how long does it take for returns information in one country to be incorporated into share prices in the other? Thus, our focus is on the intraday interdependence structure between the U.S. and Japanese equity markets. The analysis includes an investigation of return volatilities as well. Also, an ancillary purpose of this paper is to determine if the same conclusion of Kato and BFG hold for a longer time period, which includes 1989.

Consistent with market efficiency, we find that the local market reacts quickly (within the first hour) to the lagged returns information in the other market. Especially, we find that subsequent hourly returns in the Japanese market are independent of the previous returns in the U.S., even after large movements. The evidence suggests that the documented significant correlation between current Japanese open to close returns and lagged U.S. returns is attributable to a sticky Japanese opening index value.

Other, rather anomalous, results are also provided by this study. First, the initial hour U.S. market returns are highly correlated (.238) with the lagged Japanese returns, despite a low correlation (.066) between U.S. overnight returns and lagged Japanese returns. Second, unlike previous studies we find that the Japanese market does influence the U.S. market once a simple filter is applied. Third, both markets exhibit heightened first hour volatility and often sustained

levels of intraday volatility after sessions in which the other market exhibits substantial value changes.[2]

This paper is organized as follows. Section 2 describes the data and methodology used. Correlation results between the open to close performance in one market and the subsequent hourly returns in the other are reported in section 3.1. Section 3.2 analyzes the effects of a large movement in one market on the intraday returns in the other, while section 3.3 investigates the impact of a large change in one market on the hourly volatilities in the other. Section 4 concludes the paper.

## 2. Data and Methodology

### 2.1. Data

Hourly data for the Nikkei 225 from October 5, 1985 to December 31, 1989 were obtained from Nihon Keizai Shimbun (Japan Economic Journal). The index consists of 225 of the largest capitalized stocks on the First Section of the TSE.[3] The TSE is open from 9:00 to 11:00 a.m. and 1:00 to 3:00 p.m. Tokyo time, Monday through Friday.[4] Until July 1986, the TSE was open on the first, third, and fourth Saturdays of each month. From August 1986 through January 1989, Saturday sessions were held on the first and third Saturdays of each month. Saturday hours were 9:00 to 11:00 a.m. No Saturday trading has occurred since January 1989.[5]

Hourly data for the SP500 for the same period were obtained from Standard and Poor's. Since prices were extremely volatile during the crash, the week of October 19 to 23, 1987 was deleted from the sample.

## 2.2. Methodology

To analyze the impact of the U.S. market on Japan, correlations are calculated between the lagged SP500 open to close returns (arithmetic) and the Nikkei 225 first hour returns, second hour returns, and so on. To assess the effect of the Japanese market on the U.S., opposite correlations are computed.[6] When prices could not be obtained for a lagged or current trading day in one country due to a closed market, the corresponding observation is deleted from the sample, ensuring that the open to close returns in one country are always followed by the intraday returns in the other.

The effects of a large movement in one market on the hourly changes in the other are also investigated. Specifically, mean and median hourly returns in one market are calculated separately after the other increases by 1.5 percent, and by 2.0 percent, and after the market decreases by these same percentages. The transmission of volatility is also investigated by computing hourly standard deviations after applying the same filters.

# 3. Results

## 3.1. Hourly Correlations Between Markets

Correlations between the open to close returns in one country and the subsequent returns in the other country are reported in Tables I and II. Open to close results are similar to the Kato and BFG findings: the lagged U.S. returns have a great impact on the Japanese overnight returns (.385), and a lesser but significant impact on the subsequent Japanese open to close returns (.222). The Japanese daily

performance exhibits substantially less effect on the U.S. overnight (.066) and open to close (.109) returns.

With hourly data, we can determine the (approximate) speed of adjustment of the Japanese market to the lagged changes in the U.S. market. From Table I, the Japanese market reacts quickly to the U.S. returns information, with a correlation between the lagged SP500 returns and the first hour Nikkei 225 returns equal to .418. Nikkei 225 returns from 10:00 a.m. to 11:00 a.m. and during the lunch break (11:00 a.m. to 1:15 p.m.) are both negative and statistically significant, suggesting a possible overreaction effect. However, these correlations are small in magnitude (-.072 and -.133). Correlations for the afternoon trading hours (-.023 and .055) are insignificant at the 5 percent level. The overall pattern of subsequent Japanese intraday return correlations suggests that traders are rapidly incorporating information about lagged U.S. returns and, further, that the significant open to close correlation (.222) is attributable to sticky opening index values and is not indicative of market inefficiency.

