1995

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Citation/Publisher Attribution
Chen, S. K., Jarrett, J., & Rhee, S. G. (1995). The Impact of Futures Trading on Cash Market Volatility: Evidence from the Tokyo Stock Exchange. *Research in International Business and Finance, 12*, 214-250.

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THE IMPACT OF FUTURES TRADING ON CASH MARKET VOLATILITY:
EVIDENCE FROM THE TOKYO STOCK EXCHANGE

Shaw K. Chen, Jeffrey E. Jarrett, and S. Ghon Rhee

ABSTRACT

This paper has examined Japanese stock market volatility using alternative estimates of volatility and several testing procedures to compare the time periods before and after the introduction of index futures contracts. On the basis of 100 randomly selected stocks, empirical evidence from these tests indicates that futures trading had an insignificant impact on price volatility in the cash market. The results are generally consistent with what has been reported for the U.S. market.

INTRODUCTION

The impact of futures trading on stock market volatility is a popular subject of debate among investors and regulators, as well as researchers. One argument is that futures trading reduces volatility because the larger number of traders tends to increase the liquidity in the underlying cash markets. The Tokyo Stock Exchange

Research in International Business and Finance
Volume 12, pages 241-250.

ISBN:1-55938-919-2

(TSE) subscribes to this reasoning. In fact, the 1991 TSE Fact Book states that the aim of stock index futures is to assure greater liquidity of the market through increasing investment opportunities.

Cox (1976) states that an active futures market will lead to speedier and more efficient price adjustments. This notion is empirically supported by Froot, Gammill, and Perold (1990). They report that the predictability of short-term stock returns has declined markedly since 1983 while program trading has experienced a growth in the U.S. market. The absence of predictability is a fundamental feature of a well-functioning market. However, Stein (1984) argues that futures trading brings more uninformed speculative traders into the markets. As a consequence, the markets destabilize and volatility increases. It seems, therefore, that these two conflicting arguments can only be resolved by empirical evidence.

Many researchers including Edwards (1988a and 1988b), Grossman (1988), and Schwert (1990) report that derivative markets have no significant impact on stock market volatility. Skinner (1989) observes a decline in the volatility of underlying individual stocks after stock options were introduced. In contrast, Harris (1989) finds that the volatility of S&P 500 stocks marginally increased relative to a control group of comparable stocks. In addition, Lockwood and Linn (1990) document increased cash market volatility after introduction of index futures trading.

On September 3, 1988, the Tokyo Stock Exchange (TSE) and the Osaka Securities Exchange (OSE) started trading in index futures contracts based on the Tokyo Stock Price Index (TOPIX) and the Nikkei Stock Average (NSA). This event marked an expansion of equity trading in Japan. TOPIX is a value-weighted composite index of all common stock listed on the first section of the Tokyo Stock Exchange, while NSA is a price-weighted average of 225 stocks traded on the TSE. In 1989, the mean ratio of the stock index futures trading value to that of the cash market was only 0.88. This ratio increased dramatically to 2.65 in 1990, 5.31 in 1991, and 5.21 in 1992, indicating that the mean size of the index futures markets became five times greater than that of the cash market. In view of this large expansion in the index futures markets, and faced with the unprecedented bear market trend since January 1990, Japanese financial market regulators believed that equity derivative markets were the cause of the cash market depression. Consequently, Japanese regulatory authorities made it more costly to transact in the derivative markets by increasing margin requirements and brokerage commission rates, while attempting to increase the attractiveness of the cash market. Despite these activities, very little empirical evidence is documented on the Japanese market concerning the impact of index futures trading on market volatility.

In this paper, we provide evidence from an extensive statistical analysis to provide additional insight into these markets. We introduce four measures of price volatility to examine stock price behavior before and after index futures trading was instituted. The remaining sections of this paper are organized as follows: first, data considerations and the experimental designs are described in the second section; second, test results and their implications are presented in the third section; and finally, summary and conclusions are provided in the last section.

