Stock Index Derivatives, IPOs and Japanese Days-of-the-Week Stock Return Patterns

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Abstract

The effect of presence of stock index derivatives on daily stock prices is considered by comparing the days-of-the-week return patterns between two Exchanges, one with stock index derivatives and the other without them. Since ordinary statistical tools require equidistant data, new techniques of investigating daily stock pricing are applied. Nonlinear nonparametric time series analytic tools by Bandt-Pompe (2002) and Wayland *et al.* (1993) are applied first and then a test by random shuffling to detect existence of periodic pattern in a time series data is proposed. The proposed technique makes it possible to carry out hypotheses testing which has not been executed. The empirical analysis investigated the interpolated daily stock price indexes of Nikkei 225 and Nikkei JASDAQ Average since 1989. The results indicate that there is a difference of the day-of-the-week effect due to the presence of stock index derivatives and it is also partly related to initial public offerings (IPOs).

Keywords: stock index derivatives, anomaly, high frequency data, hypothesis testing, interpolation, rank, permutation, random shuffle
JEL(s): C12, C14, C22, G13, G14

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Abstract: The effect of presence of stock index derivatives on daily stock prices is considered by comparing the days-of-the-week return patterns between two Exchanges, one with stock index derivatives and the other without them. Since ordinary statistical tools require equidistant data, new techniques of investigating daily stock pricing are applied. Nonlinear nonparametric time series analytic tools by Bandt-Pompe (2002) and Wayland *et al.* (1993) are applied first and then a test by random shuffling to detect existence of periodic pattern in a time series data is proposed. The proposed technique makes it possible to carry out hypotheses testing which has not been executed. The empirical analysis investigated the interpolated daily stock price indexes of Nikkei 225 and Nikkei JASDAQ Average since 1989. The results indicate that there is a difference of the day-of-the-week effect due to the presence of stock index derivatives and it is also partly related to initial public offerings (IPOs).

1. The Introduction

Abnormal stock returns have been globally documented on specific days-of-the-week and in specific months, for example, and called as anomalies. These phenomena require both appropriate treatment of data and appropriate tools of analysis because they are nonlinear and noisy. Nonlinearity and noise are carefully treated and possible explanations of anomaly are also explored in the following.

On stock market anomaly study, dummy variables for the days-of-the-week or the months have been employed extensively in a linear OLS regression analysis. There is, however, a problem of multicolinearity among dummy variables in this approach. Chien-Lee-Wang (2002) noted the impact of stock price volatility throughout the week or the year on the application of dummy variable regression model and showed that it yields misleading results.

This paper applies nonlinear time series analytic methods to the days-of-the-week effect on stock price index in Japan. We question “Do Nikkei 225 and JASDAQ Average stock return make peculiar fluctuations on Monday, Friday or other days?” Nonlinear nonparametric time series analytic tools by Bandt-Pompe (2002) and Wayland *et al.* (1993) are firstly applied to answer the question.

This paper also proposes a test by random shuffling of return ranking to detect the existence of periodic pattern in a time series data, which has not been known in any literatures.

Although the nonlinear time series techniques are an improved and simpler measure of chaotic complexity, these techniques are free from the defect mentioned by Chien-Lee-Wang (2002) and also the proposed technique makes it possible to carry out hypotheses testing which has not been executed. The empirical analysis investigates the interpolated daily stock price index of Nikkei 225 and JASDAQ Average since 1989.

Outliers are carefully excluded by means of ranking, so that outliers are not the cause of the anomaly. What we will find is based on a firm background of data processing.

Dimson-Marsh-Stauton (2002) claimed and documented that some anomalies are disappearing and some have disappeared. But the disappearance might be true only after the researches on a specific anomaly have published. We will document that there is an evidence of the days-of-the-week effect and also that it is partly related to initial public offerings (IPOs) and stock index derivatives, which have not been documented so far.

The study is organized as follows. Section 2 reviews the literatures. Section 3 and sections 4 and 5 present the data and methodology. Section 6 discusses the results, and section 7 concludes.

2. Preceding and Related Researches

2-1. Anomaly Studies by Nonlinear Method

There are too many related researches on stock return anomaly so that we have to skip the survey, but notionally similar studies and their relationship with the current study have to be briefly noted.

(1) Seasonality of Stock Return

Tong (2000) utilized a tricky method of including the dummy variables into regression equation and successfully documented globally the monthly stock return anomaly. Although the devise by Tong (2000) is free from the multicolinearity problem pointed out by Chien-Lee-Wang (2002), it is an analysis of linear relationship and applied only to monthly data, not weekly data. We will verify the phenomenon of the weekly effect with statistically more satisfying tools.

After a framework of analysis is well designed, Miyano-Tatsumi (2004) have already applied the Wayland test and other tools to the daily stock price index data of Nikkei 225 and Nikkei JASDAQ Average from January 4, 1989 to August 29, 2003 to detect the days-of-the-week effect on the stock index returns and documented the existence of Monday and Friday effect for Nikkei 225 and Nikkei JASDAQ Average.

But they did not mention on the detail of JASDAQ Average stock return anomaly. To know how and to what the anomaly is related, the nonlinear time series analyses will be applied to JASDAQ Average stock price index data.

(2) The Days-of-the-Week Effect on Metal Returns

Miyano-Tatsumi (2006) also applied the same techniques to the London Metal Exchange listed daily spot & 3 month futures price indexes of aluminum and copper from January 4, 1989 to August 29, 2003. They documented that there is an evidence of the days-of-the-week effect and also that speculative behavior rather than hedging has been eminent since 1989. A merit of their research might be to study the spot & 3 month futures price indexes at the same time.

2-2. Methodological Argument

Modeling and analyzing high-frequency and nonlinear data have become important in finance. Financial time series data exhibits significant nonlinearity, with this nonlinearity predominantly associated with a weekly pattern and also a seasonal pattern.

