Stock Market Efficiency in Nepal: A Variance Ratio Test

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Abstract

The paper examines random-walk behaviour and weak-form market efficiency on daily and weekly market returns of All Share Price Index and nine sectoral indices in the Nepal Stock Exchange (NEPSE) using Lo and MacKinlay (1988) variance-ratio tests and corrected data as suggested by Miller et al. (1994). The study finds that the random-walk hypothesis is strongly rejected for weekly indices of the observed and corrected returns. It shows that market participants have opportunities to predict future price and earn abnormal returns from the Nepalese stock market. Whereas, overall and development banking sectors support the random-walk hypothesis in daily observed and corrected returns. It indicates that technical analysis may not be fruitful to earn excess returns in overall and development banking sectors.

Key Words: Market efficiency, Random-walk, Variance ratio

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I. INTRODUCTION

According to Fama (1970, 1991), in an efficient stock market, share prices reflect all information available to market participants and that, by implication, share prices cannot be predicted, thus precluding any abnormal profit returns. From view-point of market participants, the stock price behaviour is very important to determine future abnormal returns.

For weak form tests, information can include only past history of security prices. Tests for weak-form market efficiency are, more generally, referred to as test of return predictability (Fama 1991). The weak-form of market efficiency is investigated by examining whether stock prices in equity markets exhibit specific patterns, which allow future prices to be predicted. For a market to be efficient in weak-form then no such patterns should exist and prices should follow a random walk. The weak-form inefficiency of the stock market provides an opportunity to the traders for predicting the future prices and earning abnormal profits.

Fama and French (1988) reported that NYSE has negative serial correlation (mean reverting) in market returns over observation intervals of three to five years, i.e., stock returns are predictable. They argued that autocorrelation may reflect market inefficiency or time-varying equilibrium expected returns generated by rational behaviour.

On contrary to Fama and French (1988), Lo and MacKinlay (1988) using a simple volatility based specification test, concluded that the NYSE-AMEX return indices showed positive serial correlation in market returns and the random-walk model is strongly rejected. They argued that the negative serial correlation in Fama and French's (1988) study for long (three- to five-years) holding-period returns was, on purely theoretical grounds, not necessarily inconsistent with positive serial correlation for shorter holding-period returns. They also claimed that the sum of a random-walk and mean-reverting process cannot be a complete description of stock-price behaviour. Similarly, Lo and MacKinlay (1988) opined that the rejection of the random-walk model did not necessarily imply the inefficiency of stock price formation.

Jegadeesh (1990) showed that the monthly returns on individual stocks exhibited significant negative first-order serial correlation and significantly positive higher-order (longer lags) serial correlation. The study also showed that the return in January was significantly different from other months. The stock returns showed a specific pattern. It is a strong evidence of predictable behaviour of security returns. It indicates the rejection of the hypothesis that the stock prices follow a random-walk. The author pointed out that the predictability of stock returns can be attributed either to market inefficiency or to systematic changes in expected stock returns. Fama and French (1988), Lo and MacKinlay (1988), and Jegadeesh (1990), the studies in the developed markets, showed the predictability of future returns and concluded that the market was inefficient in weak-form, i.e., price formation is dependent on or follow specific patterns. But, these studies did not explain the economic implication of the inefficient markets.

Similarly, Urrutia (1995) tested the efficiency of Latin American countries. The time series behaviour of sample Latin American equity prices did not seem to fit mean-

reverting processes either, since variance-ratios larger than unity imply positive return autocorrelation. Thus, results of the variance ratio test rejected the random walk hypothesis for all sample equity markets. However, findings from the run tests indicate that the Latin American equity markets are weak-form efficient. Urrutia (1995) is successful to link between the market inefficiency and economy, which are lacking in the previous studies; for example, Fama and French (1988) and Lo and MacKinlay (1988). Worthington and Higgs (2009) reported that the monthly Australian stock returns followed a random-walk, but daily returns did not because of short-terms autocorrelation in returns.

In the context of Nepal, Pradhan and Upadhyay (2006), Bhatta (2010) and Dangol (2010a) found that the Nepalese stock market did not follow random-walk hypothesis and was inefficient in weak form for daily, weekly and monthly market returns series. Similarly, Dangol (2010b) examined random-walk behaviour on daily market returns of the Nepal Stock Exchange (NEPSE) and found that the Nepalese stock market did not show characteristics of random-walk and thus, it was not efficient in the weak form. It implicates that market participants have opportunities to predict future price and earn abnormal returns from the Nepalese stock market.