DATA AND DESIGNS

To investigate the impact of TOPIX futures trading on the behavior of TSE stock price volatility, we collected daily price data for 100 randomly selected stocks from the PACAP Databases-Japan compiled by the PACAP Research Center of the University of Rhode Island for the time period from May 1987 to December 1989. Random sampling of 100 firms is preferred to examining all 225 component stocks of the NSA for the following reasons. First, a large number of the NSA stocks are illiquid. When the 225 stocks are ranked based on trading volume, the bottom 100 stocks accounted for less than 15% of the total trading volume of the NSA stocks in 1991. Second, contrary to common perception, a fairly large number of NSA stocks are issued by small-size companies. Third, a few high-priced stocks tend to dominate the NSA index quotes. Therefore, the NSA is considered an inappropriate benchmark index for the entire market.

The 100 stocks are classified into three groups according to their stock price level. The resulting groups are: (1) low-priced stocks; (2) medium-priced stocks; and (3) high-priced stocks. The justification for this grouping design is due to the belief that stock prices are highly correlated to the size of the firm and price volatility is affected by the price levels. A list of the companies selected is presented in the Appendix.

Two sets of data are employed to test the equality of price volatility before and after the introduction of index futures contracts. The first data set covers the period from May 1987 to September 1989, thus encompassing the period one year before and after the futures inception. To reduce the potential bias associated with the backlash of the worldwide market crash, we excluded October, November, and December of 1987, and January of 1988 from our sample.

Four volatility measures are calculated. The first measure, *V*1, is estimated by averaging the squared daily rate of return in a month, assuming the mean rate of return is zero (Grossman 1988; Skinner 1989). The second measure, *V*2 (which is similar to *V*1) calculates the sample standard deviation of price change in each month assuming the rate of return is not zero. The third measure, *V*3, uses daily high, low, and opening prices to compute the monthly mean ratio of daily price spread to the opening price. The fourth measure, *V*4, follows the extreme value method of Parkinson (1980) and Garman and Klass (1980), where we calculate the mean daily high–low variance estimator within a month.

A second set of data is utilized to examine the equality of the daily return variability one month before and after September 3, 1988. There are many tests of variability that can be employed, but many have application drawbacks. Therefore, we utilize the Ansari–Bradley (1960) distribution-free test and the modified Levene parametric statistic with the daily returns.

The Ansari–Bradley nonparametric test for two independent samples assumes that the two populations have identical means and medians but different amounts of dispersion. The test will determine whether the group with a greater amount of variability yields a sample with greater variability. Thus, we would expect the sample with greater variability to have a smaller sum of ranks. The modified Levene (1960) test suggested by Brown and Forsythe (1974) is performed by assuming that $x_{ij} = \mu_i + \varepsilon_{ij}$, where x_{ij}, is the jth observation in the ith group (i= 1,2); the mean μ_i is neither known nor assumed equal; ε_{ij}, is i.i.d. with zero mean and unequal standard deviations.

EMPIRICAL RESULTS

Mean volatility of the four different volatility measures, $V1$, $V2$, $V3$, and $V4$, for each stock are presented in Table 1. As expected, the low-priced stock group has higher volatility than the high-priced stock group for all four measures. The reported volatility measures in the first three columns lead us to conclude that volatility has declined for all three groups of companies after September 1988.

Using the median test and Wilcoxon's two-sample test, we examine whether the two different time periods possess the same volatility one year before and after September 1988. The number of companies having significantly lower, significantly higher, or insignificantly different mean or median are presented in Table 1. For most companies, we are unable to reject the hypothesis that there are no changes in values for the different groups of companies. However, the number of companies having significantly different means or medians increased using the Wilcoxon test. Also, the number of companies with significantly different means or medians increased for all groups using both tests with the $V3$ and $V4$ measures. One interesting observation from Table 1 is that all of the mean values in the "after" category for $V1$, $V2$, and $V4$ are much lower than their respective values in the "before" category. This indicates that volatility declined after the advent of stock index futures.

In addition, a relative measure of variability is used to avoid problems associated with spurious correlation. We adjusted the $V1$ measures with values computed from the whole market as the base by deflating the daily squared returns of a company using the daily squared returns of TOPIX. The results from the adjusted measures are shown in the last panel. The most interesting and important finding is that both the median test and the Wilcoxon test suggest that price volatility has not changed for the majority of stocks.