Correlations between the current Nikkei 225 daily returns and subsequent SP500 returns are reported in Table II. A puzzling finding is that the first hour correlation is substantial (.238) despite a rather low correlation between the U.S. overnight returns and the lagged Japanese returns (.066). This result, however, may be driven by a sticky SP500 opening value. The subsequent intraday correlations reported in Table II are statistically insignificant.

3.2. Effects of Large Movements on Hourly Returns

Tables III through VI report mean and median hourly returns in one market after large changes have occurred in the other. Overall, the results indicate that the local market responds rapidly to the information about the other market. For example, after the SP500 increases by 2 percent or more, the first hour return in Japan averages .906 percent, with 90 percent of the return observations positive (Table III). Slight evidence of overreaction exists, as the subsequent three intraday returns are, on average, negative. The first hour return is not as dramatic when the U.S. market decreases by 2 percent or more (-.638 percent, Table IV). The results following a 1.5 percent or greater absolute value change are similar (Tables V and VI), with predictably large first hour absolute returns.

The U.S. market also appears to react dramatically in the first hour of trading in response to a major movement in the Nikkei 225. For example, after the Japanese market is up by 2 percent or more, the average SP500 first hour return is .712 percent (Table III). However, this mean is statistically insignificant, likely due to the lack of observations (13). The first hour mean return for the +1.5 percent trigger is significant (Table V).

The results presented in Tables III through VI are consistent with market efficiency. The two markets react quickly to the lagged returns information; first hour mean returns are large (in absolute value), and subsequent intraday returns are generally independent of the previous market returns.

3.3. Effects of Large Movements on Hourly Volatilities

The overall hourly volatilities of both markets, reported in Table VII and illustrated in Figures 1 and 2, follow a familiar u-shaped pattern, falling from the opening hour and rising until market close (see [11], [14], [24], [32]). After a substantial (1.5 percent or greater) absolute value change in one market, however, subsequent first hour volatility in the other market is statistically significantly greater.[7] For example, the first hour SP500 volatility is 1.122 percent after a fall in the Nikkei 225 of 1.5 percent or more. This first hour volatility is more than twice the overall first hour volatility of the SP500 for the sample period (.556 percent), and is statistically significantly greater than the corresponding hourly volatility for the remaining sample (F-statistic = 4.67). For the Japanese market, first hour volatility is .741 percent after the SP500 declines by 1.5 percent or more, and is statistically significantly greater than the corresponding hourly volatility for the remaining sample (F-statistic = 2.27).

Substantial first hour volatility may be anticipated in the local market following such large value changes in the other market. However, it appears that such high volatility often persists during subsequent intraday periods. For instance, the SP500 continues to exhibit statistically greater volatility during the four 1-hour trading sessions occurring between 10:00 a.m. and 2:00 p.m. following a large decline in the Nikkei 225. Also, the volatility of the Japanese market remains abnormally high throughout the entire trading day following a

substantial decline in the SP500. We are unable to justify such persistent intraday volatilities.

## 4. Conclusion

Using intraday data for the SP500 and Nikkei 225, we document the intraday correlation structure between the U.S. and Japanese equity markets. Consistent with the semi-strong form of the efficient market hypothesis, we find that the focal market reacts quickly to the returns information provided by the other market. The correlation between first hour returns in Japan and lagged U.S. returns is substantial, and vice versa. Furthermore, subsequent intraday returns exhibited by the focal market are generally independent of the lagged returns, regardless of their magnitude. The evidence suggests that the previously recorded large correlation between current Japanese open to close returns and lagged U.S. returns is attributable to a sticky opening Nikkei 225 value.

First hour volatility in the local market is substantial following large value changes in the other market. Unlike returns, however, subsequent intraday volatility appears to retain its dependency on the lagged behavior. This may signal market overreaction and inefficiency.

## Footnotes

[1]There is a 14 hour time difference between New York and Tokyo. The Tokyo Stock Exchange (TSE) opens at 7:00 p.m. EST (9:00 a.m. Tokyo time) and closes at 1:00 a.m. EST (3:00 p.m. Tokyo time).