The previous studies show the mixed results regarding the random-walk hypothesis and weak-form of market efficiency. The reasons for inefficiencies are observed due to autocorrelation structures in their returns series. The developed markets show autocorrelation on its returns series, may be systematic changes in expected stock returns or rational behaviour of the investors. On the other hand, the majority of the emerging equity markets provide positive autocorrelation indicating unusual rapid economic growth.

Dangol (2011) examined the random-walk behaviour and weak form of market efficiency in the Nepalese and Indian stock markets employing variance ratio as methodologies and found that the variance-ratio tests were rejected the random-walk hypothesis for both countries' stock markets. There was no evidence for weak form efficiency in the return series of the Nepalese stock market. However, the study showed the Indian stock markets efficient in the weak-form. It implies that market participants have opportunities to predict future prices and earn abnormal returns in the Nepalese stock market, while the development of trading strategies might not be able to earn excess returns in the Indian stock markets. Furthermore, mean-reverting process was found in both the Nepalese and Indian stock markets, suggesting overinflated stock prices, abnormally high volatility and frequent market correction from a bubble effect.

In conclusion, the studies on weak form of market efficiency reveal that the stock prices are randomly formulated in a majority of the developed stock markets. But few emerging markets have also shown characteristics of random-walk behaviour, whereas, the emerging markets including South-Asian region are inefficient in the weak form. The reasons for inefficiencies are largely due to autocorrelation structures in their returns series. The developed markets show autocorrelation on its returns series, probably because of systematic changes in expected stock returns or rational behaviour of the

investors. On the other hand, the majority of the emerging equity markets provide positive autocorrelation that indicates unusual rapid economic growth.

As such, in the context of Nepal, there is the need for evaluating the level of market efficiency and random-walk behaviour of stock prices. Thus, the main objective of the study is to test random-walk behaviour of the stock returns in Nepal.

It intends to measure the behaviour of the stock returns in the Nepalese stock market. Once the behaviour of the stock returns is determined, then one can better understand the market and the economy. It makes stock prices reflect the true picture of the company as well as the condition of the overall economy. It can provide better confidence to decision-makers on their investment decisions and help in reducing the level of risk.

The prior assumption of the study is that the market is efficient and the return series follow a random-walk. If this is true, then past information including past prices are irrelevant in predicting future stock prices for the companies listed in the Nepalese stock market. If successive returns are independent, then, the market is said to be efficient in its weak-form.

The Section II of the paper contains details about research methods. The Section III shows empirical results and discussions, while Section IV consists of the conclusions and implications.

II. RESEARCH METHODS

Data

The study employs daily and weekly returns of value-weighted portfolios of stocks listed with the Nepal stock exchange (NEPSE) for the period of ten years between Mid-July 2000 and Mid-July 2010.

The natural log of the relative price has been computed for the daily/weekly intervals to produce a time series of continuously compounded returns, such that:

$$R_t = \text{Ln}\left(\frac{P_t}{P_{t-1}}\right) \times 100 \qquad \text{..... (1)}$$

where P_t and P_{t-1} represent the stock index price or individual security closing price at time t and t-1 and Ln refers to natural log. The reasons to take logarithm returns are justified by both theoretically and empirically. Theoretically, logarithmic returns are analytically more tractable when linking returns over longer intervals. Empirically, logarithmic returns are more likely to be normally distributed, which is a prior condition of standard statistical techniques (Strong, 1992).

