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THE TOKYO STOCK EXCHANGE: AN ANALYSIS OF STOCK MARKET PRICES

by

*Richard H. Pettway**
and
*T. Craig Tapley***

I. Introduction

In the recent literature there has been considerable interest in the efficiency and characteristics of foreign capital markets: D'Ambrosio [3], Singapore; Dryden [4], United Kingdom; Hong [8], Australia, Hong Kong, Japan, Singapore; Pesando [19], Canada; Pretz [20], Australia; and Jennergren & Korsuold [12], Scandinavia. This study extends the literature on foreign capital markets by examining the efficiency of the most important equity market in Japan, the Tokyo Stock Exchange (TSE).[1] This research differs from past studies in that we not only examine three of the major stock Indexes for Japan, but also five individual companies of international stature and interest traded on the TSE.

In addition to the normal tests of weak form efficiency, we will also examine the data for day of the week effects. Day of the week effects have been found to exist in U.S. capital markets by Cross [2], French [6], Gibbons & Hess [7], Chiang & Tapley [1], and Lakonishok & Levi [15]. It will be important to determine whether these effects are specific to the U.S. capital market, or whether they are actually international in scope.

International interest in the Tokyo Stock Exchange has increased as investors have become more concerned with diversification through foreign capital markets.[2] This increased interest in the TSE is evidenced by the fact that non-residents were the largest

* University of Florida, Gainesville, Florida, 32611, U.S.A. This paper was begun while Pettway was a Fulbright Research Scholar and Visiting Professor at Keio University.
** University of Florida.

1) At present, there are eight stock exchanges in Japan: Tokyo, Osaka, Nagoya, Kyoto, Hiroshima, Fukuoka, Niigata, and Sapporo. The Tokyo exchange is by far the largest, accounting for 86% of the total volume of transactions performed by all of the Japanese exchanges in 1980. See [16]. Further, there have been two interesting research papers which provide some analysis of the Japanese equity market prior to 1977. These papers are in Japanese. See [13, 14].

2) As an example of potential diversification, returns of securities listed on the TSE had a .08 correlation coefficient with the returns of stocks listed on the NYSE for the 60 months ending December 1981. These returns are price-change returns in U.S. dollars; therefore, they include currency adjustments. See [21].

net purchasers of stock in 1980 and the second largest purchasers in 1981. In January of 1982, non-residents accounted for over 46% of all net purchases of stocks made by all eleven categories of net purchasers on the TSE.[3] This fact is somewhat surprising when one realizes that non-residents are subject to income withholding taxes of up to 20% on dividends and/or interest.[4]

The Tokyo Stock Exchange is extremely important on an international scale. In 1980 the TSE ranked third, compared to the combined markets of Europe, in terms of total market capitalization, and second in terms of transaction volume. Among the major equity markets of the world such as U.S., Japan, U.K., West Germany, and Switzerland, the TSE ranked first in terms of total return on investment (capital gains plus dividends and currency adjustment), at an annual compounded rate of approximately 16.7%, during the period 1970 to 1980. Even though the yen appreciated during the period, the capital gains plus dividend returns on the TSE also ranked first among these countries.[5]

Specifically, the TSE had 974 companies listed with a market value of $397.6 billion at the end of 1981 on the first section.[6] This market capitalization places the TSE second, behind the NYSE, in terms of the dollar value of listed securities, and makes it 2.4 times larger than the dollar value of stocks listed on the London Stock Exchange.[7]

With these attractive features, there has been an increased interest by non-Japanese brokers in becoming members of the TSE. As of January 1983, there are six non-Japanese brokerage firms operating in Japan under license by the Minister of Finance: four American, one British, and one from Hong Kong.[8]

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3) See [18], page 23.

4) Residents of the United States are subject to a withholding tax of 15% on dividends and 10% on interest from investments in Japan.

5) *How to Invest in Japanese Stocks* (Tokyo: Nomura Securities Co., Ltd., January 1982), page 2. Currently, the *Wall Street Journal* reports the values of and the changes of the World Index of stock market prices derived by Capital International S.A., Geneva and also publishes country indexes of the leading stock markets of the world. Capital International also publishes an excellent source of comparable performance of the equity capital markets of the world in its *Capital International Perspective* monthly and quarterly. Even though the index used for Japan by Capital International is different from the three popular equity indexes used in Japan and used in this paper, the total returns over the decade are of the same general magnitude as those reported above. For example, using Capital International's Japan index and converting yen to dollars, the annual compounded rate of change of capital gains plus dividends in dollars for 1970 through 1980 was approximately 15.1%. For the 20 year period 1960–1980, the Japan index had an annual compound rate of return of 15.6%. See [10].

6) As of the end of 1981, there were 974 firms having an aggregate market value of 88.0 trillion yen listed on the first section of the TSE and 438 firms having an aggregate market value of 3.9 trillion yen listed on the second section. Also in December of 1981, the average daily sales volume on the 1st section was 258 million shares whereas the average daily volume of the 2nd section was 5 million shares. See [17]. Thus, because of the much greater numbers of listed securities, value, volume, and interest, the research in this paper will concentrate only on the 1st section of the TSE.

7) *Tokyo Stock Market Quarterly Review* (Tokyo: Daiwa Securities Co., Ltd., December 31, 1981).

8) In early 1982, the 83 members of the TSE removed their prohibition against foreign broker members. As of January 1983, the six non-Japanese brokers operating under license from MOF were Merrill Lynch, Smith Barney, Prudential-Bache, Salomon Brothers, Vickers Da Costa, and

The TSE is now one of the significant capital markets of the world. It is therefore appropriate to consider whether capital market theories of efficiency, which were developed primarily with knowledge of and application to the NYSE, might also apply to this emerging world market in the East. Further the TSE provides a unique forum to perform additional tests for day of the week effects.[9] The data for our study of weak form efficiency and day of the week effects will be described in Section II. In Sections III and IV, we will discuss the standard tests of weak form efficiency, and in Section V we will discuss the test for day of the week effects. A summary and conclusion will be presented in Section VI.