We now compare the variation of daily returns one month before and one month after futures trading. The Ansari-Bradley test for the equality of two independent

Table 1. Price Volitility Change in Daily Return Volatility: One Year Before and After Trading of Futures Contracts

Group	Mean of Volatility Measures			Median Test*			Wilcoxson Test*		
	Before	After	Change	Decrease	Increase	No Change	Decrease	Increase	No Change
				Panel A: V1					
1	0.00066	0.00055	−0.00011	3	0	31	9	1	24
2	0.00060	0.00048	−0.00012	2	2	29	6	2	25
3	0.00055	0.00039	−0.00016	5	0	28	11	1	21
				Panel B: V2					
1	0.02386	0.02139	−0.00247	5	0	29	10	1	23
2	0.02248	0.02059	−0.00189	3	2	28	5	3	25
3	0.02152	0.01820	−0.00332	6	2	25	11	1	21
				Panel C: V3					
1	0.02474	0.02251	−0.00223	7	1	26	9	4	21
2	0.02338	0.02185	−0.00153	5	5	23	5	9	19
3	0.02278	0.01923	−0.00355	8	2	23	12	4	17
				Panel D: V4					
1	0.00016	0.00014	−0.00002	5	0	29	10	2	22
2	0.00015	0.00012	−0.00003	4	1	28	5	6	22
3	0.00014	0.00010	−0.00004	8	1	24	12	3	18
				Panel E: V1 (Deflated by the TOPIX daily volatility)					
1	2,630	144,768	142,138	0	0	34	0	2	32
2	2,748	86,222	83,474	0	1	32	0	5	28
3	1,625	87,825	86,199	0	2	31	2	3	28

Note: *Values reported here are number of companies with significantly lower, significantly higher, and insignificant measures of volatility after trading of futures contracts at the 0.05 level.

Table 2. Change in Daily Return Volatility: One Month Before and After Trading of Futures Contracts

	Group 1	*Group 2*	*Group 3*
Standard Deviation (Before)	0.0212148	0.0220154	0.0192983
Standard Deviation (After)	0.0244655	0.0254748	0.0175727
Change in Standard Deviation	0.0032507	0.0034594	−0.0017256
Ansari–Bradley Test[1]			
Number of Higher	6	5	3
Number of Lower	2	3	3
Number of No Change	26	24	25
Total[2]	34	32	31
Modified Levene Test[1]			
Number of Significant Change[3]	5	6	5
Number of No Change	29	26	26
Total[2]	34	32	31

Notes: [1]All tests are at the 5% level of significance.
[2]Total number of companies used in the test is 97. No trimmed means were available for three firms.
[3]This test follows an F-distribution. Only right-tail test is conducted.

samples of daily returns is used to see if the two groups have the same mean, but different variability. One expects that the group with greater variability would produce a sample with smaller ranks. From all three groups of companies investigated, Table 2 shows a relatively small number of companies, 8, 8, and 6, respectively, for groups 1, 2, and 3, with statistically significant variations for the one month before and one month after periods. The number of companies with significant variations is even smaller when we separate them into two groups based on the magnitude of the variations.

Results from the modified Levene test are similar to those of the Ansari-Bradley test. The total number of companies with statistically significant variation in returns, however, is even smaller. This leads us to believe that the introduction of futures trading did not change the volatility in the Japanese market.

CONCLUSION

This paper has examined Japanese stock market volatility using alternative estimates of volatility and several testing procedures to compare the time periods before and after the introduction of index futures contracts. On the basis of 100 randomly selected stocks, empirical evidence from these tests indicates that futures trading had an insignificant impact on price volatility in the cash market. The results are generally consistent with what has been reported for the U.S. market.

Introduction

Furthermore, the deviations in annual mean surface runoff over the Indian subcontinent has also been observedand concluded that the estimated annual discharge would increase up to ~ 25% by 2080 [1]. demand for various sectors such as domestic, industrial and agricultural uses, has already increased in last few decades [2]. Consequently, the expansion of agricultural sectors, land use pattern, development of industrial and urban centers are modifying the hydrological cycle, resulting in the per capita water demand of 1341 and 1140 m3 /person/year by 2025 and 2050 respectively [3].