Estimating the True Index-Correcting for Infrequent Trading

In investigating the pattern of sole equity market of Nepal, it is important to take its characteristics like thin-trading into consideration. To separate the effect of thin trading,

the study has applied corrections to the observed index by using a methodology proposed by Miller, Muthuswamy and Whaley (1994). To correct for infrequent trading, this methodology basically suggests a moving average model (MA) to remove the impact of thin trading, as the MA reflects the number of non-trading days and calculates returns adjusted for the effect of non-trading days. However, given the difficulties in identifying the non-trading days, Miller et al. (1994) have shown that it is equivalent to estimate an auto-regressive or AR (1) model from which the non-trading adjustment can be obtained. Specifically, this model estimated the following specifications related to the returns, R at time t:

$$R_t = \alpha_1 + \alpha_2 R_{t-1} + \varepsilon_t \quad \text{..... (2)}$$

$$R_t^{adj} = \frac{\varepsilon_t}{(1 - \alpha_2)} \quad \text{..... (3)}$$

where R_t^{adj} is the return at time t adjusted for thin-trading. Miller et al. (1994) find thin trading adjustment reduces the negative correlation among returns. The model above assumes that non-trading adjustment is constant over time.

Methodology to Test Hypothesis: Variance Ratios in Stock Returns Series

The study has used the variance-ratio method of Lo and MacKinlay (1988) to test for random-walk in the return series. The idea behind the variance-ratio test is that if the natural logarithm of a time series Y_t is a pure random-walk, the variance of its q-differences grows proportionally with difference q. That is, the variance of the increments in a random-walk is linear in the sampling interval. Therefore, if a time series follows a random-walk process, the variance of its q-differences should by q times the variance of its first differences. The variance- ratio, VR(q), is defined as:

$$VR(q) = \frac{\sigma^2(q)}{\sigma^2(1)} \quad \text{..... (4)}$$

Where, $\sigma^2(q)$ is 1/q the variance of the q-differences and $\sigma^2(1)$ is the variance of the first differences. According to Lo and MacKinlay (1988), formulas for the calculation of $\sigma^2(q)$ and $\sigma^2(1)$ are as follows:

$$\sigma^2(q) = \frac{1}{q(nq - q + 1)(1 - \frac{q}{nq})} \sum_{t=q}^{nq} (Y_t - Y_{t-q} - q\hat{\mu})^2 \quad \text{..... (5)}$$

and

$$\sigma^2(1) = \frac{1}{(nq - 1)} \sum_{t=1}^{nq} (Y_t - Y_{t-1} - \hat{\mu})^2 \quad \text{..... (6)}$$

where,

$$\hat{\mu} = \frac{1}{nq}(Y_{nq} - Y_0)$$

Y_0 and Y_{nq} are the first and last observations of the time series. The test is performed under both homoskedastic and heteroskedastic specifications. Under homoskedasticity, the asymptotic variance of the variance ratio is expressed as follows:

$$\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \quad \text{..... (7)}$$

Under heteroskedasticity, the asymptotic variance can be expressed as:

$$\phi^*(q) = \sum_{k=1}^{q-1}\left[\frac{2(q-k}{q}\right]^2 \hat{\delta}(k) \quad \text{..... (8)}$$

where, $$\hat{\delta}(k) = \frac{\sum_{t=k+1}^{nq}(Y_t - Y_{t-1} - \hat{\mu})^2 (Y_{t-k} - Y_{t-k-1} - \hat{\mu})^2}{\left[\sum_{t=1}^{nq}(Y_t - Y_{t-1} - \hat{\mu})^2\right]^2}$$

The homoskedasticity and heteroskedasticity consistent Z-statistics are denoted by Z(q) and Z*(q) and expressed as follows:

$$Z(q) = \frac{VR(q)-1}{\sqrt{\phi(q)}} \sim N(0,1) \quad \text{..... (9)}$$

and

$$Z^*(q) = \frac{VR(q)-1}{\sqrt{\phi^*(q)}} \sim N(0,1) \quad \text{..... (10)}$$

Under a single variance-ratio test, the null hypothesis is that VR(q) = 1 or that the chosen index follows a random-walk. If the null hypothesis is rejected and VR(q) > 1, then the computed Z(q) and Z*(q) are positive and returns are positively serially correlated. If the null hypothesis is rejected and VR(q) < 1, then the computed Z(q) and Z*(q) are negative and returns are negatively serially correlated, i.e., mean reverting.

III. EMPIRICAL TEST RESULTS

This study has employed variance ratio tests for the null hypothesis, namely homoskedastic and heteroskedastic increments random-walk. Tables 1 to 4 report the variance-ratio tests, which are computed for interval q = 2, 4, 8, 16 daily (weekly) observation interval, i.e., for each q by comparing the variance of the one-day (week) base interval with that of two-day (week), four-day (week), eight-day (week) and sixteen-day (week) observation intervals. The rejection of the random-walk hypothesis under homoskedasticity is not sufficient on its own, as it could be due to heteroskedasticity or autocorrelation in the examined series. Hence, it is important to focus mainly on heteroskedasticity consistent Z-statistics.