Since chaos study made clear that nonstochastic factors cause seemingly stochastic dynamic behavior, various methods of nonlinear time series analysis such as Wayland-Bromley-Pickett-Passamante (1993) and Bandt-Pompe (2002) have been presented. The nonlinear time series analysis begins with embeddings, which could naturally be applicable to periodicity analysis.

Another key element is noise. Most analytic methods break down as soon as noise is added to the time series. For these respects, both the nonlinear time series analysis proposed by Wayland *et al.* (1993) and permutation entropy method proposed by Bandt-Pompe (2002) are promising for the analysis of economic and financial time series data.

Equidistant time series samples are required when time series analytic techniques are applied to data. Most researches have been applied to unequidistant time series data, which cause additional noise. The current paper solves this problem by interpolating the missing data, which is inevitable for such high frequency data as daily data.

As for the analytical tool of comovement, the Copula analysis or Kendall’s tau has been well known these days. Although Copula analysis or Kendall’s tau has been utilized as a nonlinear devise, it carries out pair wise matching of two variables. This paper, however, analyzes the degree of coincidence in long run periodic movement of only one single variable.

3. Data and Processing

3-1. Data Analyzed

Hereafter we will apply the method of the nonlinear time series analysis to the daily stock price index data of Nikkei JASDAQ Average and also Nikkei 225 from January 4, 1989 to August 29, 2003. Nikkei JASDAQ stock average [(1] refers to the Dow™ index resulting from computing the simple mean value of the share prices of all companies listed on JASDAQ market, excluding the Bank of Japan and stocks under the management of the securities Exchange.

This index covers the JASDAQ market - targeting stocks of many growing, but small and medium, corporations – which often serves as the indicator of one of general stock market trends, comparable to NASDAQ in US.

There is not liquidity problem for Nikkei JASDAQ Average since the trading volumes are so large enough that there is no need to correct thin trading and therefore price jump has not been observed.

The daily stock price index is based on the afternoon closing price at 15:00, but we have to use the morning closing price at 11:30 for the last and the beginning trading days of the year. See Tatsumi (2004) more for the practices and workings of the JASDAQ market.

An interpolation method explained in the next subsection will be applied to this index and used extensively below.

3-2. Interpolation

Monday return without Saturday and Sunday interpolation is the rate of change from Friday closing price through Monday closing price. Although this return calculates the rate of 3 day price change, the returns on the other days of the week calculate exactly 1 day change. If we combine these data into a series, data with different time intervals are mixed. Time series analytic tools require equidistant on the other hand. This is the reason why an interpolation method will be used extensively in the following.

The sample does not exist naturally on holidays and weekends. Also the data of the last day in December and the first three days in January are not measured, since these days are the year end holiday and New Year holidays in Japan.

The nonexistent or missing data of stock prices are linearly interpolated in the following study. Monday return with the interpolation is therefore the rate of change from the estimated Sunday closing price through Monday closing price. Filling in the nonexistent values with the estimates, which comprise 5,348 observations, these are then calculated to yield daily returns.

The method of the interpolation is to replace the missing values by the values interpolated by two days just before and just after when there exists data. If there are n consecutive data missing, the coefficient of interpolation for the i-th value will be $((n-i+1)/ (n+1), i/ (n+1))$. Suppose there are no data on six consecutive days. Then the coefficients of interpolation will be (6/7, 1/7), (5/7, 2/7), (4/7, 3/7), (3/7, 4/7), (2/7, 5/7), and (1/7, 6/7).

(3) Return Calculation

The return is defined as the rate of change from the last day's closing price to the today's closing price divided by the today's closing price. This is because we would like to avoid the usage of the estimated Sunday price if possible, since it is not the real price to be quoted in the market. We do not adjust dividend when making return from the stock price index.

Annualized percentage daily returns are calculated as 36000 times of them. Fundamental statistics of daily returns are the same as that already listed in Miyano-Tatsumi (2004). Nikkei JASDAQ Average daily return has lower standard deviation (SD) than that of Nikkei 225. There is evidence of high kurtosis in both series.

4. Nonlinear and Nonparametric Analysis

4-1. Permutation Entropy

(1) Description of Permutation Entropy

Bandt-Pompe (2002) proposed a measure of complexity, called as the permutation entropy, for time series data. A brief description is given.

Let $\pi = n!$ be all possible permutations of order $n \geq 2$ for a sequence of n real numbers. Given a sequence of data points $\{u(i)\}$, $i = 0, \cdots, N-1$, we count the number of realizations of π, denoting as $m(\pi)$, for the components of each embedding vector $\mathbf{u}(i) = (u(i), u(i+1), \cdots, u(i+n-1))$ of dimension n. We calculate the relative frequency for π as $p(\pi) = m(\pi)/(N - n + 1)$ and define the permutation entropy[(2] as

$$H(n) = -\sum_{\pi} p(\pi)\log_2 p(\pi),$$

where it is clear that $0 \leq H(n) \leq \log_2 n!$. The maximum of H(n) is attained when $p(\pi) = 1/n!$ for all π. This entropy is the information contained in comparing n consecutive values of the time series. The time series may present some kind of deterministic dynamics when H(n) is smaller than $\log_2 n!$.

Bandt-Pompe (2002) claimed that in their experiment H(n) increases linearly with n, recommending a practical redefinition of the permutation entropy as the normalized permutation entropy

$$h(n) = H(n) / (n-1) \log_2 n!,$$

where $0 \leq h(n) \leq 1$. The lower bound corresponds to an increasing or decreasing process, while the upper bound to a completely stochastic sequence, as calculated in the following subsection.

(2) Special Cases

Let the numbers of embedding vectors and permutations be respectively N–n+1 and n!. For increasing or decreasing processes, the permutation entropy becomes

$$H(n) = -\, n!\ ((N-n+1)/(N-n+1))\log_2 ((N-n+1)/(N-n+1)) = -\, n!\ \log_2 (1) = 0, \text{ for all n.}$$

For a completely random sequence, in an i.i.d. sequence all n! possible permutations appear with the same probability. In general [(3], the normalized permutation entropy becomes 1 since

$$H(n) = -\, n!\ (1/n!)\log_2 (1/n!) = -\log_2 (1/n!) = \log_2 n!\ , \text{ for all n.}$$

4-2. Permutation Entropy Results

(1) Presentation of Results

The results of the normalized permutation entropy are depicted in **Figure 1** and **Figure 2**.