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2. Article Author, A. A., & Article Author, B. B. (Year). Title of article. *Title of Journal, volume number* (issue number if necessary), inclusive page numbers.

3. Article Author, A. A., & Article Author, B. B. (Year). Title of article. *Title of Journal, volume number* (issue number if necessary), inclusive page numbers.

Reference style: **APA** (**American Psychological Association**)

1. References should be numbered consecutively in the order in which they are first mentioned in the text (not in alphabetic order).
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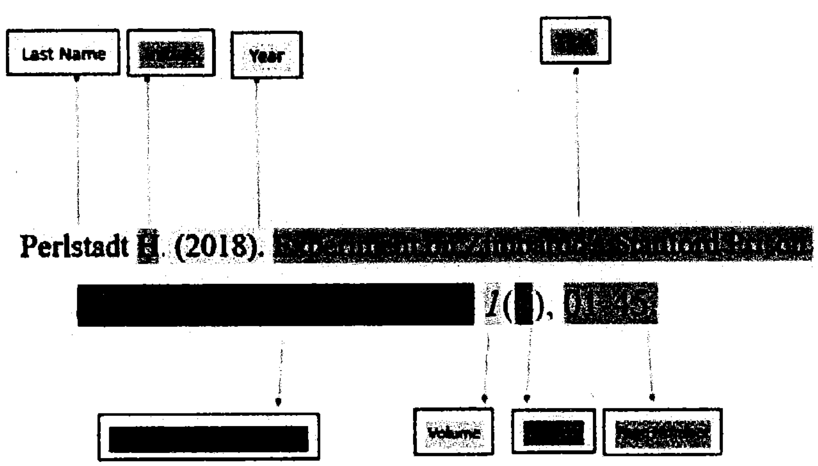
Use the style of the examples below

Example: Journal article (print)

Author(s) Name. (Year) "Title". *Journal of Business Strategy Finance and Management, 1*(1), 01-11.



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APPENDIX

FIRM LISTING

Akebono Brake	Ask Corporation
Atsugi Nylon Industrial	Chisan Tokan Co. Ltd.
Copal	Dai Nippon Toryo
Daifuku Co. Ltd.	Dantani Corp.
Danto	Fuji Spinning
Fujitsu General Ltd.	Furukawa Battery
Gun-ei Chemical Industry	Hakuyosha
Hamai	Hanshin Elect. Railway
Hirose Electric	Hitachi Condenser
Hitachi Sales	Hochiki
Hokkaido Coca–Cola	Honshu Chemical Industry
Howa Machinery	Hyakugo Bank
I.B.J	Inax
Ishii Precision Tool	Itoham Foods Inc.
Iwasaki Electric	Iwatani Int'l Corp.
Joban Kosan	Kaken Pharm
Kamigumi	Kanegafuchi Chemical
Kawaguchi Chemical	Keiyo Gas
Kinden Corporation	Kitz Corp.
Koa Oil	Kojima Iron Works
Kokoku Steel Wire	Kurimoto Iron
Kyowa Bank	Marubeni Corp.
Maruzen Showa Unyu	Mitsubishi Bank
Mitsubishi Oil	Mitsubishi Trust Bank
Mitsumi Electric	Mizuno Corporation
Kogyo	Nankai Worsted
New Japan Securities	Nihon Matai
Nippon Kan. Kaku. Sec.	Nippon Kayaku
Nippon Koei	Nippon Seiro
Nippon Synth Chemical	Nissan Construction
Nissan Motor	Nisshin Steel
Nok Corporation	Ohbayashi Corp.
Okumura Corp.	Orix Corporation

Oval Engineering
S.M.K.
Sakai Textile Mfg.
Sanoh Industrial
Sawafuji Electric
Shinwa Kaiun
Sony
Suzuki Metal
Taisho Pharm
Takiron Co.
The Nisshin Oil Mills
Tokyo Theatres
Topre
Toshiba Steel Tube
Tosho Printing
Toyota Motor
Yamaichi Securities
Rohto Pharm.
Sagami Rubber Industries
Sanki Engineering
Sanyo Industries
Seiko Corporation
Showa Tansan
Superbag
Tachihi Enterprise
Taiyo Fishery
The Japan Paper Industry
The Shizuoka Bk. Ltd.
Tokyo Tomin Bank
Toshiba Ceramics
Toshiba Tungaloy
Toyo Suisan
Union Optical
Yuasa Trading Co.