Results for Daily Returns

Table 1 shows the variance-ratio tests for daily returns on observed data. In the overall study period, random-walk hypothesis in overall market retunrs, development banking and insurance sectors under heteroskedasticity is not rejected but it is rejected under homoskedasticity. On the contrary, random-walk hypothesis is rejected in commercial banking, finance, hydropower, hotel, trading manufacturing and other sectors in both under heteroskedasticity and homoskedasticity. In the case of the overall index, the random-walk hypothesis is not rejected under heteroskedasticity. Hence, the overall index is able to properly represent the performance of individual sectors. Similarly, development banking and insurance sector also accept the random-walk hypothesis.

According to Table 3, when corrected indices for adjustment of infrequent trading are used, the random-walk hypothesis is accepted by overall market and development banking returns series under heteroskedasticity. The empirical evidence obtained from the variance ratio tests for daily observed and corrected returns indicates that the random-walk hypothesis under the assumption of homoskedasticity is rejected for all series, periods and sub-periods.

In first half period (July 17, 2000–July 16, 2005), the hypothesis of random-walk under assumption of homoskedasticity is accepted at all cases of q for series – overall index, development banking, finance, insurance and other sectors in both daily observed and corrected data, and manufacturing sector in only corrected data. Similarly, in second half period (July 17, 2005-July 15, 2010) the hypothesis of random-walk under assumption of homoskedasticity is strongly accepted at all cases of q for four returns series (i.e., hotel, trading, manufacturing and other sectors) in daily observed data and five returns series (i.e., finance, hotel, trading, manufacturing and other sectors) in the corrected data.

Results for Weekly Returns

Results of the variance ratio tests on the weekly observed return data, present in Table 2, confirm that the null hypothesis of random-walk under assumption of homoskedasticity is rejected for all series in all cases of q in overall study period and the sub-periods. Besides that, the heteroskedasticity-consistent variance ratio test provides the evidence that null hypothesis of random-walk cannot be accepted for weekly observed returns series except for the trading sector (q=3 and q=4), manufacturing sector (q=2, q=3 and q=4) and other

sector (q=4). Moreover, the evidence against the null hypothesis of random-walk under assumption of heteroskedasticity in the cases of trading, manufacturing and other sectors is inadequate, because there are only a few rejections reported.

Further, when the corrected returns are employed (Table 4), similar results are obtained from the tests. Specially, the null hypothesis of random-walk under assumption of homoskedasticity is rejected for all series at all cases of q in the overall study period and sub-periods, while the null hypothesis under the assumption of heteroskedasticity cannot be accepted for series in some cases of q.

In first half period (July 17, 2000–July 16, 2005), the hypothesis of random-walk under assumption of homoskedasticity is strongly accepted in all cases of q for only three series – development banking, manufacturing and other sectors in both weekly observed and corrected data. Similarly, in second half period (July 17, 2005-July 15, 2010) the hypothesis of random-walk under assumption of homoskedasticity is accepted in all cases of q for only two series – hotel and trading sectors in weekly observed returns and for three series – hotel, trading and other sectors in weekly corrected returns series.

Table 1: Variance Ratio Tests of Daily Stock Returns (Observed Data)