For the daily interpolated return, Nikkei 225 is much closer to the random process than Nikkei JASDAQ Average, as seen from **Figure 1**.

As for each day-of-the-week return of Nikkei JASDAQ Average in **Figure 2**, the Wednesday return is fluctuating more randomly than that of other days-of-the-week. We will come back to this point later.

(2) Drawbacks of Permutation Entropy

Even with the permutation entropy it is difficult to distinguish among specific patterns of movement, except two extremes: an increasing or decreasing process and a completely random sequence where all possible n! permutations appear with the same probability. What kind of distribution exits between these two extreme is not known.

The permutation entropy can not tell the level of randomness of a given time series process. Moreover the permutation entropy can not distinguish between short run pattern of movement and long run pattern of movement.

4-3. Wayland Algorithm-the Degree of Visible Determinism

The nonlinear time series analysis by Wayland *et al.* (1993), based on the parallelness of neighboring trajectories in phase space, is an improved and simpler variant of the Kaplan-Glass algorithm (1993). We interpret it as a statistical method invented by physicians, but applicable to economic and financial time series data.

(1) Embedding and Time Translation

Given a time series { u (t)}, D-dimensional phase space is constructed at t_0 by embedding, as $\mathbf{u}(t_0) = \{ u(t_0), u(t_0 - \triangle t), u(t_0 - 2\triangle t), \cdots, u(t_0 - (D-1)\triangle t)\}$, where D is the embedding dimension and $\triangle t$ is an appropriate time lag.

Embedding could describe pattern of the movement of the time series. If embedding vectors are close together, they might have a similar pattern.

The central point of the Wayland algorithm is as follows. *K* nearest neighbors of $\mathbf{u}(t_0)$, denoted as $\mathbf{u}(t_i)$, $i = 0,1,2,\cdots,K$, are randomly found then. The vector $\mathbf{u}(t_i + T\triangle t)$ is called the image of $\mathbf{u}(t_i)$ because each $\mathbf{u}(t_i)$ becomes $\mathbf{u}(t_i + T\triangle t)$ as a time of $T\triangle t$ passes.

The image is generated by time translation. Therefore the change in time series process as times go could be described approximately by translation vector,

$\boldsymbol{v}(t_i) = \mathbf{u}(t_i + T\triangle t) - \mathbf{u}(t_i)$.

(2) Translation Error and Properties of Wayland Test

The K translation vectors should point in similar directions if determinism is visible, i.e., the time series process is deterministic. The similarity in direction is gauged in terms of a measure referred to as translation error E_{trans}.

$$E_{trans} = \frac{1}{K+1}\sum_{i=0}^{K}\frac{\| \boldsymbol{v}(t_i) - \hat{\boldsymbol{v}} \|}{\| \hat{\boldsymbol{v}} \|},$$

where

$$\hat{\boldsymbol{v}} = \frac{1}{K+1}\sum_{i=0}^{K} \boldsymbol{v}(t_i).$$

The translation error measures how the pattern of the movement changes over time. In chaotic terms, it measures the diversity of directions of nearby trajectories, therefore the degree of visible determinism of the time series data. The more visible the determinism is, the smaller E_{trans} will be.

In Wayland test the E_{trans} estimator is partly dependent on the embedding dimension D. If $E_{trans} \rightarrow 0$, the original time series process is considered to be deterministic. If the original time series process is white-noise, then the translation vector $\boldsymbol{v}(t_i)$ becomes uniformly distributed and the E_{trans} estimate will be close to 1. If the E_{trans} estimate is larger than 1, the original time series process is considered to be stochastic.

If D is less than the intrinsic dimension of the original time series process, the E_{trans} estimate is higher. Even if D is larger than the intrinsic dimension, the E_{trans} estimate may be higher because of the redundancy of the embedding space. The detail is not well known for the intermediate range of D (Miyano (1996)).

4-4. Presentation of Wayland Test Results

In the following, $\triangle t$ will be set to be equal to 7 for daily interpolated returns or 1 for day-of-the-week returns of Nikkei JASDAQ Average, while K will be set 4. We will try 1, 5 to 8 week translation for weekly interpolated returns, 5 week translation for day-of-the-week returns of Nikkei JASDAQ Average. In the following experimental works shown in **Figure 3** and **Figures 4**, the E_{trans} are estimated for 20 sets of 301 randomly chosen vectors $\mathbf{u}(t_0)$. To reduce the errors associated with the estimates, the median for each set of $\mathbf{u}(t_0)$ is sought and then the average over 20 medians is taken.

(1) Sock Return Dynamics

By Wayland test we could know several dynamic behaviors of the stock returns.

First of all, since the translation error of one week ahead is relatively large and flat for every dimension of embedding as seen from **Figure 3**, the weekly return has a tendency to move with one period time lag. The return may have the high one-period autocorrelation coefficient.

Secondly, the translation error of 7-week translation is far below from 1. Roughly speaking this suggests two month periodicity. Furthermore since the translation error is minimized at the embedding dimension of 4 weeks, there is a property of 4-week periodicity for weekly returns. This also suggests monthly periodicity.

From **Figures 4**, we see that the Monday return follows unknown stochastic process, which is different from white noise. Although we do not see any large difference among other days-of-the-week, Friday and Wednesday on average are close to Monday.

(2) Drawbacks of Wayland test

There are several drawbacks in Wayland algorithm. First of all, there is no clear threshold of E_{trans} by which the underlying dynamics is classified into either a deterministic process or a stochastic process.

Secondly, in order to determine the appropriate value of the time translation T, we have no definite criterion, instead of trial-and-error. We rather introduce financial economics rationale in here, that is, time series anomalies.