[2]Other than Kato and BFG, related research includes studies of correlations of national securities markets with implications for international diversification ([2], [10], [13], [15], [22], [23], [26], [29]), studies of international equity market linkages around the October 1987 crash ([1], [4], [6], [12], [21], [25], [30]), general studies of the transmission mechanisms among international equity markets ([7], [8], [9], [16], [17], [31]), and studies investigating the speed of adjustment of markets to various economic events ([18], [27], [28]).

[3]The First Section of the TSE contains the most actively traded stocks of the largest Japanese firms. The market value of the Nikkei 225 accounts for approximately 50 percent of the market value of all stocks traded on the First Section. The Nikkei 225 is arithmetically averaged and value weighted. See Brenner, Subrahmanyam and Uno [5] and Kato, Schwartz and Ziemba [20] for more detail on Japanese market indices.

[4]The opening for the Nikkei 225 is obtained at 9:01 a.m. The reported price after the lunch break occurs at 1:15 p.m. The remaining index values are reported on the hour.

[5]Historically, the TSE was open on all Saturdays until the end of 1972. Until July 1983, the market was closed on the third Saturday of the month. See Kato, Schwartz and Ziemba [20].

[6]Since the New York Stock Exchange opens at 9:30 a.m. EST, the first U.S. return is a half-hour return from 9:30 to 10:00 a.m.

[7]Similar results (not reported) obtain for the 2 percent filter.

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Table I

Correlations Between Lagged SP500 Returns and
Subsequent Nikkei 225 Returns

| Nikkei 225 Returns | Correlations | P-Values | Observations |
|---|---|---|---|
| Close to Open (Overnight) | .385 | .000 | 978 |
| Open to Close (Daily) | .222 | .000 | 1019 |
| Open to 10:00 a.m. | .418 | .000 | 1018 |
| 10:00 a.m. to 11:00 a.m. | -.072 | .022 | 1017[a] |
| 11:00 a.m. to 1:15 p.m. | -.133 | .000 | 921[b] |
| 1:15 p.m. to 2:00 p.m. | -.023 | .484 | 921[b] |
| 2:00 p.m. to Close | .055 | .095 | 921[b] |

[a]One observation at 10:00 a.m. was missing.

[b]Saturday trading hours were 9:00 a.m. to 11:00 a.m.

Table II

Correlations Between Lagged Nikkei 225 Returns
and Subsequent SP500 Returns

| SP500 Returns | Correlations | P-Values | Observations |
|---|---|---|---|
| Close to Open (Overnight) | .066 | .047 | 906 |
| Open to Close (Daily) | .109 | .000 | 1014[a] |
| Open to 10:00 a.m. | .238 | .000 | 1012 |
| 10:00 a.m. to 11:00 a.m. | .023 | .461 | 1012 |
| 11:00 a.m. to 12:00 p.m. | .049 | .119 | 1012 |
| 12:00 p.m. to 1:00 p.m. | -.046 | .147 | 1012 |
| 1:00 p.m. to 2:00 p.m. | .022 | .484 | 1007[b] |
| 2:00 p.m. to 3:00 p.m. | -.005 | .867 | 1003[b] |
| 3:00 p.m. to Close | -.025 | .421 | 1003[b] |

[a]There were two trading days in which only opening and closing data were available.

[b]Missing data for 2:00 p.m. and 3:00 p.m. values from October 26, 1987 through November 6, 1987.

Table III

Descriptive Statistics for Market Returns in Japan
or U.S. After Other Market Increases by 2% or More

Panel A: Japan

| Nikkei 225 Returns | Means | Medians | P-Values | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | .093% | .091% | .000 | 28 | 89 |
| Open to 10:00 a.m. | .906 | .749 | .000 | 30 | 90 |
| 10:00 a.m. to 11:00 a.m. | -.128 | -.130 | .072 | 30 | 37 |
| 11:00 a.m. to 1:15 p.m. | -.030 | .014 | .533 | 26 | 60 |
| 1:15 p.m. to 2:00 p.m. | -.059 | -.086 | .117 | 26 | 33 |
| 2:00 p.m. to Close | .103 | .051 | .067 | 26 | 66 |