Indices	Statistics	Overall Period (2000 July 17 – 2010 July 15)				First Half Period (2000 July 17 – 2005 July 16)				Second Half Period (2005 July 17 – 2010 July 15)			
		q = 2	q = 4	q = 8	q = 16	q = 2	q = 4	Q = 8	q = 16	q = 2	q = 4	q = 8	q = 16
Overall	VR(q)	0.456	0.234	0.116	0.059	0.391	0.201	0.101	0.051	0.728	0.373	0.184	0.095
	Z(q)	*-26.275	*-19.786	*-14.433	*-10.330	*-20.983	*-14.717	*-10.474	*-7.430	*-9.188	*-11.340	*-9.338	*-6.955
	Z*(q)	-1.851	-1.695	-1.647	-1.623	-1.672	-1.426	-1.353	-1.322	*-4.876	*-6.659	*-6.360	*-5.303
Commercial Banking	VR(q)	0.492	0.252	0.128	0.064	0.413	0.213	0.110	0.055	0.689	0.352	0.175	0.091
	Z(q)	*-24.545	*-19.299	*-14.236	*-10.267	*-20.219	*-14.491	*-10.361	*-7.399	*-10.535	*-11.713	*-9.439	*-6.989
	Z*(q)	*-4.366	*-4.139	*-3.995	*-3.735	*-3.634	*-3.145	*-2.949	*-2.742	*-5.190	*-6.593	*-6.362	*-5.382
Development Banking	VR(q)	0.410	0.205	0.105	0.054	0.355	0.179	0.089	0.045	0.598	0.299	0.164	0.085
	Z(q)	*-26.261	*-18.901	*-13.466	*-9.565	*-18.619	*-12.678	*-8.898	*-6.263	*-13.590	*-12.672	*-9.567	*-7.037
	Z*(q)	-1.775	-1.552	-1.473	-1.441	-1.507	-1.246	-1.165	-1.130	*-2.838	*-3.257	*-3.237	*-3.143
Finance	VR(q)	0.352	0.172	0.088	0.045	0.339	0.167	0.086	0.044	0.372	0.184	0.093	0.048
	Z(q)	*-31.285	*-21.336	*-14.888	*-10.479	*-22.779	*-15.341	*-10.650	*-7.485	*-21.251	*-14.759	*-10.373	*-7.316
	Z*(q)	*-2.563	*-2.122	*-1.972	-1.912	-1.727	-1.411	-1.305	-1.264	*-2.224	-1.875	-1.756	-1.704
Insurance	VR(q)	0.352	0.178	0.090	0.046	0.339	0.171	0.087	0.044	0.539	0.270	0.143	0.082
	Z(q)	*-31.307	*-21.231	*-14.859	*-10.471	*-22.786	*-15.259	*-10.638	*-7.485	*-15.590	*-13.202	*-9.798	*-7.057
	Z*(q)	-1.664	-1.370	-1.277	-1.240	-1.584	-1.288	-1.196	-1.160	*-5.412	*-5.263	*-4.714	*-4.100
Hydropower	VR(q)	0.629	0.334	0.179	0.086	N.A.	N.A.	N.A.	N.A.	0.629	0.334	0.179	0.086
	Z(q)	*-9.780	*-9.378	*-7.316	*-5.474	N.A.	N.A.	N.A.	N.A.	*-9.780	*-9.378	*-7.316	*-5.474
	Z*(q)	*-7.342	*-7.263	*-6.014	*-4.482	N.A.	N.A.	N.A.	N.A.	*-7.342	*-7.263	*-6.014	*-4.842
Hotel	VR(q)	0.487	0.244	0.134	0.064	0.486	0.232	0.132	0.064	0.488	0.260	0.138	0.067
	Z(q)	*-24.794	*-19.521	*-14.146	*-10.267	*-17.709	*-14.139	*-10.115	*-7.327	*-17.308	*-13.379	*-9.859	*-7.174
	Z*(q)	*-2.869	*-2.783	*-2.692	*-2.650	*-4.260	*-3.939	*-3.538	*-3.198	-1.353	-1.303	-1.298	-1.308
Trading	VR(q)	0.501	0.259	0.128	0.069	0.431	0.231	0.113	0.057	0.526	0.270	0.135	0.074
	Z(q)	*-24.104	*-19.122	*-14.235	*-10.218	*-19.619	*-14.154	*-10.332	*-7.378	*-16.028	*-13.201	*-9.898	*-7.119
	Z*(q)	*-1.994	*-1.970	*-1.984	*-1.970	*-3.976	*-3.466	*-3.309	*-3.153	-1.412	-1.453	-1.476	-1.469
Manufacturing	VR(q)	0.413	0.196	0.095	0.048	0.466	0.212	0.102	0.052	0.343	0.176	0.088	0.044
	Z(q)	*-28.354	*-20.759	*-14.772	*-10.443	*-18.405	*-14.516	*-10.460	*-7.418	*-22.230	*-14.905	*-10.434	*-7.346
	Z*(q)	*-2.682	*-2.364	*-2.221	*-2.151	*-2.016	-1.898	-1.790	-1.732	-1.780	-1.449	-1.350	-1.308
Other	VR(q)	0.446	0.229	0.115	0.057	0.508	0.262	0.133	0.066	0.392	0.202	0.100	0.051
	Z(q)	*-26.747	*-19.899	*-14.452	*-10343	*-16.959	*-13.595	*-10.097	*-7.310	*-20.558	*-14.441	*-10.294	*-7,295
	Z*(q)	*-2.203	*-2.011	-1.958	-1.934	-1.423	-1.422	-1.430	-1.435	-1.680	-1.432	-1.360	-1.326