Thirdly it is difficult, though not impossible, to estimate the reliable interval for estimates of E_{trans}, which in turn prohibits carrying out hypothesis testing. How can we judge, for example, when the E_{trans} fluctuates drastically depending on the embedding dimension? Wayland test cannot generally give any simple and clear conclusion.

We next propose a much simpler procedure in the following section.

5. Periodicity Analysis by Rank

5-1. Analytical Framework

(1) Setting

Let a time series {u(t)}, t = 1,2,···, N, be given, consisting of N consecutive data points of variable u observed equidistant in time. Suppose we would like to detect whether m consecutive samples in the time series have any periodicity. For examples, m is 5 for a weekly pattern of daily data and 12 for a yearly pattern of monthly data. The latter is exactly the seasonality problem.

For simplicity of exposition without loss of generality, let N be μ times of m. The whole sample is then divided to μ groups by m consecutive samples. In terms of vectors, {u(t)} = {(u(1), u(2), ··, u(m)), (u(m+1), u(m+2), ··, u(2m)), (u(2m+1), u(2m+2), ··, u(3m)), ····,

$(u((\mu\text{-}1)m+1), u((\mu\text{-}1)m+2), \cdot\cdot, u(\mu m))\} = \{\mathbf{u}(m), \mathbf{u}(2m), \mathbf{u}(3m), \cdot\cdot\cdot\cdot, \mathbf{u}(\mu m)\}$.

We then compose vectors by rank, ranking among the m values.

$\mathbf{y}(im) = (x((i\text{-}1)m+1), x((i\text{-}1)m+2), \cdot\cdot, x(im)), i=1,2,\cdots, \mu,$

where x is the positive integer up to m. The number of combination of the rank becomes m! =M [(4]. We will call these μ vectors as the original data and consider separately the m-dimensional vectors in the original data.

(2) Hypothesis Testing in General

It may be likely that we would like to know whether the rank of a specific column is on average higher than that of other columns in the vectors. More specifically it is interesting to know whether the rank of a specific column has a tendency to be higher than the overall average. Here the averaging of the specific column is taken over the μ values.

The procedure to test this hypothesis follows. The ranks of the m columns in the original μ vectors are randomly shuffled 40 times in order to know how often the ranking would appear. The randomness is assured by utilizing the uniform and independent white noise. The numbers (40 times) of shuffling might be appropriate for the application of Central Limit Theorem.

For each column, 40 ranks thus obtained are used to calculate its average and standard deviation. The derived distribution of the ranks can be used to test a hypothesis whether the realized original rank is significantly larger or smaller than the overall average rank.

If we could assume Gaussian process for x, this distribution could be utilized to test the hypothesis and test statistics might become that of the familiar student's t-test.

5-2. Application to Daily JASDAQ Return Anomaly

(1) Random Shuffling Analysis by Rank

When we consider the days-of-the-week effect by the random shuffling approach, the weekday returns are only considered. Let the stock returns on Monday through Friday be R_1, R_2, R_3, R_4, and R_5, and then calculate ranking among them. The highest return gets the number 1 and the lowest is 5. A weekly rank vector will be denoted as y (5) = (x_1, x_2, x_3, x_4, x_5). There will be 5! =120 rank vectors.

The reason why we shuffle data is twofold. It is because they might be noisy, which is also the main reason to consider the rank instead of the absolute value. Second is to know the random process of the rank, since the random shuffling generates the random process.

(2) Method of Hypothesis Testing

The procedure of the hypothesis testing is as follows. We shuffle randomly the daily prices within week, that is, from Monday through Friday within the same week, 40 times. They are called as 40 surrogate data, getting 41 data sets including the original data.

For data with the interpolation, we then count their ranking within week. The highest return gets the number 1 and the lowest is 5.

For each day of the specific week we calculate average of the 40 surrogate return rankings and call it as the average surrogate return ranking. For each weekday we then calculate average and standard deviation of both the original return ranking and the average surrogate return ranking.

The difference between the average of the original return ranking and the average of the average surrogate return ranking divided by the standard deviation of the average surrogate return ranking for each day of the week would be considered the student's t distributed.

This t statistics has the meaning under a null hypothesis that the stock return generating process for each day of the week is random and mutually independent [(5]. The null hypothesis should be rejected if the t statistics satisfies the condition $|t| > 2.02$, because the degree of freedom is 40. We will call this null hypothesis as random process hypothesis.

(3) Presentation of Results

The hypothesis tests executed are presented in **Table 1**. Some null hypotheses are not rejected since the t statistics are lower in the case with the Saturday and Sunday interpolation. Returns would be random on Tuesday to Thursday for Nikkei 225, on Wednesday and Thursday for Nikkei JASDAQ Average. At least it is concluded that Monday and Friday returns are not random. Positive ranking number on Monday for Nikkei JASDAQ Average means lower ranking (lower return) than the average, whereas negative ranking number on Friday higher ranking (higher return).

The null hypotheses on all the days-of-the-week for JASDAQ are rejected in the case without the interpolation. Even for Nikkei 225 only return on Tuesday is significant in the case without the interpolation. Although these conclusions look firm, we have to defer the discussion of any conclusions deriving from this case until the subsection (5) below.

It is to be noted that the significance of Wednesday is not rejected for Nikkei JASDAQ Average. Furthermore it is surprising to know that the level of t-value coincides roughly with the results of the previous tests. We will come back to this point later.

(4)The Effect of the Order of Random Shuffling

We have started with the price index with the interpolation of the weekday holidays and the New Year related holidays' prices. But we may shuffle randomly the daily return instead of the daily stock price within week. Although their difference is just a shuffle before or after calculating the return, the economic meaning may differ. Depending on the null hypothesis we are investigating, the procedure of random shuffling might differ.

Table 2 shows, however, that the results of the daily return random shuffling are almost the same as in **Table 1**. For our Japanese data, there is no difference regarding when to shuffle, which means no substantial difference in their economic meanings.

(5)The Effect of Interpolation

Whether or not and furthermore how we interpolate the Saturday and Sunday stock prices might affect Monday return and therefore weekly return ranking, leading naturally to a drastic change in the result.