ACKNOWLEDGMENT

We are grateful for the comments and suggestions of Abdur R. Chowdhury and John Doukas, editor of this volume, and participants at the Fourth Annual PACAP Finance Conference held in Hong Kong in June 1992.

NOTES

1. We confined our study to the TOPIX index futures. TOPIX is a market-value weighted index of all first section listed stocks compiled by the Tokyo Stock Exchange. This index is different from the Nikkei Stock Average (NSA) computed by the Nihon Keizai Shimbun-Sha using 225 component stocks. The NSA index futures are traded on the Osaka Securities Exchange.

2. October 21, 1987 and January 6, 1988 are the second and the fourth largest day-to-day fluctuations in TOPIX history from 1969 to 1990. In addition, October 20 and 23 of 1987 are the first and the tenth largest declines for TOPIX.

3. V3 is calculated as:

$$V_3 = \frac{1}{n}\sum_{1}^{n}\left(\frac{P_h - P_1}{P_o}\right)_i$$

where P_h, P_l, and P_o are high, low, and open price, respectively, and n is the number of trading days in the month.

4. V_4 is calculated as:

$$V_4 = \frac{1}{41n2}\left(\frac{1}{n}\right)\sum_{i=1}^{n} d_i^2$$

where $d_i = \ln(P_h/P_l)$.

5. All returns are computed in log form, $\ln(1+r_t)$, where r_t is the daily return adjusted for stock dividends, right offerings, and payment of bonus shares for day t as specified in the PACAP User Guide.

6. The Ansari–Bradley test statistic is calculated as follows: (1) combine two samples together and rearrange observations in ascending order; (2) assign ranks to observations: the smallest and the largest measurements are each given a rank of 1; the second smallest and the second largest measurements are each given a rank of 2; continue the process until all observations have been assigned a rank; (3) calculate the sum of the ranks assigned to observations in the first sample, say T; (4) calculate the test statistic according to the following formula:

$$T^* = \frac{T - [n_1(n_1+n_2+2)/4]}{\sqrt{n_1 n_2 (n_1+n_2+2)(n_1+n_2-2)\,]/48(n_1+n_2-1)}}$$

if $n_1 + n_2$ is even, and

$$T^* = \frac{T - \left[n_1(n_1+n_2+1)^2/4(n_1+n_2)\right]}{\sqrt{n_1 n_2 (n_1+n_2+1)\left[3+(n_1+n_2)^2\right]/48(n_1+n_2)^2}}$$

if $n_1 + n_2$ is odd; and (5) compare the test statistic T^* with the critical values from the standard normal distribution. Here, n_1 and n_2 refer to the number of observations in the first group and second group, respectively.

7. The modified Levene test statistic is calculated by

$$W = \frac{\sum_i n_i (\bar{z}_{i.} - \bar{z}_{..})^2}{\sum_i \sum_j (z_{ij} - \bar{z}_{i.})^2 / \sum_i (n_i - 1)}$$

where $\bar{z}_{i.} = \Sigma z_{ij}/n_i$, $\bar{z}_{\cdot} = \Sigma\Sigma z_{ij}/\Sigma n_i$, and $z_{ij} = |x_{ij} - \bar{x}_i| \bar{z}_{i.} \bar{x}_i$ is replaced with a 10% trimmed mean of the *i*th group and the test statistic is compared with critical value from F-table with 1 and $\Sigma_i (n_i - 1)$ degrees of freedom. n_i is the number of observations in group i. Trimmed mean is an estimate in the location problem to construct a class of estimates providing some intermediate behavior that includes both the mean and the median. It has been shown that the performance of a trimmed mean with moderate α, say 0.1 in this study, is never much worse than that of the sample mean and can be much better (Bickel 1965).

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