Notes: The table presents results of the variance ratio tests of daily market returns series on the observed data of Nepal Stock Exchange (NEPSE). Variance ratios are given for overall market returns series as well as for nine other sectors returns series for full sample study period from July 17, 2000 to July 15, 2010 and the two sub-periods. Estimates of VR(q) – variance ratio, Z(q) – test statistic for null hypothesis of homoskedastic increments random-walk, Z*(q) - test statistic for null hypothesis of heteroskedastic increments random-walk are reported. Asterisk (*) indicates Z(q) and Z*(q) significance at 5 per cent level. Sampling intervals (q) are in days.

Table 2: Variance Ratio Tests of Weekly Stock Returns (Observed Data)

Indices	Statistics	Overall Period (2000 July 17 – 2010 July 15)				First Half Period (2000 July 17 – 2005 July 16)				Second Half Period (2005 July 17 – 2010 July 15)			
		q = 2	q = 4	q = 8	q = 16	Q = 2	q = 4	q = 8	q = 16	q = 2	q = 4	q = 8	q = 16
Overall	VR(q)	0.493	0.274	0.134	0.073	0.512	0.263	0.137	0.073	0.483	0.287	0.138	0.081
	Z(q)	*-11.454	*-8.772	*-6.615	*-4.760	*-7.829	*-6.318	*-4.679	*-3.375	*-8.220	*-6.060	*-4.634	*-3.322
	Z*(q)	*-6.611	*-5.604	*-4.781	*-3.787	*-3.661	*-3.293	*-2.861	*-2.365	*-5.740	*-4.646	*-3.869	*-2.944
Commercial Banking	VR(q)	0.482	0.261	0.119	0.066	0.494	0.255	0.119	0.068	0.474	0.273	0.125	0.072
	Z(q)	*-11.670	*-8.925	*-6.733	*-4.795	*-8.106	*-6.380	*-4.776	*-3.393	*-8.373	*-6.180	*-4.706	*-3.353
	Z*(q)	*-5.873	*-5.033	*-4.465	*-3.527	*-3.419	*-3.057	*-2.770	*-2.215	*-5.730	*-4.609	*-3.847	*-2.949
Development Banking	VR(q)	0.634	0.310	0.175	0.099	0.516	0.291	0.140	0.084	0.660	0.313	0.187	0.107
	Z(q)	*-7.616	-*7.678	*-5.801	*-4.259	*-6.472	*-5.068	*-3.890	*-2.784	*-5.412	*-5.841	*-4.374	*-3.226
	Z*(q)	*-3.463	*-4.033	*-3.583	*-2.810	-1.586	-1.541	-1.587	-1.552	*-3.055	*-3.736	*-3.199	*-2.438
Finance	VR(q)	0.495	0.283	0.132	0.085	0.370	0.193	0.099	0.058	0.562	0.333	0.155	0.107
