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# The Changing Market Efficiency of Tokyo Stock Exchange (Nikkei)

**Manish Kumar*, Subrata Roy****

**Abstract**

A stock market is known as a secondary market which plays the role of buying and selling stocks and securities. The efficiency of the market depends upon how quickly the market assimilates new information. The market consists mainly of three types of market- weak form, semi-strong form, and strong form. The weak form of market efficiency indicates that all the previous market prices and information are fully displayed in stock prices in the semi-strong form of the market. The stock prices reflect all the publicly available information. In the case of strong form, the market is said to be efficient when the stock prices display all the information, where insider information is of no use. Any new information that helps to alter the prospect of the organisation's potential profitability must instantly be displayed in the stock prices without delay. The Tokyo Stock Exchange (NIKKEI) began on 9th July 1950. The Tokyo Stock Exchange (NIKKEI) measures the performance of 225 large, publicly owned companies in Japan from a wide array of industry sectors. It is a price-weighted index operating in Japanese Yen (JP¥). The purpose of this paper is to test the market efficiency of the Tokyo Stock Exchange (NIKKEI) by using the daily time series data from the period 1st April 2010 to 31st March 2020. The study applied various statistical tools and techniques, including run tests, unit root tests, and VR tests. The study examines the market efficiency of the Tokyo Stock Exchange (NIKKEI) by considering the daily closing index prices and also observed that the null hypothesis of the daily returns of the indices is rejected and accepted.

**Keywords:** Market Efficiency, NIKKEI, Run Test, Unit Root Test and VR Test

## Introduction

A stock market is known as a secondary market which plays the role of buying and selling stocks and securities. The efficiency of the financial market depends upon how quickly the market assimilates new information. A market is said to be efficient when the stock prices fully reflect all the available information where the making of abnormal profit is impossible. Any new information that helps to alter the prospect of the organisation's potential profitability must instantly be displayed in the stock prices without delay. Fama (1965a) gave the three types of market efficiency, namely (i) weak form, (ii) semi-strong form and (iii) strong form. In a weak form of efficient market current price reflects all the information contained in the past prices. In the semi-strong form of market efficiency, the stock prices reflect all the publicly available information, and in the case of strong form, the market is said to be efficient when the stock prices display all the information where insider information is of no use. The Tokyo Stock Exchange is the largest stock market in the Asia Stock Market and the third largest stock exchange in the world by the aggregate market of the capitalization of listed companies. The stock exchange is owned by the Japan Exchange Group (JPX). It has been begun on 9th July 1950. The stock indices are also known as NIKKEI. The Tokyo Stock Exchange (NIKKEI) measures the performance of 225 large, publicly owned companies in Japan from a wide array of industry sectors. It is a price-weighted index operating in Japanese Yen (JP¥). The purpose of this paper is to test the market efficiency of the Tokyo Stock Exchange (NIKKEI) by using the daily time series data from the period 1st April 2010 to 31st March 2020. The study applied various statistical tools

* Research Scholar, Department of Commerce, Mahatma Gandhi Central University, Motihari, Bihar, India.
Email: mkcro282@gmail.com
** Associate Professor, Department of Commerce, Mahatma Gandhi Central University, Motihari, Bihar, India.
Email: subrata1_roy@yahoo.com

and techniques, including run tests, unit root tests, and VR tests. It is observed that the null hypothesis of the daily returns of the indices is rejected and accepted. The study examines the market efficiency of the Tokyo Stock Exchange (NIKKEI) by considering the daily closing index prices and also observed that the null hypothesis of the daily returns of the indices is rejected and accepted.

The remaining paper is designed into six sections. The literature review is described in 2nd Section. The 3rd Section deals with data and the study period. The 4th Section describes the methodology. The 5th Section analyses the result, and finally, the 6th Section ends with a conclusion.

## Literature Review

Butler (1992) examines the market efficiency of thinly traded stock markets in Kuwait and Saudi Arabia by taking into consideration of daily closing prices over the period from 1985 to 1989. The study shows that allocation efficiency is vital in the Saudi stock market. There is a significant autocorrelation found between the individual stocks. Kuwait has developed a centralized auction-based stock exchange. On the other side, Saudi Arabia grants a brokerage monopoly to twelve banks through the over-the-counter market. McAleer et al. (2003) examine the integration and contagion effect of exchange rates of ASEAN regions from 1994 to 2002 by considering 2273 daily observations. The ASEAN region comprises Indonesia, Malaysia, the Philippines, Singapore and Thailand. The study uses an econometric equation by incorporating a dummy variable in the model. They observe that the establishment of a common currency is possible only when the disturbances are of similar nature. Finally, they establish that the degree of association among the ASEAN countries increased during the financial downturn. Gupta et al. (2007) examine the weak form of market efficiency of the Indian stock exchanges, representing the two majorities of the equity market in India. Thus they consider daily data over a period from 1991 to 2006. They apply three tests ADF, PP and KPSS tests. It is found that the markets are not efficient in weak form. They also observe that the "Badla system" is a complex mechanism of forward settlement that is not transparent and is not accessible to many market participants.