II. Data

The data consists of 642 daily price observations over the period January 4, 1979 to April 3, 1982.[10] These price observations were collected for three stock indexes and five individual companies. The stock indexes are the Nikkei Dow Jones (NDJ); the Tokyo Stock Exchange Stock Price Index, Simple Average (TSE/SA); and the Tokyo Stock Exchange Stock Price Index, Weighted Average (TSE/WA).[11] These three indexes are well-known and popular stock indexes available to investors on the performance of the first section of the Tokyo Stock Exchange.

Since we wish to study diversification potential and small as well as large portfolio performance, five individual stocks were selected from those which had large international interest The five companies selected were: Sony, Matsushita Electric, Nippon Steel, Shionogi, and Dai-Nippon Printing.[12] Thus, we have selected various portfolios of equities to study, ranging from individual security portfolios, to an intermediate size portfolio of 225 securities, to two total market portfolios of all 974 listed firms.

Jardine Fleming. Also it should be realized that two Japanese brokerage firms, Nomura and Daiwa, have recently become member of the NYSE.

9) At present, there is no completely adequate explanation for day of the week effects, which have been found in prior studies of returns on many American financial markets. However, if it can be shown that the TSE is free of day of the week effects, then this would imply that their existence in U.S. capital markets may arise from institutional peculiarities of the U.S. marketplace.

10) The reason for selecting this period for study is that 1979 to early 1982 is the period of largest international interest in the stocks listed on the TSE.

11) The Nikkei Dow Jones Average is the publication of the major financial newspaper in Japan, the *Nihon Keizai Shimbun*, and contains 225 stocks which are broken into groups in a similar fashion to the NYSE Dow Jones Average. The TSE Stock Price Index (TSE/SA), provided by the exchange, is the simple sum of the prices of all traded shares divided by the number of separate firms traded at a point in time. The TSE Stock Price Index (TSE/WA), also provided by the exchange, is a share price average weighted by the number of shares of each company issued at a particular point in time.

12) These five stocks were randomly selected from a list of the most active stocks with foreign investor interest during the period. Nippon Steel Corporation, the world's biggest producer of steel, is the largest of the five companies studied with 3,530 trillion yen in total assets as of September 1981, and 5.1% of its equity shares owned by non-Japanese. Nippon Steel was a member of all three indexes use in this study, the Nikkei Dow-Jones, the TSE/SA, and the TSE/WA. As of March 31, 1982, it ranked 11th largest of all TSE listed companies in terms of the market value of its stock outstanding. Matsushita Electric Industrial Company, the largest electric

Daily returns were then calculated as first differences of the natural logarithms of consecutive closing price observations.[13] Summary statistics for the return data are contained in Table 1. One immediate observation from this data is that portfolio diversification does exist in the Japanese marketplace. The standard deviations are consistently lower for the three stock indexes than for the individual stocks. Also shown in Table 1 are the beta coefficients of systematic risk, where each of the three stock indexes are taken as a proxy for the market portfolio. It is apparent that in the Japanese marketplace, as in the U.S. marketplace, it is very important to carefully choose the proxy used for the market portfolio.

III. Tests of Independence – Correlation Coefficients

Analyses of serial correlation and runs tests are standard methods of testing the degree of weak form efficiency of return data. [14] If price changes on the TSE may be described as following a random walk, then we would expect successive price changes (returns) to be drawn independently from identical distributions. A popular method for testing the independence of these returns is by the use of serial correlation coefficients.

The correlation between daily returns, lagged 1 to 12 days, for each of the eight data sets is reported in Table 2. It should be noticed that the correlation coefficients for a one-day lag are only significant for the TSE/SA and TSE/WA indexes. [15] The results of

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appliance enterprise in the world, had 1,434 trillion yen in total assets in May 1981, and 12.9% of its shares owned by foreigners. Matsushita is also a member of all three indexes and ranked 2nd largest on March 31, 1982, in terms of the market value of outstanding equity shares. Sony Corporation, a leading maker of acoustic equipment, color TVs, and VTRs, had 683 trillion yen in total assets as of October 1981, and 46.3% of its shares owned by non-Japanese. Sony also is a member of all three indexes and ranked 14th in market value of its equity shares outstanding. Dai-Nippon Printing is Japan's largest printing enterprise with an electric parts division with very impressive growth. Its total assets were 344 trillion yen as of May 1981, and 11.8% of its equity was foreign owned. Dai-Nippon Printing is also a member of all three indexes and ranked 53th in terms of equity value of shares outstanding on March 31, 1982. Shionogi & Company is a pharmaceutical manufacturer depending heavily on sales to physicians and is the largest antibiotic manufacturer in Japan. Shionogi had 146 trillion yen in total assets at the end of September 1981 and 17.6% of its shares are owned by non-Japanese. Shionogi was not a member of the Nikkei Dow-Jones Index, but a member of the TSE/SA and TSE/WA and ranked 96th in terms of the market value of stock outstanding as of March 30, 1982. This data was obtain from [11 and 22].

13) Dividends were not included in these returns because companies in Japan traditionally pay dividends only twice per year and, more importantly, their dividends are usually insignificant in terms of size and impact. The TSE is considered a "capital gain" market. The actual annual dividend yields are very low in Japan, 1.8% as of March 31, 1982, on all stocks listed on the TSE. The dividend yields of the five specific stocks studied are also quite low for the year ending March 31, 1982: Dai-Nippon Printing 1.5%; Matsushita Electric Industry 1.0%; Nippon Steel 3.1%; Shionogi 1.0%, and Sony 1.0%. See [22].