Panel B: United States

| SP500 Returns | Means | Medians | P-Values | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | .044% | .021% | .058 | 12 | 67 |
| Open to 10:00 a.m. | .712 | .224 | .151 | 13 | 62 |
| 10:00 a.m. to 11:00 a.m. | -.194 | -.294 | .149 | 13 | 31 |
| 11:00 a.m. to 12:00 p.m. | .052 | .040 | .644 | 13 | 62 |
| 12:00 p.m. to 1:00 p.m. | -.213 | -.041 | .098 | 13 | 46 |
| 1:00 p.m. to 2:00 p.m. | .019 | .000 | .776 | 13 | 54 |
| 2:00 p.m. to 3:00 p.m. | -.011 | -.000 | .926 | 13 | 54 |
| 3:00 p.m. to Close | -.032 | -.000 | .793 | 13 | 54 |

Table IV

Descriptive Statistics for Market Returns in Japan or U.S.
After Other Market Decreases by 2% or More

Panel A: Japan

| Nikkei 225 Returns | Mean | Median | P-Value | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | -.052% | -.047% | .001 | 26 | 12% |
| Open to 10:00 a.m. | -.638 | -.707 | .002 | 27 | 19% |
| 10:00 a.m. to 11:00 a.m. | .128 | .300 | .366 | 27 | 66% |
| 11:00 a.m. to 1:15 p.m. | .189 | .094 | .019 | 26 | 74% |
| 1:15 p.m. to 2:00 p.m. | -.031 | -.001 | .711 | 26 | 44% |
| 2:00 p.m. to Close | -.059 | .000 | .487 | 26 | 56% |

Panel B: United States

| SP500 Returns | Mean | Median | P-Value | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | -.052% | -.023% | .213 | 12 | 42% |
| Open to 10:00 a.m. | -.579 | -.350 | .163 | 15 | 33% |
| 10:00 a.m. to 11:00 a.m. | -.081 | .094 | .570 | 15 | 60% |
| 11:00 a.m. to 12:00 p.m. | .126 | .075 | .438 | 15 | 53% |
| 12:00 p.m. to 1:00 p.m. | -.090 | -.034 | .694 | 15 | 47% |
| 1:00 p.m. to 2:00 p.m. | .062 | .051 | .186 | 15 | 80% |
| 2:00 p.m. to 3:00 p.m. | -.064 | -.014 | .396 | 15 | 47% |
| 3:00 p.m. to Close | -.070 | -.181 | .550 | 15 | 47% |

Table V

Descriptive Statistics for Market Returns in Japan or U.S.
After Other Market Increases by 1.5% or More

Panel A: Japan

| Nikkei 225 Returns | Mean | Median | P-Value | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | .078 | .078 | .000 | 63 | 87% |
| Open to 10:00 a.m. | .641 | .602 | .000 | 66 | 86% |
| 10:00 a.m. to 11:00 a.m. | -.084 | -.094 | .045 | 66 | 38% |
| 11:00 a.m. to 1:15 p.m. | .022 | .064 | .390 | 60 | 62% |
| 1:15 p.m. to 2:00 p.m. | -.017 | -.022 | .400 | 60 | 42% |
| 2:00 p.m. to Close | .098 | .099 | .003 | 60 | 65% |

Panel B: United States

| SP500 Returns | Mean | Median | P-Value | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | .033 | .066 | .002 | 30 | 70% |
| Open to 10:00 a.m. | .470 | .184 | .028 | 32 | 66% |
| 10:00 a.m. to 11:00 a.m. | -.059 | -.000 | .418 | 32 | 50% |
| 11:00 a.m. to 12:00 p.m. | .059 | .047 | .265 | 32 | 63% |
| 12:00 p.m. to 1:00 p.m. | -.090 | -.001 | .143 | 32 | 43% |
| 1:00 p.m. to 2:00 p.m. | -.020 | -.000 | .630 | 30 | 43% |
| 2:00 p.m. to 3:00 p.m. | .029 | -.000 | .595 | 30 | 53% |
| 3:00 p.m. to Close | .000 | .001 | .938 | 30 | 57% |

Table VI

Descriptive Statistics for Market Returns in Japan or U.S.
After Other Market Decreases by 1.5% or More