Moreover, it is observed that the area of volatility spillover is extended across markets. Finally, they suggest applying generalized autoregressive conditional heteroskesdasticity (GARCH). Sewell (2011) makes a pilot study based on the literature on the efficient market hypothesis. He finds that half of the paper he reviewed supports the efficient market hypothesis during a period from 1980 to 1990, and the efficiency is achieved due to information. Some of the studies also opine that the market is not informationally efficient. But, economists suggest that EMH is the strongest hypothesis for an efficient market. Li and Liu (2012) examine the random walk hypothesis of 34 MSCI countries by considering daily data over a period from 1988 to 2010. Thus, the study applies a variance ratio test and observes that twenty-five stock markets follow random walk out of thirty-four. But, they also highlight that four emerging markets don't follow RWH out of nine emerging stock markets. Asiri et al. (2013) try to explore the random walk and market efficiency of sixteen indices by considering daily time series data over a period from October 30, 2006, to November 15, 2012. The study uses various econometric tools and techniques like Dicky-Fuller unit root, Pearson correlation coefficient, Durbin-Watson (autocorrelation), and Wald-Wolfowitz run-tests. The study reports that only four indices follow random walk behaviour. In 2014, Konak and Seker sought to examine the stock market efficiency by considering the daily closing prices of the FTSE 100 index over a period from January 2001 to November 2009. The study uses various statistical tools and techniques like ADF, PP, BDS and GARCH regression equations. It is found that the FTSE 100 index follows RDW. The study also reports that FTSE 100 is efficient in its weak form. Kumar et al. (2017) examine whether macroeconomic variables are the major determinants of stock market returns. The study considers two macro variables, oil price and exchange rate. The study uses monthly data on Brent Crude Prices and exchange rates INR/USD from September 2005 to August 2015. It also considers the US Dollar price of the Sensex. The study uses various statistical tools and techniques like the co-integration test, Augmented Dickey-Fuller test and VAR mode. They observe that a huge part of India's current account deficit is because of the oil import, which gives the theoretical ground to consider oil price as an important macro variable that affects the stock market. Further, the study suggests that the daily data may be used to estimate models like ARIMA, ARCH, etc. Fernando

et al. (2018) examine the weak form of efficiency of the Colombo Stock Exchange (CSE) by taking into account the daily market closing index values that are obtained from its respective website over a period from June 2010 to June 2015. The study applies various parametric and non-parametric statistical tests. Also, it uses technical and fundamental analysis to predict/forecast future prices based on previous and currently available information. Therefore, the study opines policymakers to take the necessary steps to build an efficient mechanism. The study reports that the market is efficient in its weak form and also suggests taking into consideration the transaction cost and dividends to predict the market.

## Data and Study Period

The study is based on secondary data. Data considers the daily closing value of the Tokyo Stock Exchange (NIKKEI). The daily data is obtained from the official website of the Tokyo Stock Exchange (NIKKEI). Data are collected over a period from 1st April 2010 to 31st March 2020.

## Methodology

In the study, the measures to test the market efficiency applied various statistical tools and techniques such as the Run test, Unit Root test (like Augmented Dickey-Fuller (ADF) test, and Phillips-Perron (PP) test), and Variance Ratio (VR) test.

### Run Test

The run test is a technique for the calculation of market efficiency. It is a non-parametric statistical test that checks sampling distribution under market efficiency and random walk. A run test is a sequence of successive alteration of the logarithmic rate of returns with positive or negative signs (such as: +, - or 0) and a state of affairs when the expected number of the run is considerably completely different from the determined variety of runs, the check rejects the null hypothesis that daily returns are random. The following equation indicates the run test.

$$Z = R - \frac{X}{\sigma}$$

Where,

R = total number of runs

X = 2n1n2+1/n1+n2

n1 = number of positive runs

n2 = number of negative runs

n = n1+n2

Z = normal variance

$$\sigma = \sqrt{2}n1n2(2n1n2 - n)/n^2(n-1)$$

If the z price is over and fewer than +1.96, then it is said vital, which means that the distribution follows a random walk and vice-versa.

### Unit Root Test

The presence of unit root in a time series is tested using the Augmented Dickey-Fuller test. According to Hassan et al. (2007), the unit root test is used to study market efficiency because it demands randomness (non-stationary) in the stock prices. The unit root indicates no stationary implies that if the data points move away from the past mean for long time periods.

$$\Delta r_t = \alpha + \delta r_{t-i} + \sum_{i=1}^{p} X\beta\Delta r_{t-1} + \varepsilon_t$$

$$\Delta r_t = r_t - r_{t-1}; r_t = In(\mathrm{R}_t)$$

The null and alternative hypotheses are as follows:

$H_0$: the series contains unit root

$H_1$: the series is stationary

The acceptance of the null hypothesis implies non-stationary. If the ADF test rejects the null hypothesis of a unit root in the return series, that is, if the absolute value of ADF statistics exceeds the McKinnon critical value, the series is stationary and concludes that the series does not follow a random walk.