14) Our tests are actually examinations of the random walk hypothesis. For simplicity, we assume that the theory of random walk and weak form market efficiency are synonymous.

15) Given the relatively large sample size (641 return observations), we assume that the distribution is consistent and unbiased. However, if the actual distribution of returns is Stable Paretian, then the computed standard error used in determining the significance of the correlation coefficients will

Table 1 – Summary Data (Daily Returns): 1/4/79 – 4/3/82

	Mean Return	Standard Deviation	Minimum Value	Maximum Value	Beta NDJ	Beta TSE/SA	Beta TSE/WA
NDJ	0.00017381	0.00623495	-0.04213428	0.04454613	1.00	1.24	1.11
TSE/SA	0.00000966	0.00440362	-0.02210045	0.1868820	0.62	1.00	0.71
TSE/WA	0.00025332	0.00529409	-0.03765297	0.03368950	0.80	1.03	1.00
Sony	0.00101002	0.02265529	-0.13664246	0.12571335	2.08	2.70	2.40
Matsushita	0.00052773	0.02337461	-0.13465691	0.15028191	2.37	2.98	3.19
Nippon Steel	0.00054723	0.01773943	-0.08167839	0.06654358	1.29	1.37	1.90
Shionogi	0.00074251	0.01869404	-0.07217216	0.06324387	0.88	1.60	1.08
Dai-Nippon	0.00028911	0.01323970	-0.06795025	0.06749821	1.00	1.31	1.30

Table 2 – Lagged Correlations (Daily Returns)

Lag (Days)	NDJ	TSE/SA	TSE/WA	Sony	Matsushita	Nippon Steel	Shionogi	Dai-Nippon
1	.03794	.18502*	.11808*	.02095	.04519	.02509	-.02330	.06056
2	-.07433	-.01642	-.03952	-.02194	-.07879*	-.05667	-.06411	.01229
3	.05220	-.00114	.04517	-.04903	.07465	.01303	.01036	-.03833
4	.01957	.01690	.00697	.04807	-.00843	-.06426	-.04328	-.05419
5	-.03909	-.04296	-.04322	.00994	-.03595	-.00298	.02669	.07806*
6	.00860	.00219	-.03335	-.05576	-.04608	.00820	.02799	-.13143*
7	-.02587	-.00900	-.01868	-.01248	.00268	.07190	.00802	.02049
8	-.04597	.00020	-.05635	.02872	-.01144	-.01791	.00916	.00601
9	.02988	.04365	.04873	-.05887	-.01886	-.03940	-.08303*	.05014
10	.01628	.03096	.04991	.01669	.03596	.10331*	-.01934	-.01955
11	-.09672*	-.03436	-.09277*	-.04222	-.07305	-.04978	.02328	-.04778
12	-.00335	.02033	.01968	.11853*	.06402	-.11255*	-.00954	.05871

*Significant at .05.

calculating serial correlation coefficients based on data lagged two to twelve trading days are similar to those of Fama [5] in that, in general, there appears to be no pattern of significance.

It is possible that, although daily returns are generally independent, adjacent returns calculated over a longer holding period may not be independent. To test this possibility, returns were calculated for different holding periods from 1 to 16 days. Because of multiple starting dates for these various holding periods, all possible combinations of starting dates were employed. The first-difference correlation coefficients were then averaged and are reported in Table 3.[16)]

The most striking feature of these results is the high degree of significance as the holding period increases. However, this is not surprising when we consider the fact that this was a period of generally increasing market prices on the TSE.[17)] What is surprising is that this increasing market effect was not picked up by the NDJ index nor Shionogi. In fact, Shionogi, although insignificant, has negative correlation coefficients for all holding periods.

It should be pointed out that significant correlation coefficients for the longer holding periods do not necessarily imply market inefficiency, if they are, in fact, the result of generally increasing prices during this period. Inefficiency, from an investor's point of view, would require *ex ante* knowledge that prices were going to continue to increase during this time period.

However, it does appear as if the TSE/SA and the TSE/WA indexes exhibit at least some dependence of returns for one-day lags. The significant positive correlations seem to imply the possibility that positive returns are followed by positive returns and that negative returns are followed by negative returns. We will use runs tests to analyze this possibility further.

IV. Tests of Independence – Runs Analysis

A run is simply a series of price changes (returns) of the same sign. For stocks, runs may be either positive, negative or zero change. This section examines runs where the

understate the true variability. Thus, insignificant values may be deemed significant. We are much less concerned with this problem than if significant correlation coefficients were deemed insignificant.

16) These returns were also calculated as continuously compounded, log relative returns. However, when longer returns periods are tested, various returns series can be produced because of the multiplicity of starting dates. For instance, a non-overlapping sixteen-day return series could be calculated starting on any of the days one through sixteen; thus, there are sixteen possible return series, each of a holding period of sixteen days. Since correlation coefficients calculated on each series would be based on adjacent, non-overlapping holding periods, all correlation coefficients can be regarded as arising from independent observations of the data. An unbiased estimate of the true population correlation can then be calculated as the arithmetic average of all of the independent series.

17) Although the standard correlation coefficient is based on deviations from the average return, an upward price trend will result in positive serial correlations. This effect will be intensified as the holding period for calculating returns increases, since an increase in the holding period will reduce the amount of day-to-day variability generated by white noise.