	Z(q)	*-11.413	*-8.666	*-6.632	*-4.697	*-10.105	*-6.916	*-4.885	*-3.430	*-6.972	*-5.667	*-4.545	*-3.228
	Z*(q)	*-4.140	*-3.697	*-3.416	*-2.760	*-2.893	*-2.360	*-2.057	-1.659	*-2.984	*-2.831	*-2.710	*-2.188
Insurance	VR(q)	0.624	0.348	0.182	0.094	0.446	0.242	0.134	0.064	0.803	0.460	0.238	0.126
	Z(q)	*-8.505	*-7.876	*-6.254	*-4.652	*-8.886	*-6.497	*-4.692	*-3.410	*-3.130	*-4.592	*-4.097	*-3.159
	Z*(q)	*-3.431	*-3.624	*-3.362	*-2.819	*-2.832	*-2.449	*-2.160	-1.798	-1.904	*-2.863	*-2.702	*-2.285
Hydropower	VR(q)	0.497	0.271	0.147	0.088	N.A.	N.A.	N.A.	N.A.	0.497	0.271	0.147	0.088
	Z(q)	*-6.204	*-4.805	*-3.557	*-2.554	N.A.	N.A.	N.A.	N.A.	*-6.204	*-4.805	*-3.557	*-2.554
	Z*(q)	*-4.493	*-3.939	*3.203	*-2.401	N.A.	N.A.	N.A.	N.A.	*-4.493	*-3.939	*3.203	*-2.401
Hotel	VR(q)	0.561	0.232	0.127	0.067	0.571	0.196	0.114	0.066	0.555	0.276	0.148	0.077
	Z(q)	*-9.926	*-9.274	*-6.675	*-4.793	*-6.879	*-6.886	*-4.802	*-3.403	*-7.079	*-6.154	*-4.583	*-3.335
	Z*(q)	*-2.180	*-2.479	*-2.299	*-2.103	*-3.335	*-3.513	*-2.572	-1.880	-1.137	-1.228	-1.233	-1.236
Trading	VR(q)	0.454	0.235	0.130	0.065	0.427	0.228	0.124	0.062	0.465	0.241	0.135	0.070
	Z(q)	*-12.332	*-9.241	*-6.649	*-4.800	*-9.185	*-6.613	*-4.748	*-3.414	*-8.509	*-6.456	*-4.651	*-3.361
	Z*(q)	*-2.295	*-2.110	-1.901	-1.713	*-3.520	*-2.997	*-2.662	*-2.386	-1.751	-1.631	-1.472	-1.328
Manufacturing	VR(q)	0.397	0.194	0.099	0.051	0.382	0.191	0.097	0.052	0.543	0.239	0.146	0.073
	Z(q)	*-13.641	*-9.743	*-6.880	*-4.872	*-9.906	*-6.932	*-4.893	*-3.453	*-7.265	*-6.466	*-4.592	*-3.350
	Z*(q)	*-2.078	-1.804	-1.696	-1.647	-1.917	-1.630	-1.533	-1.485	*-3.838	*-4.044	*-3.241	*-2.643
Other	VR(q)	0.494	0.261	0.138	0.066	0.545	0.276	0.165	0.078	0.412	0.243	0.104	0.057
	Z(q)	*-11.433	*-8.928	*-6.584	*-4.795	*-7.294	*-6.201	*-4.526	*-3.358	*-9.350	*-6.434	*-4.820	*-3.407
	Z*(q)	*-2.082	*-2.015	*-1.979	-1.957	-1.308	-1.381	-1.357	-1.384	*-2.059	-1.737	-1.660	-1.528