In order to solve this problem, we take Monday returns out and execute the ranking test in the same way as above. **Table 3** shows the result. Returns are random on Tuesday to Thursday for Nikkei 225, on Wednesday and Thursday for JASDAQ, getting the same results as the interpolation case in **Table 1**.

These results might suggest that we have to interpolate the Saturday and Sunday stock prices, otherwise it leads to misleading results on Monday return.

5-3. The Days-of-the-Week Effect ~ Summary of Findings

(1) The Random Process Hypothesis

Since the random process hypothesis is rejected for Monday and Friday, Nikkei JASDAQ Average returns can be said to have the days-of-the-week effect, which is very familiar in stock market all over the world. The effect means both non-randomness and return difference. Further research needs to be done however [(6]. Financial economic reasoning on Monday and Friday is required, which will become our future work.

(2) Difference among the Analytic Tools

Both Wayland test and random shuffling approach lead consistently to the same conclusion in the current Nikkei JASDAQ Average stock return anomaly study [(7]. But the normalized permutation entropy shows a little different picture.

The normalized permutation entropy of Nikkei JASDAQ Average returns on Monday and Friday in **Figure 2** might be higher at first sight. The translation errors of Nikkei JASDAQ Average returns on Wednesday and Friday in **Figure 4** might also be higher at first sight. Since there are no tools to measure whether the difference among the days-of-the-week is significant, this is just a conjecture. We should say that they might be so or might not be so.

6. Discussions, Considerations and Remarks

Financial interpretation and methodological arguments are in order.

6-1. The Days-of-the-Week Effect and IPOs

(1) Problem Stated

In the random shuffling approach we have just seen that the random process hypothesis is not rejected on Wednesday. However, in the permutation entropy approach the Wednesday return shows more random fluctuation than that of other days-of-the-week. What is happening on Wednesday in JASDAQ? We will turn to this point next.

The number of Japanese IPOs has been increased great deal since the later years of the 1990's. The exchange's transaction volume has been rising sharply recently, with daily turnover hovering at some 70-100 billion yen. This is due to growing volume in online trading as well as the rising popularity of new issues.

The IPO stocks have been very frequently incorporated into the index and it then becomes known among professionals that the stock price index has been accordingly influenced by the IPOs. It should also be noted that market stock price on the IPO first trading day is often deemed as bubble.

(2) The Index Construction Procedure and IPO Procedure

How Nikkei JASDAQ Average is constructed will be related to the phenomenon.

It is postulated that new IPO stocks are included into the index composition of Nikkei JASDAQ Average next day after the first trading day (rigorously speaking, when the initial price has determined), although it is one month after the first trading day in the case of TOPIX. Therefore Nikkei JASDAQ Average is said to reflect trend of IPO stocks very quickly.

Nikkei 225 is constructed similarly to Nikkei JASDAQ Average, but the 225 stocks are selected from the Tokyo Stock Exchange (TSE) listed stocks. Furthermore the selection is generally limited to non IPO stocks because of liquidity.

IPO procedure for investors who have been allocated shares proceeds as follows. The IPO subscribers have to pay the due amount to indicated bank account for their allocated shares till the predetermined deadline date. Then the day after the deadline date of the payment is set to be the first trading day of IPOs, when the IPO subscribers could sell the shares if they want. This procedure might be related to the Wednesday anomaly phenomenon.

Banks are closed on Saturday and Sunday, although payment is possible these days through automatic teller machine in Japan. Therefore the deadline dates of the payment are usually set on Monday through Thursday, not on Friday. In turn the first trading day will be either day from Tuesday through Friday. We will see whether this is true or not next.

(3) The First Trading Day and the Return

Table 4 is the days-of-the-week distribution of JASDAQ IPO first trading day from 1996 to 2003. IPOs on Monday constitute only 6.1% for the past 8 years. There are the peaks on Wednesday and Thursday.

The JASDAQ market is now facing stiff competition from other markets for startup firms, launched in the past few years by Japan's two biggest bourses - the TSE and the Osaka Securities Exchange (OSE), Japan's second biggest bourse. TSE Mothers is established in 1999, while OSE Heracles (formally NASDAQ Japan, funded by The Nasdaq Stock Market) established in 2000.

Table 5 is the days-of-the-week distribution of IPO first trading day of all these markets. IPOs on Monday constitute only 7.0% for the past 8 years. There are also the peaks on Wednesday and Thursday.

We now understand that depending on the IPO procedure, the first trading on Monday is generally very rare and the first trading day is frequently set on either day from Tuesday through Friday. This effect on Monday is incorporated in the index number on Tuesday, as clear from the index construction procedure.

The stock return is defined as the rate of change from the last day's closing price to the today's closing price divided by the today's closing price. This is in order to avoid the usage of estimated Sunday price for Monday return calculation since it is not the real price to be quoted in the market. Therefore Tuesday return is the change of the price from Monday price divided by Tuesday price, whereas Wednesday return is the change from Tuesday price divided by Wednesday price.

In the definition of Wednesday return Tuesday price appears in the numerator, while Tuesday return definition has it in the denominator. Therefore Wednesday return rather than Tuesday return might be more influenced by Tuesday price, which in turn is affected by the IPOs and the bank customs.

(4) The Days-of-the-Week Effect Considerations

The number of JASDAQ IPOs has been increased great deal since the later 1990's. The IPO stocks have been very quickly and frequently incorporated into the index. Nikkei JASDAQ Average has therefore a tendency to be affected by the stock price of the IPO first trading day. Market stock price on the IPO first trading day is deemed as bubble. If there is a bubble in the stock price on the first trading day, Wednesday return is less affected.

This means that on Wednesday IPO first trading day bubble is observed less frequently, which in turn might make Wednesday return more random than other days-of-the-week.

The finding does not contradict with a hypothesis that IPO timing is associated with market stock price hike and IPOs activities are initiated when the market stock price is increasing or expected to go up.