Table 3 – First-Difference Correlations for Adjacent Returns and Various Holding Periods†

Holding period (T)	NDJ	TSE/SA	TSE/WA	Sony	Matsushita	Nippon Steel	Shionogi	Dai-Nippon
1	.03794	.18502*	.11808*	.02095	.04519	.02509	-.02330	.06056
2	-.02795	.06359	.03736	-.03478	-.01839	-.03843	-.07277	.02236
3	.01459	.03751	.04170	-.02117	.01953	-.06594	-.05836	-.01771
4	-.00154	.01824	-.00199	-.01764	-.02702	-.05993	-.03417	-.05832
5	-.03616	.00936	-.04278	-.03797	-.05839	-.03175	-.01516	-.04874
6	-.05590	.02052	-.05341	-.06947	-.07281	.00601	-.03018	-.07108
7	-.08511*	.03324	-.05342	-.05180	-.05713	-.00876	-.04234	-.03389
8	-.10001*	.05867	-.03061	-.03591	-.02291	-.04093	-.05429	.01007
9	-.06757	.10932*	.04423	-.01302	.04210	-.02276	-.06775	.05191
10	-.02827	.15739*	.11896*	.02288	.10347*	.01474	-.05741	.08993*
11	-.01265	.18261*	.16277*	.04545	.14312*	.02901	-.04280	.10765*
12	.00948	.20478*	.20832*	.07837	.20041*	.04719	-.03900	.12637*
13	.02974	.22011*	.24739*	.09098*	.24186*	.09276*	-.02916	.13554*
14	.03718	.22123*	.27065*	.09376*	.27789*	.13900*	-.03145	.13858*
15	.04159	.21878*	.28174*	.10352*	.29655*	.17923*	-.04622	.13007*
16	.03546	.20820*	.27564*	.10510*	.29637*	.20955*	-.05441	.12327*

*Significant at .05

†Values for periods of length T are arithmetic averages, where the period starts on day τ (τ=1, T)

price changes are calculated over adjacent holding periods of one, four, nine and sixteen days. Three types of runs analysis will be employed: (1) comparing the actual to the expected number of runs of all signs, (2) comparing the actual to the expected number of runs of each sign, and (3) comparing the actual to the expected length of the run for each sign.[18)]

The actual and expected number of runs of all signs are reported in Table 4.[19)] One problem with the use of a runs tests is that a judgment must be made on whether or not the actual number of runs is significantly different from the expected number of runs. It is useful therefore to calculate a measure that quantifies this divergence. One such measure is the percentage difference between the actual and the expected number of runs.[20)] These values, designated as (R-M)/M, are also reported in Table 4.

For the most part, the actual number of runs is fairly close to the expected number of runs for all holding periods and for all data sets. The evaluation of this test is, of course, a matter of judgment, but most runs are within ten percent of the expected number of runs. The most notable exceptions are the results for both of the TSE indexes, which is what we might expect given the significant serial correlation coefficients for a one-day holding period. Another interesting result is that, in almost every case, the actual number of runs is less than the expected number of runs.

The results reported in Table 4 do indicate that there is at least some divergence between the actual and the expected number of runs of all signs. The next step is to determine whether this result is brought about by runs of a particular sign. This is done by comparing the actual number of runs of each sign to the expected number of runs of each sign. These values are reported in Table 5.

First, notice the small number of zero price change runs, on a daily basis, for the three stock indexes. This result is to be expected since these indexes are compilations of many different securities. We would expect zero price change runs in one security to be offset by either positive or negative runs in other securities.

Second, notice the small degree of discrepancy between the actual and the expected number of runs of each sign. It would appear that any discrepancy between the actual and the expected number of runs of all signs can not be attributed to runs of a particular sign. In fact, given this data, the Tokyo Stock Exchange would appear to be fairly efficient in terms of the number of runs of each sign.

However, inefficiency may still exist in terms of the length of the runs of each sign. An analysis of runs of each sign by length was performed and these results are reported in Table 6.[21)]

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18) The mathematical basis for each of these tests is explained in the Appendix.

19) Again we have taken all possible starting dates for a given holding period and have averaged their values to determine the values reported in Table 4 and 5.

20) Another possible measure of dispersion uses the standard error of the expected number of runs. However, Fama [5] has cautioned against a casual interpretation of this measure; because, in general, M increases proportionately with the sample size, whereas σ_M increases proportionately with the square root of the sample size.

21) Results are reported only for daily returns. Our results for holding periods of two to sixteen days were comparable to the daily returns reported in Table 6.

Table 4 – Runs of All Signs†

Holding Periods (T)	NDJ	TSE/SA	TSE/WA	Sony	Matsushita	Nippon Steel	Shionogi	Dai-Nippon
1-Day Periods								
Actual	308.00	282.00	299.00	355.00	358.00	387.00	367.00	377.00
Expected	318.72	320.93	319.16	365.11	378.08	399.76	370.38	397.55
(R-M)/M	-0.03364	-0.12130	-0.06317	-0.02770	-0.05312	-0.03193	-0.00912	-0.05170
4-Day Periods								
Actual	72.50	69.25	73.50	88.00	81.75	92.00	84.25	85.50
Expected	79.96	80.28	79.20	85.80	85.40	93.39	84.65	88.32
(R-M)/M	-0.09337	-0.13745	-0.07189	0.02615	-0.04228	-0.01466	-0.00479	-0.03338
9-Day Periods								
Actual	34.33	33.67	31.44	36.89	34.11	40.22	37.44	33.11
Expected	35.44	35.50	35.04	37.46	36.70	39.49	36.71	36.87
(R-M)/M	-0.03105	-0.05129	-0.10254	-0.01531	-0.06997	0.01914	0.01948	-0.10104
16-Day Periods								
Actual	19.38	17.00	15.75	18.94	19.25	19.69	21.06	18.50
Expected	19.66	19.85	18.73	20.49	20.49	21.43	20.23	20.78
(R-M)/M	-0.01500	-0.14451	-0.16136	-0.07671	-0.06265	-0.08102	0.04219	-0.10819