Panel A: Japan

| Nikkei 225 Returns | Mean | Median | P-Value | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | -.048% | -.038% | .000 | 55 | 13% |
| Open to 10:00 a.m. | -.498 | -.506 | .001 | 59 | 20% |
| 10:00 a.m. to 11:00 a.m. | .078 | .155 | .389 | 59 | 66% |
| 11:00 a.m. to 1:15 p.m. | .118 | .084 | .013 | 52 | 71% |
| 1:15 p.m. to 2:00 p.m. | -.081 | -.083 | .110 | 52 | 33% |
| 2:00 p.m. to Close | -.004 | -.011 | .958 | 52 | 50% |

Panel B: United States

| SP500 Returns | Mean | Median | P-Value | Observations | Percent Positive |
|---|---|---|---|---|---|
| Close to Open (Overnight) | -.022% | -.004% | .272 | 28 | 43% |
| Open to 10:00 a.m. | -.276 | -.072 | .168 | 33 | 39% |
| 10:00 a.m. to 11:00 a.m. | .026 | -.021 | .780 | 33 | 48% |
| 11:00 a.m. to 12:00 p.m. | .073 | .007 | .421 | 33 | 52% |
| 12:00 p.m. to 1:00 p.m. | -.028 | .039 | .943 | 33 | 52% |
| 1:00 p.m. to 2:00 p.m. | .026 | .016 | .700 | 31 | 52% |
| 2:00 p.m. to 3:00 p.m. | .014 | -.012 | .869 | 30 | 47% |
| 3:00 p.m. to Close | -.000 | .003 | .966 | 30 | 53% |

Table VII

Hourly Volatilities (Return Standard Deviations in Percent) for Japan or U.S. After Other Market Changes by 1.5% or More

Panel A: Japan

| | Standard Deviations (%) | | |
|---|---|---|---|
| Nikkei 225 Returns | Overall | U.S. $\geq$ 1.5% | U.S. $\leq$ -1.5% |
| Open to 10:00 a.m. | .531 | .691* | .741* |
| 10:00 a.m. to 11:00 a.m. | .407 | .335 | .687* |
| 11:00 a.m. to 1:15 p.m. | .215 | .194 | .333* |
| 1:15 p.m. to 2:00 p.m. | .300 | .157** | .361* |
| 2:00 p.m. to Close | .362 | .248** | .510* |

Panel B: United States

| | Standard Deviations (%) | | |
|---|---|---|---|
| SP500 Returns | Overall | U.S. $\geq$ 1.5% | U.S. $\leq$ -1.5% |
| Open to 10:00 a.m. | .551 | 1.150* | 1.122* |
| 10:00 a.m. to 11:00 a.m. | .337 | .407* | .541* |
| 11:00 a.m. to 12:00 p.m. | .291 | .294 | .531* |
| 12:00 p.m. to 1:00 p.m. | .269 | .339* | .606* |
| 1:00 p.m. to 2:00 p.m. | .248 | .226 | .369* |
| 2:00 p.m. to 3:00 p.m. | .296 | .293 | .246 |
| 3:00 p.m. to Close | .473 | .355** | .448 |

*(**)Indicates that the volatility is statistically significantly greater (less) than the corresponding hourly volatility for the remaining sample, based on the F-test, at the 5 percent level.