6-2. Stock Index Derivatives and Weekend Uncertainty

There is a possible explanation, due to stock index derivatives and weekend uncertainty, which causes specific days-of-the-week (for example Monday) loss on stock return and could be applied to Japan. We turn to this point finally.

(1) Weekend Uncertainty Model

It is sure that there are both informed traders and uninformed traders in market. The informed traders are likely to have better information from the weekend than the uninformed traders. Because the uninformed traders are at a disadvantage strategically on Monday, the uninformed stay out of the market and the market price is more likely to reveal information of the informed. Using such argument by Foster and Viswanathan (1990) we could conclude that the uninformed traders are unwilling to trade on Monday. This causes negative stock return and low liquidity on Monday.

In these regards Boynton-Oppenheimer-Reid (2006) had done successfully the related empirical study for TSE listed stocks, using both OLS and robust regression.

(2) Institutional Changes: Historical Facts

While Nikkei JASDAQ Average does not have stock index derivatives, OSE introduced Nikkei 225 Derivatives in September 1988 and June 1989 (see **Table 6**).

Japanese Exchanges started changing trading rule on Saturday since 1972. On October 7, 1972, both delivery and settlement were ceased. On January 20, 1973, trading on the third Saturday was stopped. Since February 1989, trading on Saturday was completely abolished (see also **Table 6**). These institutional changes had increased the weekend uncertainty.

Since February 1989 on, therefore, there has been no trading on Saturday in both TSE and JASDAQ and furthermore Nikkei 225 has had stock index derivatives in OSE, whereas Nikkei JASDAQ Average does not have stock index derivatives at all. The institutional difference has increased the weekend uncertainty in JASDAQ great deal.

(3) The Introduction of Stock Index Derivatives

The effect of introducing stock index derivatives on daily stock prices was investigated by comparing the two periods of January 1975- January 1989 and February 1989-December 2001 in Boynton-Oppenheimer-Reid (2006). They carried out OLS and robust regressions with dependant variable of the daily return and independent variables of intercept +the-day-of-the-week dummies. The results showed that Tuesday abnormal loss had disappeared and Mondays had started to have abnormal losses since February 1989.

These are rather straightforward implications of their research, although not the points which Boynton-Oppenheimer-Reid (2006) would like to make. The purpose of their paper is investigation of Japanese TSE day-of-the-week return patterns and evaluation of effect of weekend uncertainty and trading volume on the stock return, and the anomaly has shown to occur for liquid stocks, consistent with Foster and Viswanathan (1990).

(4) Defensiveness to Weekend Uncertainty

In both Nikkei JASDAQ Average and Nikkei 225 we observe Monday loss. But we observed loss on Friday in Nikkei JASDAQ Average instead of Friday gain in Nikkei 225. This might be due to investors in JASDAQ taking defensive strategy to avoid the uncertainty of weekend under the inconvenient circumstance of both nonexistence of stock index derivatives and short selling restriction. It is known that the short selling rule in JASDAQ is far behind that of TSE.

The word "defensive" means that (uninformed) investors sell stocks on Friday since the investors in JASDAQ where there are no hedging devises are afraid of events which may occur during weekend.

As for Nikkei 225, investors could hedge the downside risk of stocks listed in TSE at least partly by Nikkei 225 derivatives in OSE and therefore there is no need to sell unconditionally on Friday.

6-3. Methodological Improvement Possibilities

We did not utilize GARCH, well known as a nonlinear technique, because it is parametric and uses arbitrary function. As for a periodicity analysis we did not utilize ordinary spectral analysis because it is a linear technique in the sense that it detects periodicity from linear addition of nonlinear functions, i.e., Fourier expansion.

Although our random shuffling technique is simple and easily programmed, we are sure that an evidence of its power has been shown. The present paper makes it possible to carry out hypotheses testing. There remain several remarks, however, on the methodology.

The nonlinear time series analysis could have begun with another embeddings [(8]. Given a time series { u(t)}, we construct m-dimensional phase space at t_0 with delayed vectors consisting of lagged sequences of data points as,

$$\mathbf{u}(t_0) = \{ u(t_0), u(t_0-1), u(t_0-2), \cdots, u(t_0-(m-1)) \},$$

where m is the embedding dimension and also periodic time. Then we have 5 times more samples in the experiment, which might be good for the case of small size sample.

What kind of periodicity is this study detecting? The answer is average return. One might be interested in periodicity of volatility (standard deviation) or higher moments, which could have been executed similarly.

The final remark on perspective of nonlinear analysis is that because tools for nonlinear time series analysis are still developing, we have to watch their progress and judge which to use for nonlinear time series analytical tools.

7. The Conclusion

This paper has shown and proved the existence of daily anomaly of Japanese stock index returns (especially JASDAQ stock return) since 1989, which has not been documented so far. Although it might be true that the anomaly will disappear because our current ongoing researches have published (as Dimson-Marsh-Stauton (2002) pointed out), what we have found is based on a firm background of data processing and hypothetical testing. We have carefully excluded noise and outliers by means of interpolation, ranking and shuffling, so that noise and outliers are not the cause of the anomaly. It has been also denied through hypothetical testing based on random shuffling technique that it is a result of random process.

Taking account of stock index derivatives and the JASDAQ IPO customs, we conclude that the anomaly is caused by both weekend uncertainty and stock index derivatives and it also should be partly related to IPOs.

FOOTNOTES

1) This index has been being published since November 1983 and has established itself as an indicator of the JASDAQ market trend. JASDAQ stands for Japanese Association of Securities Dealers Automated Quotation System. The JASDAQ market, market for start-ups and previously an over-the-counter market, is home to over 900 firms, owned and operated by the Japan Securities Dealers Association (JSDA).