†Values for periods of length T are arithmetic averages, where the period starts on day τ (τ=1, T)

Table 5 – Runs of Each Sign†

Holding period (T)	Positive			Negative			No change		
	Actual	Expec.	A-E	Actual	Expec.	A-E	Actual	Expec.	A-E
1-Day periods									
NDJ	154.00	153.52	0.48	154.00	153.52	0.48	0.00	0.00	0.00
TSE/SA	141.00	140.15	0.85	140.00	140.10	-0.10	1.00	0.88	0.12
TSE/WA	149.00	148.20	0.80	148.00	148.00	0.00	2.00	1.87	0.13
Sony	150.00	154.38	-4.38	162.00	154.38	7.17	43.00	44.82	-1.82
Matsushita	150.00	149.25	0.75	151.00	150.26	0.74	57.00	57.55	-0.55
Nippon Steel	149.00	147.48	1.52	158.00	152.93	5.07	80.00	85.62	-5.62
Shionogi	155.00	157.41	-2.41	162.00	157.15	4.85	50.00	51.45	-1.45
Dai-Nippon	143.00	143.61	-0.61	157.00	150.48	6.52	77.00	81.96	-4.96
4-Day periods									
NDJ	36.25	35.80	0.45	36.25	35.80	0.45	0.00	0.00	0.00
TSE/SA	34.75	34.09	0.66	34.25	34.08	0.17	0.25	0.22	0.03
TSE/WA	37.00	36.29	0.71	36.50	36.29	0.21	0.00	0.00	0.00
Sony	40.75	40.52	0.23	41.25	40.60	0.65	6.00	5.86	0.14
Matsushita	37.50	37.86	-0.36	38.75	37.91	0.84	5.50	5.02	0.48
Nippon Steel	38.75	38.44	0.31	39.25	38.72	0.53	14.00	13.86	0.14
Shionogi	40.25	39.27	0.98	39.50	39.40	0.10	4.50	4.59	-0.09
Dai-Nippon	36.50	37.25	-0.75	40.00	38.18	1.82	9.00	9.11	-0.11
9-Day periods									
NDJ	17.67	16.68	0.99	16.67	16.68	-0.01	0.00	0.00	0.00
TSE/SA	17.33	16.36	0.97	16.33	16.36	-0.03	0.00	0.00	0.00
TSE/WA	16.22	15.27	0.95	15.22	15.27	-0.05	0.00	0.00	0.00
Sony	17.56	17.00	0.56	17.33	17.04	0.29	2.00	1.87	0.13
Matsushita	16.33	16.05	0.28	16.56	16.05	0.51	1.22	1.08	0.14
Nippon Steel	18.78	17.51	1.27	17.22	17.49	-0.27	4.22	4.21	0.01
Shionogi	18.56	17.52	1.04	17.67	17.59	0.08	1.22	1.32	-0.10
Dai-Nippon	15.89	15.49	0.40	15.78	15.50	0.28	1.44	1.22	0.22
16-Day periods									
NDJ	10.19	9.20	0.99	9.19	9.20	-0.01	0.00	0.00	0.00
TSE/SA	9.00	8.04	0.96	7.94	8.04	-0.10	0.06	0.07	-0.01
TSE/WA	8.38	7.46	0.92	7.38	7.46	-0.08	0.00	0.00	0.00
Sony	9.31	8.72	0.59	8.94	8.66	0.28	0.69	0.64	0.05
Matsushita	9.50	8.85	0.65	9.06	8.74	0.32	0.69	0.72	-0.03
Nippon Steel	9.56	8.68	0.88	8.50	8.64	-0.14	1.63	1.45	0.18
Shinonogi	10.50	9.80	0.70	10.13	9.79	0.34	0.44	0.43	0.01
Dai-Nippon	8.94	8.41	0.53	8.63	8.38	0.25	0.94	0.81	0.13

†Values for periods of length T are arithmetic averages, where the period starts on day τ (τ=1, T)

Table 6 – Runs of Each Sign by Length (Daily Periods)