### Variance Ratio Test (VR Test)

The variance ratio test statistic is obtained from the assumption of linear relations in observation intervals regarding the variance of increments. If the logarithmic

time series rate of return follows a random walk, then the qth differenced variable is q times higher than the first-differenced variable.

$$VR(q) = \frac{\frac{1}{q} Var(\ln R_{\text{NIKKEI},t} - \ln R_{NIKKEI,t-q})}{Var(\ln R_{NIKKEI,t} - \ln R_{NIKKEI,t-1})} = \frac{\sigma^2(q)}{\sigma^2(1)}$$

Here,

$H_0$ is VR (q) = 1

## Result and Analysis

Empirical analysis on NIKKEI is based on daily observation from 1st April 2010 to 31st March 2020. Fig. 1 shows the graph of Tokyo Stock Exchange (NIKKEI).


**Fig. 1: Tokyo Stock Exchange (NIKKEI)**

For the purpose of analysis, the study has involved E-views 12. The descriptive statistics of the return series for stock have reported in Table 1 below. The results relating to descriptive statistics show that Tokyo Stock Exchange (NIKKEI) is negatively skewed with very low mean and variance, suggesting lower expected returns and risk. The measure of kurtosis suggests that the daily index return series in Tokyo Stock Exchange (NIKKEI) has fatter tails than the normal distribution over the period. This is termed as Lepto-kurtosis, or simply fat tails Jarque-Bera (JB) statistic with significant p-value indicates that the return series are not normal. Table 1 presents two sets of test statistics, particularly the Q-statistic and Runs test. It is observed that the Q statistics of the logarithmic rate of returns of both the market indices are not statistically significant, which means acceptance of the null hypothesis (H0: weak-form of market efficiency).

It is also observed from the Runs test that the test statistics of the indices are statistically significant. It is also found that the test statistics of both the market indices are found to be positive, which means the existence of a negative serial correlation in the distribution of the logarithmic rate of returns. Thus, it may be opined that in both markets, the indices are inefficient at their weak forms and don't follow random walks during the period.

**Table 1: Descriptive Statistics**

| *Index* | *OB* | *Mean* | *Max.* | *Min.* | *Standard Deviation* | *Skew.* | *Kurt.* | *J-B* | *P-Value* |
|---|---|---|---|---|---|---|---|---|---|
| lnNIKKEI | 2467 | 16106.31 | 24270.62 | 8160.010 | 4968.960 | -0.1808 | 1.4130 | 203.209** | 0.0000 |

**Indicates 5% significance level.

Source: Authors' own calculation.

The outcome of the unit root test based on two approaches is presented in Table 2. It is observed that the test statistic based on ADF and PP tests is insignificant in the level form in both the logarithmic rate of return series of the indices, which means the series is non-stationary. But they become stationary when the difference operator is taken. Therefore, the null hypothesis of unit root is rejected, meaning that the daily logarithmic rate of return series of the indices is stationary and doesn't follow a random walk and market efficiency. Thus, the markets are inefficient in their weak forms.

**Table 2: Unit Root Tests**

| *Index* | *ADF Test* | | | | *PP Test* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Level* | | *1st Difference* | | *Level* | | *1st Difference* | |
| | *T-Stat.* | *Prob.* | *T-Stat.* | *Prob.* | *T-Stat.* | *Prob.* | *T-Stat.* | *Prob.* |
| lnNIKKEI | -1.2075 | 0.6734 | -50.1392** | 0.0001 | -1.2081 | 0.6688 | -50.1391 | 0.0001 |

*Significant at 5% level.

Source: Authors' own calculation.

It is observed from Table 3 that the value of the variance ratio test is lower than the critical value (2.49) at a 5% level of significance, which indicates acceptance of the null hypothesis of random walk. Thus it may be opined that the NIKKEI is efficient in its weak form.

**Table 3: Variance Ratio Test**

| *Index* | *Lo-Mackinlay VR Test* | | | | |
|---|---|---|---|---|---|
| | *Period* | *VR* | *Std. Error* | *Z- Statistic* | *Prob.* |
| lnNIKKEI | 2 | 0.9903 | 0.0367 | -0.2636 | 0.7920 |
| | 4 | 1.0250 | 0.0647 | 0.3869 | 0.6988 |
| | 8 | 1.0189 | 0.0946 | 0.2006 | 0.8410 |
| | 16 | 0.9900 | 0.1338 | -0.0741 | 0.9409 |

Source: Authors' own calculation.

## Conclusion and Recommendation

The study tries to examine the market efficiency of the Tokyo Stock Exchange (NIKKEI). It is observed from the analysis that the index follows a random walk and is efficient at its weak form, which is supported by the unit root tests. However, the result of variance ratio tests accepts the null hypothesis of random walk. Thus, it may be recommended that the study is helpful to the financial planner, policymakers and investors who are interested in investing in NIKKEI and for their investment decision. The researchers may conduct a further study by considering other financial markets.

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