2) Numerical example according to Bandt-Pompe (2002, P.2) will help understanding. Given a time series u(i) ={4, 7, 9, 10, 6, 11, 3 }, in the case of n = 2, there are four pairs for which { 2, 1 } and two pairs for which { 1, 2 }. Therefore,

$$H(2) = -(4/6)\log_2 (4/6) - (2/6)\log_2 (2/6) = 0.918,$$

In the case of n = 3, there are five embedding vectors: {4, 7, 9 }, { 7, 9, 10 }, { 9, 10, 6 }, { 10, 6, 11 } and { 6, 11, 3 }. By taking ranks, there are n! = 3! = 6 types of permutation. Out of all n! permutations of order n, zero cases for which { 1, 2, 3 }, two for which { 2, 1, 3 }, zero cases for which { 1, 3, 2 }, two cases for which { 3, 2, 1 }, one case for which { 2, 3, 1 }, and zero cases for which { 3, 1, 2 }. Therefore,

$$H(3) = -(1/5)\log_2 (1/5) - 2(2/5)\log_2 (2/5) = 1.522.$$

3) For above example,

$$H(2) = -2(3/6)\log_2 (3/6),$$
$$H(3) = -6(1/6)\log_2 (1/6),$$
$$H(4) = -24(1/24)\log_2 (1/24),$$
$$H(5) = -120(1/120)\log_2 (1/120).$$

4) Are there any tendencies in the frequency if we calculate its frequency f_j from the μ rank vector data? One extreme is the equal occurrence which leads to the uniform distribution of f_j, j=1, 2, ･･, M. The other extreme is the concentration at a periodic pattern, i.e., $f_j = 1$ for some j and 0 for other j's. It will be convenient to invent a measure to show how often a specific pattern is observed. The following quantity might have the desirable properties.

$$\sum_{j=1}^{M} \frac{M}{1-M}\left(f_j - \frac{1}{M} \right)^2$$

The minimum is zero when f_j distributes uniformly. The maximum 1 is attained when the frequency concentrates at a periodic pattern. This is a rough measure of persistence of a periodic pattern.

5) It might be helpful for understanding to explore the case of the frequencies of the rank vectors. The frequencies ought to be randomly shuffled 40 times. For each rank vector of 120, 40 frequencies are then used to calculate its average and standard deviation. The derived distribution of the frequencies can be utilized to test hypothesis whether the realized frequency is significantly larger or smaller than such a specific value as zero,1/M, or others.

6) There might be a possible explanation, due to Foster and Viswanathan (1990), which causes Monday loss on stock return and could be applied to Japan, as stated below.

In JASDAQ we observed Monday loss and also Friday loss instead of Friday gain in Nikkei 225. This might be due to investors in JASDAQ taking defensive strategy to avoid the uncertainty of weekend under the inconvenient circumstance of both nonexistence of stock index derivatives and short selling restriction.

7) The results of Nikkei 225 are inconsistent each other among the analytical tools. We will collaborate this in the future.

8) Although many dynamical systems are subject to multiple independent variables to determine their time evolution, there are often cases where only a single variable can be observed. It has been claimed that the embedology is proved to guarantee to reproduce the whole characteristics of the underlying dynamics from time series data about a single variable despite a Q-dimensional multivariate system. However, our technique does not depend on this theorem.

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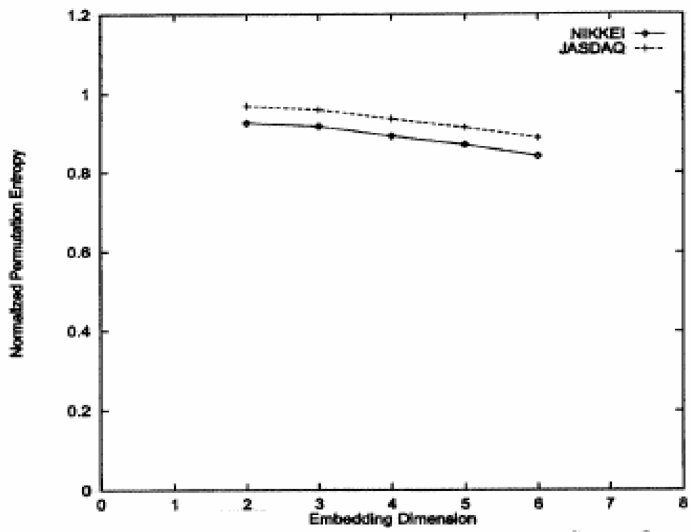
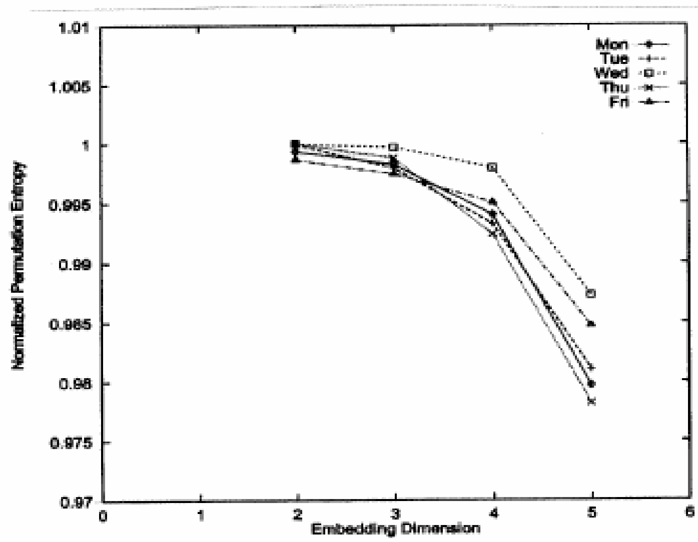
Figure 1. Normalized Permutation Entropy of Nikkei 225 and Nikkei Jasdaq Average



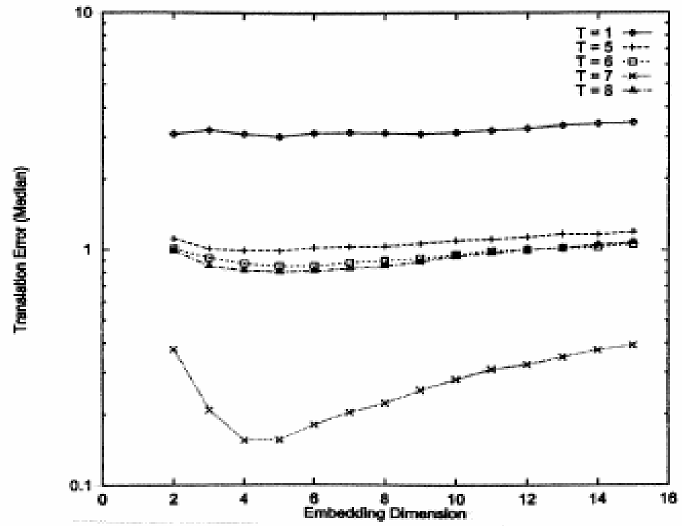
Applied to Returns with Interpolations on Saturday, Sunday and National Holidays.