	Positive			Negative			No Change		
	Prob.	Expec.	Actual	Prob.	Expec.	Actual	Prob.	Expec.	Actual
NDJ									
Length = 1	0.45781	70.50	70.00	0.54219	83.50	77.00	1.00000	0.00	0.00
2	0.23822	38.23	35.00	0.24822	38.23	39.00	0.00000	0.00	0.00
3	0.13458	20.73	26.00	0.11364	17.50	25.00	0.00000	0.00	0.00
4	0.07297	11.24	6.00	0.05203	8.01	7.00	0.00000	0.00	0.00
5	0.03956	6.09	8.00	0.02382	3.67	3.00	0.00000	0.00	0.00
6	0.02145	3.30	5.00	0.01090	1.68	1.00	0.00000	0.00	0.00
7	0.01163	1.79	1.00	0.00499	0.77	2.00	0.00000	0.00	0.00
8	0.00631	0.97	2.00	0.00229	0.35	0.00	0.00000	0.00	0.00
9	0.00342	0.53	1.00	0.00105	0.16	0.00	0.00000	0.00	0.00
10	0.00185	0.29	0.00	0.00048	0.07	0.00	0.00000	0.00	0.00
TSE/SA									
Length = 1	0.47188	66.53	62.00	0.52969	74.16	63.00	0.99844	1.00	1.00
2	0.24921	35.14	30.00	0.24912	34.88	35.00	0.00156	0.00	0.00
3	0.13161	18.56	21.00	0.11716	16.40	20.00	0.00000	0.00	0.00
4	0.06951	9.80	12.00	0.05510	7.71	11.00	0.00000	0.00	0.00
5	0.03671	5.18	7.00	0.02592	3.63	8.00	0.00000	0.00	0.00
6	0.01939	2.73	4.00	0.01219	1.71	1.00	0.00000	0.00	0.00
7	0.01024	1.44	1.00	0.00573	0.80	1.00	0.00000	0.00	0.00
8	0.00541	0.76	3.00	0.00270	0.38	0.00	0.00000	0.00	0.00
9	0.00286	0.40	0.00	0.00127	0.18	0.00	0.00000	0.00	0.00
10	0.00151	0.21	0.00	0.00060	0.08	0.10	0.00000	0.00	0.00
TSE/WA									
Length = 1	0.44688	66.58	62.00	0.55625	82.32	75.00	0.99688	1.99	2.00
2	0.24718	36.83	40.00	0.24684	36.53	39.00	0.00312	0.01	0.00
3	0.13672	20.37	21.00	0.10953	16.21	20.00	0.00001	0.00	0.00
4	0.07562	11.27	10.00	0.04861	7.19	6.00	0.00000	0.00	0.00
5	0.04183	6.23	7.00	0.02157	3.19	3.00	0.00000	0.00	0.00
6	0.02314	3.45	2.00	0.00957	1.42	3.00	0.00000	0.00	0.00
7	0.01280	1.91	1.00	0.00425	0.63	2.00	0.00000	0.00	0.00
8	0.00708	1.05	3.00	0.00188	0.28	0.00	0.00000	0.00	0.00
9	0.00392	0.58	2.00	0.00084	0.12	0.00	0.00000	0.00	0.00
10	0.00217	0.32	1.00	0.00037	0.05	0.00	0.00000	0.00	0.00
Sony									
Length = 1	0.54375	81.56	80.00	0.53438	86.57	90.00	0.92188	39.64	38.00
2	0.24809	37.21	31.00	0.24882	40.31	38.00	0.07202	3.10	3.00
3	0.11319	16.98	20.00	0.11586	18.77	20.00	0.00563	0.24	2.00
4	0.05164	7.75	14.00	0.05395	8.74	5.00	0.00044	0.02	0.00
5	0.02356	3.53	0.00	0.02512	4.07	5.00	0.00003	0.00	0.00
6	0.01075	1.61	4.00	0.01170	1.89	2.00	0.00000	0.00	0.00
7	0.00490	0.74	1.00	0.00545	0.88	1.00	0.00000	0.00	0.00
8	0.00224	0.34	0.00	0.00254	0.41	1.00	0.00000	0.00	0.00
9	0.00102	0.15	0.00	0.00118	0.19	0.00	0.00000	0.00	0.00
10	0.00047	0.07	0.00	0.00055	0.09	0.00	0.00000	0.00	0.00

Table 6 (Cont'd)

	Positive			Negative			No Change		
	Prob.	Expec.	Actual	Prob.	Expec.	Actual	Prob.	Expec.,	Actual
Matsushita									
Length = 1	0.56094	84.14	77.00	0.54531	82.34	69.00	0.89375	50.94	47.00
2	0.24629	36.94	42.00	0.24795	37.44	51.00	0.09496	5.41	9.00
3	0.10814	16.22	15.00	0.11274	17.02	17.00	0.01009	0.58	1.00
4	0.04748	7.12	8.00	0.05126	7.74	5.00	0.00107	0.06	0.00
5	0.02085	3.13	7.00	0.02331	3.52	6.00	0.00011	0.01	0.00
6	0.00915	1.37	0.00	0.01060	1.60	2.00	0.00001	0.00	0.00
7	0.00402	0.60	1.00	0.00482	0.73	1.00	0.00000	0.00	0.00
8	0.00176	0.26	0.00	0.00219	0.33	0.00	0.00000	0.00	0.00
9	0.00077	0.12	0.00	0.00100	0.15	0.00	0.00000	0.00	0.00
10	0.00034	0.05	0.00	0.00045	0.07	0.00	0.00000	0.00	0.00
Nippon Steel									
Length = 1	0.60938	90.80	88.00	0.55625	87.89	93.00	0.83438	66.75	63.00
2	0.23804	35.47	39.00	0.24684	39.00	34.00	0.13819	11.06	13.00
3	0.09298	13.85	12.00	0.10953	17.31	18.00	0.02289	1.83	1.00
4	0.03632	5.41	5.00	0.04861	7.68	5.00	0.00379	0.30	2.00
5	0.01419	2.11	5.00	0.02157	3.41	2.00	0.00063	0.05	0.00
6	0.00554	0.83	0.00	0.00957	1.51	3.00	0.00010	0.01	1.00
7	0.00216	0.32	0.00	0.00425	0.67	3.00	0.00002	0.00	0.00
8	0.00085	0.13	0.00	0.00188	0.30	0.00	0.00000	0.00	0.00
9	0.00033	0.05	0.00	0.00084	0.13	0.00	0.00000	0.00	0.00
10	0.00013	0.02	0.00	0.00037	0.06	0.00	0.00000	0.00	0.00
Shionogi									
Length = 1	0.54219	84.04	74.00	0.54688	88.59	90.00	0.91094	45.55	46.00
2	0.24822	38.47	48.00	0.24780	40.14	38.00	0.08113	4.06	2,00
3	0.11364	17.61	19.00	0.11229	18.19	20.00	0.00723	0.36	1.00
4	0.05203	8.06	9.00	0.05088	8.24	9.00	0.00064	0.03	1.00
5	0.02382	3.69	3.00	0.02305	3.73	3.00	0.00006	0.00	0.00
6	0.01090	1.69	0.00	0.01045	1.69	2.00	0.00001	0.00	0.00
7	0.00499	0.77	1.00	0.00473	0.77	0.00	0.00000	0.00	0.00
8	0.00229	0.35	1.00	0.00214	0.35	0.00	0.00000	0.00	0.00
9	0.00105	0.16	0.00	0.00097	0.16	0.00	0.00000	0.00	0.00
10	0.00048	0.07	0.00	0.00044	0.07	0.00	0.00000	0.00	0.00
Dai-Nippon									
Length = 1	0.61563	88.03	85.00	0.54531	85.61	84.00	0.83906	64.61	59.00
2	0.23663	33.84	32.00	0.24795	38.93	38.00	0.13504	10.40	13.00
3	0.09095	13.01	14.00	0.11274	17.70	18.00	0.02173	1.67	3.00
4	0.03496	5.00	8.00	0.05126	8.05	11.00	0.00350	0.27	1.00
5	0.01344	1.92	3.00	0.02331	3.66	4.00	0.00056	0.04	1.00
6	0.00517	0.74	0.00	0.01060	1.66	1.00	0.00009	0.01	0.00
7	0.00199	0.28	1.00	0.00482	0.76	1.00	0.00001	0.00	0.00
8	0.00076	0.11	0.00	0.00219	0.34	0.00	0.00000	0.00	0.00
9	0.00029	0.04	0.00	0.00100	0.16	0.00	0.00000	0.00	0.00
10	0.00011	0.02	0.00	0.00045	0.07	0.00	0.00000	0.00	0.00