Figure I: Nikkei 225 Hourly Standard Deviations

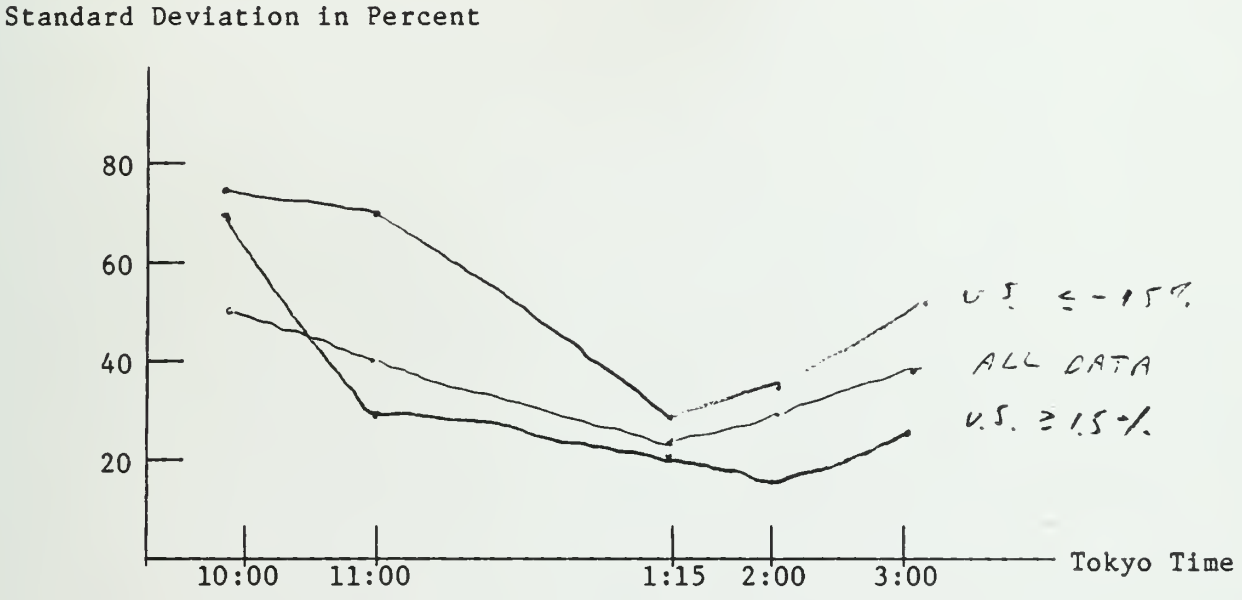
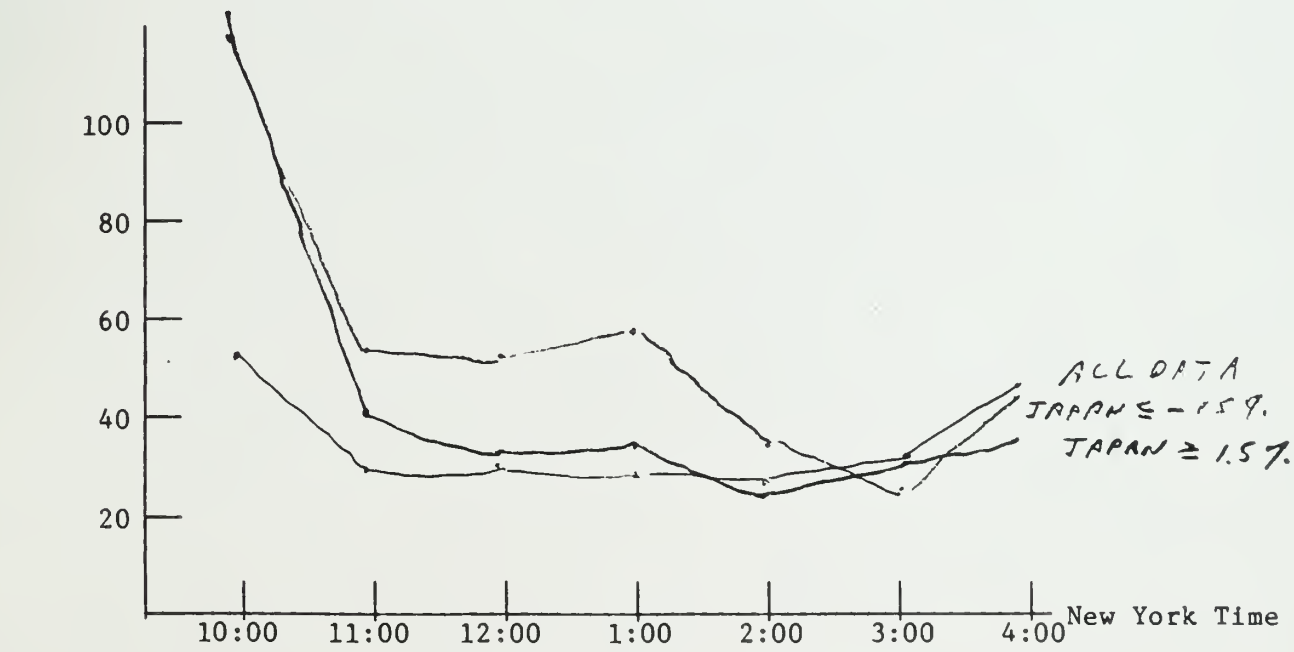



Figure II: SP500 Hourly Standard Deviations



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