Figure 2. Normalized Permutation Entropy of Nikkei Jasdaq Average



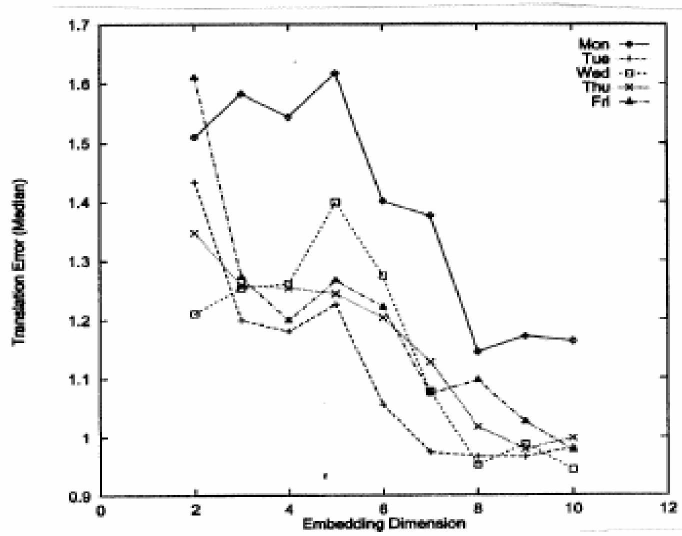
Applied to Returns of the Days-of-the-Week with Interpolations on Saturday, Sunday and National Holidays.

Figure 3. Wayland Test for Daily Nikkei Jasdaq Average



Applied to Returns with Interpolations on Saturday, Sunday and National Holidays. Δt =7, various T.

Figure 4. Wayland Test for Nikkei Jasdaq Average



Applied to Returns of the Days-of-the-Week with Interpolations on Saturday, Sunday and National Holidays. Δt =1, T=5.

Table 1. Student's t-Statistical Test using Surrogate Returns for the Case of Random Shuffle of Daily Stock Price within Week

	Interpolation		No Interpolation	
	Nikkei 225	JASDAQ	Nikkei 225	JASDAQ
Monday	-2.041560*	3.648944*	1.582316	8.640796*
Tuesday	-1.029151	6.112397*	-2.453225*	4.905159*
Wednesday	-0.142792	-0.968204	-0.618753	-2.054347*
Thursday	-0.368694	-1.609286	-0.710046	-2.937898*
Friday	2.459741*	-5.347454*	1.953381	-6.670968*

Note: * indicates significance at the 95% confidence level for the both-sided test.
number of surrogates = 40.

Table 2. Student's t-Statistical Test using Surrogate Returns for the Case of Random Shuffle of Daily Return within Week

	Interpolation		No interpolation	
	Nikkei 225	JASDAQ	Nikkei 225	JASDAQ
Monday	-1.363798	2.468376*	1.856979	7.882423*
Tuesday	-0.695004	5.324803*	-2.131381*	3.804672*
Wednesday	-0.157481	-1.129332	-0.726097	-2.206189*
Thursday	-0.333943	-1.465574	-0.784973	-2.642103*
Friday	2.436941*	-5.774423*	1.859322	-7.107755*

Note: * indicates significance at the 95% confidence level for the both-sided test.
number of surrogates = 40.

Table 3. Student's t-Statistical Test using Surrogate Returns for the Wiping-Out of No Interpolation Effect

	Daily Stock Price Shuffling		Daily Return Shuffling	
	Nikkei 225	JASDAQ	Nikkei 225	JASDAQ
Tuesday	-1.327296	8.756163*	-1.888394	5.723534*
Wednesday	-0.630372	0.027626	-0.736687	-0.728738
Thursday	-0.797523	-0.023908	-0.511837	-0.274303
Friday	2.433476*	-4.610130*	2.944555*	-4.819721*

Note: * indicates significance at the 95% confidence level for the both-sided test.

number of surrogates = 40.

Table 4. The Days-of-the-Week Distribution of JASDAQ IPOs First Trading Days

	1996	1997	1998	1999	2000	2001	2002	2003	Total
Mon	5	10	2	3	9	4	5	3	41
Tue	28	27	16	17	24	17	17	8	154
Wed	21	20	11	16	24	38	18	15	163
Thu	31	24	16	16	23	22	14	21	167
Fri	25	21	17	20	17	16	14	15	145
Total	110	102	62	72	97	97	68	62	670

Table 5. The Days-of-the-Week Distribution of IPOs First Trading Days (All Markets)

	1996	1997	1998	1999	2000	2001	2002	2003	Total
Mon	5	10	2	3	17	9	6	8	60
Tue	28	27	16	17	40	28	30	14	200
Wed	21	20	11	18	32	52	27	22	203
Thu	31	24	16	16	36	33	19	33	208
Fri	25	21	17	20	34	25	18	24	184
Total	110	102	62	74	159	147	100	101	855

Table 6. Dates of Changes and Introduction

Trading Rule Changes in Japan		Stock Index (Nikkei 225) Derivatives	
October 7, 1972	Neither delivery nor settlement and only trading on Saturday		
January 20, 1973	No trading on the third Saturday	September 1988	Stock Index Futures introduction in OSE
February 1989	No trading on Saturday	June 1989	Stock Index Option introduction in OSE