Judgment must once again be used to determine whether the observed differences are significant and imply inefficiency. There does appear to be a tendency for the expected number of positive and negative runs of length one day to exceed the actual number of one-day runs. However, this is not always the case, and there appears to be no clear pattern for run lengths longer than one day. If the Japanese market is inefficient in terms of runs, then its is, for the most part, inefficient only in terms of runs of length one day.

From our analysis there appears to be some degree of correlation between lagged returns, especially among the stock indexes, and there are some discrepancies between the actual and expected number of runs for all three tests. However, it does not appear that any such discrepancies may be severe enough to warrant a verdict of weak form inefficiency, at least from the viewpoint of the individual investor. In the next section we will discuss another type of inefficiency that might possibly be used to the advantage of an investor.

V. Day of the Week Effects

We start our analysis of the day of the week effects by assuming that prices are generated by some underlying pricing mechanism that is operational only over trading days.[22] If we also assume that this mechanism is constant across all trading days and if no day of the week effects exists, then the average return for each trading day should be insignificantly different from all other trading days. This hypothesis of no day of the week effects can be tested using the following regression model:

$$R_{it} = \alpha + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + e_{it}$$

where α and β are the parameter estimates of the regression equation, D_2 through D_6 are dummy variables for days Tuesday through Saturday (i.e., D_2 equals 1 if day t is a Tuesday and equals 0 for all other trading days, etc.), and e_{it} is an error term of the model.

In this model, the intercept term will represent the average return for Monday, and the beta coefficients will represent departures from that average return for all other trading days. If the pricing mechanism is operational over trading days and if no day of the week effect exists, then the beta coefficients should be insignificantly different from zero. This hypothesis is tested using a simple F-statistic. The results of this regression analysis are reported in Table 7.

The results do not validate the hypothesis of no day of the week effects for each of the three stock indexes nor for Shionogi. Thus, there appears to be a day of the week

22) The trading hours and operating days of the week of the TSE are not the same as those for the NYSE. On the TSE, there are generally two trading sessions Monday through Friday and one morning session on each Saturday, except for the third Saturday of each month when the exchange is closed.

Table 7 – Day of the Week Regression Coefficients

	α Monday	β_2 Tuesday	β_3 Wednesday	β_4 Thursday	β_5 Friday	β_6 Saturday	F-Value
NDJ	0.00010	-0.00152	0.00214*	-0.00084	0.00038	0.00030	4.57*
	(0.00059)	(0.00083)	(0.00083)	(0.00083)	(0.00083)	(0.00089)	
TSE/SA	-0.00002	-0.00132**	0.00142**	-0.00039	0.00024	0.00020	4.72*
	(0.00042)	(0.00059)	(0.00059)	(0.00059)	(0.00058)	(0.00063)	
TSE/WA	0.00024	-0.00135	0.00142**	-0.00057	0.00036	0.00022	3.47*
	(0.00050)	(0.00071)	(0.00071)	(0.00071)	(0.00071)	(0.00076)	
Sony	0.00129	-0.00242	0.00227	-0.00207	0.00365	-0.00400	1.78
	(0.00217)	(0.00307)	(0.00305)	(0.00305)	(0.00304)	(0.00325)	
Matsushita	0.00340	-0.00642**	-0.00165	-0.00307	-0.00411	-0.00168	1.00
	(0.00225)	(0.00317)	(0.00315)	(0.00315)	(0.00315)	(0.00337)	
Nippon Steel	0.00043	-0.00311	0.00197	-0.00036	0.00260	-0.00069	1.46
	(0.00170)	(0.00240)	(0.00239)	(0.00239)	(0.00238)	(0.00255)	
Shionogi	-0.00179	-0.00123	0.00533**	0.00351	0.00488	0.00245	2.22**
	(0.00179)	(0.00253)	(0.00251)	(0.00251)	(0.00250)	(0.00268)	
Dai-Nippon	0.00052	-0.00193	0.00040	-0.00055	0.00119	-0.00068	0.71
	(0.00128)	(0.00180)	(0.00179)	(0.00179)	(0.00178)	(0.00191)	

The regression equation is of the following form: $R_t = \alpha + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6$, where α represents the average returns for Monday, D_2 through D_6 represent dummy variables for trading days Tuesday through Saturday (0 or 1), and β_2 through β_6 represent diverenge from Monday's return for trading days Tuesday through Saturday. In parenthesis is found the standard errors of the regression coefficients.

* Significant at .01

** Significant at .05

effect for these 4 data sets, as each has a significant F-value. For the other firms, it may very well be that the daily return stream is generating white noise which may have masked an existing day of the week effect.

It is clear, at least for the TSE as a whole, that prices are not generate by a mechanism that is operational, as well as stable, over trading days. However, it is also possible that the underlying pricing mechanism is operational over calendar (continuous) time. If this is the case, then the return on Monday should be significantly higher than for the other trading days. We should then observe a significant F-value and all beta coefficients should be significantly negative. The results reported in Table 7 do not support a calendar time hypothesis.

It is important to compare our results for the TSE with those found in studies of the U.S. capital markets. In the U.S., those securities showing a significant day of the week effect generally have their lowest return on Monday [2, 6, 7]. In the Japanese market, the lowest return usually occurs on Tuesday. However, like the U.S. studies, returns on the TSE tend to reach a high on Wednesday and a second high on Friday [7].

It may be interesting to note that when the NYSE closes at 4:00 p.m. Eastern Standard Time on Monday, it is 9:00 a.m. in Tokyo on Tuesday, just before the TSE opens. In terms of low returns on Monday in New York, this is equivalent to Tuesday in Tokyo; therefore, there may be a connection between low return days. But also notice that even though the TSE and NYSE had similar high returns on Wednesday, they are not at the same point in adjusted time. Thus, there may be a day of the week effect on various equity markets in the world, but our results do not show that TSE and the NYSE had the same high or low return day either on a real time or adjusted time basis.

At least for the market as a whole, there does appear to be some type of day of the week effect, and these results have implications for market efficiency. They imply that investors with large and well diversified portfolios may be better off if they limit their purchases, on average, to Tuesdays and their sales, on average, to Wednesday.

VI. Summary and Conclusions

The Tokyo Stock Exchange has become an important equity market of the world as it ranks second to the NYSE in terms of the volume of transactions and the capitalization of its listed shares as of the end of 1981. Thus, it is important to consider whether capital market theories of efficiency, which were developed primarily with the knowledge of and the application to the NYSE, might also apply to this emerging world market in Tokyo.

The purposes of this paper are to test the validity of the random walk hypothesis with three major stock indexes and five selected individual TSE listed equities which had large international ownership. Further, the daily returns calculated for the eight data sets were used to perform tests for day of the week effects. The data employed were 642 daily price observations for each of the eight data sets over the period from January 4, 1979, through April 3, 1982, which corresponds to a period of increased non-Japanese investor interest in stocks listed on the TSE.

The findings of this study were:

1. An analysis of the eight different series of returns found that diversification is advantageous on the TSE.
2. An analysis of serial correlation tests of single holding periods for lags from one to twelve days and a first-difference correlation test of adjacent returns for all holding periods from 1 to 16 days found that there was not a high degree of dependence among the TSE returns.
3. Three types of runs tests of four different holding periods of returns of the eight different data sets found that even though there was some disparity between the actual and expected number of runs of all three tests, the difference was not sufficient to conclude that the TSE was weak form inefficient.
4. An analysis of the eight data sets found that there does appear to be some type of day of the week effect, implying that investors with large and well diversified portfolios may be better off if they limit their purchases, on average, to Tuesday and their sales, on average, to Wednesday.

Our overall conclusion is that the TSE is weak form efficient, even though there appears to be a day of the week effect among the large market portfolio indexes. These conclusions are similar to those of other researchers who have studied diversification characteristics, weak form efficiency, and day of the week effects of the U.S. capital markets. Thus, the two most important equity markets in the world both have been found to be reasonably efficient, although day of the week effects do exist on each.

APPENDIX

This appendix sets forth the equations which were used to determine the values reported in Tables 4, 5, and 6.

Expected Runs of All Signs – Table 4

The expected number of runs of all signs may be calculated as:

$$M = [(N)(N+1) - \sum_{\phi=1}^{3} n_{\phi}^2] \; / \; [N]$$

where M is the expected number of runs of all signs, N is the total number of price changes (return observations), and n_{ϕ} is the actual number of price changes of sign ϕ (ϕ = plus, minus or zero).

Expected Runs of Each Sign – Table 5

The probability of a price change of a give sign is equal to:

$$P_{\phi} = n_{\phi} / N$$

If price changes are assumed to be generated by an independent Bernoulli process with probability P_{ϕ} , then the expected number of runs of length λ for sign ϕ is equal to:

$$[N] [P_{\phi}]^{\lambda} [1 - P_{\phi}]^2$$

If we consider runs of all possible lengths for sign ϕ , then the expected number of runs of sign ϕ, in a sample of size N, is equal to:

$$[N]\,[P_\phi]\,[1 - P_\phi]$$

The probability of a run of sign ϕ, given the expected number of runs of all signs, M, may then be calculated as:

$$P^*_\phi = \left\{[N]\,[P_\phi]\,[1 - P_\phi]\right\} / [M]$$

The expected number of runs of each sign is equal to:

$$\bar{R}_\phi = [R]\,[P^*_\phi]$$

where the expected number of runs of each sign is based on the actual total number of all runs instead of on the expected total number of all runs. This prevents bias, which would be carried through if the expected total number of all runs was different from the actual total number of all runs.

Expected Length of Run of Each Sign – Table 6

The probability of a run of length λ for sign ϕ is simply the ratio of the expected number of runs of length λ for sign ϕ, divided by the total expected number of runs of sign ϕ, or:

$$[P_\phi]^{\lambda-1}\,[1 - P_\phi]$$

This implies that the expected number of runs of length λ for sign ϕ, is equal to:

$$\bar{R}^\lambda_\phi = [R_\phi]\,[P_\phi]^{\lambda-1}\,[1 - P_\phi]$$

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