Notes: The table presents results of the variance ratio tests of weekly market returns series on the observed data of Nepal Stock Exchange (NEPSE). Variance ratios are given for overall market returns series as well as for nine other sectors returns series for full sample study period from July 17, 2000 to July 15, 2010 and the two sub-periods. Estimates of VR(q) – variance ratio, Z(q) – test statistic for null hypothesis of homoskedastic increments random-walk, Z*(q) - test statistic for null hypothesis of heteroskedastic increments random-walk are reported. Asterisk (*) indicates Z(q) and Z*(q) significance at 5 per cent level. Sampling intervals (q) are in weeks.

Table 3: Variance Ratio Tests of Daily Stock Returns (Corrected Data)

Indices	Statistics	Overall Period (2000 July 17 – 2010 July 15)				First Half Period (2000 July 17 – 2005 July 16)				Second Half Period (2005 July 17 – 2010 July 15)			
		q = 2	Q = 4	q = 8	q = 16	q = 2	q = 4	Q = 8	q = 16	q = 2	q = 4	q = 8	q = 16
Overall	VR(q)	0.496	0.252	0.125	0.063	0.522	0.248	0.126	0.063	0.552	0.257	0.128	0.066
	Z(q)	*-24.350	*-19.315	*-14.281	*-10.277	*-16.470	*-13.850	*-10.180	*-7.331	*-15.176	*-13.442	*-9.974	*-7.182
	Z*(q)	-1.779	-1.717	-1.693	-1.677	-1.443	-1.472	-1.436	-1.420	*-6.762	*-6.830	*-6.102	*-5.107
Commercial Banking	VR(q)	0.486	0.249	0.127	0.064	0.492	0.247	0.130	0.063	0.536	0.255	0.128	0.066
	Z(q)	*-24.839	*-19.377	*-14.259	*-10.274	*-17.508	*-13.859	*-10.133	*-7.328	*-15.709	*-13.481	*-9.976	*-7.178
	Z*(q)	*-4.395	*-4.133	*-3.980	*-3.719	*-3.326	*-3.189	*-3.057	*-2.860	*-6.687	*-6,673	*-6.060	*-5.147
Development Banking	VR(q)	0.498	0.238	0.123	0.064	0.558	0.231	0.115	0.059	0.483	0.234	0.126	0.063
	Z(q)	*-22.339	*-18.108	*-13.191	*-9.463	*-12.771	*-11.862	*-8.638	*-6.171	*-17.494	*-13.851	*-9.996	*-7.200
	Z*(q)	-1.617	-1.596	-1.549	-1.530	-1.153	-1.279	-1.217	-1.186	*-3.625	*-3.511	*-3.328	*-3.171
Finance	VR(q)	0.544	0.221	0.115	0.058	0.568	0.217	0.112	0.056	0.517	0.226	0.117	0.061
	Z(q)	*-22.028	*-20.097	*-14.456	*-10.334	*-14.863	*-14.408	*-10.338	*-7.383	*-16.334	*-14.003	*-10.097	*-7.220
	Z*(q)	*-2.001	*-2.187	*-2.062	*-2.012	-1.248	-1.430	-1.329	-1.289	-1.863	-1.934	-1.846	-1.810
Insurance	VR(q)	0.492	0.250	0.126	0.064	0.559	0.222	0.113	0.057	0.450	0.222	0.112	0.064
	Z(q)	*-24.521	*-19.359	*-14.271	*-10.266	*-15.202	*-14.318	*-10.332	*-7.374	*-18.602	*-14.068	*-10.162	*-7.199
	Z*(q)	*-2.210	*-2.174	*-2.129	*-2.058	-1.178	-1.314	-1.230	-1.194	*-6.245	*-5.444	*-4.795	*-4.152
Hydropower	VR(q)	0.480	0.238	0.130	0.061	N.A.	N.A.	N.A.	N.A.	0.480	0.238	0.130	0.061
	Z(q)	*-13.708	*-10.732	*-7.751	*-5.620	N.A.	N.A.	N.A.	N.A.	*-13.708	*-10.732	*-7.751	*-5.620
	Z*(q)	*-9.625	*-7.984	*-6.187	*-4.837	N.A.	N.A.	N.A.	N.A.	*-9.625	*-7.984	*-6.187	*-4.837
Hotel	VR(q)	0.484	0.243	0.133	0.064	0.523	0.249	0.141	0.068	0.451	0.239	0.126	0.061
	Z(q)	*-24.914	*-19.549	*-14.159	*-10.269	*-16.443	*-13.830	*-10.001	*-7.292	*-18.574	*-13.770	*-9.997	*-7.218
	Z*(q)	*-2.882	*-2.786	*-2.694	*-2.650	*-4.072	*-3.926	*-3.542	*-3.205	-1.447	-1.335	-1.309	-1.308
Trading	VR(q)	0.485	0.251	0.124	0.066	0.479	0.255	0.125	0.064	0.491	0.251	0.125	0.068
	Z(q)	*-24.869	*-19.333	*-14.300	*-10.243	*-17.948	*-13.713	*-10.193	*-7.327	*-17.208	*-13.540	*-10.007	*-7.164
	Z*(q)	*-2.059	*-1.994	*-1.996	*-1.977	*-3.742	*-3.458	*-3.358	*-3.216	-1.520	-1.491	-1.492	-1.478
Manufacturing	VR(q)	0.567	0.243	0.118	0.059	0.578	0.249	0.120	0.061	0.557	0.231	0.115	0.057
	Z(q)	*-20.911	*-19.550	*-14.404	*-10.320	*-14.539	*-13.827	*-10.251	*-7.345	*-14.975	*-13.917	*-10.120	*-7.247
	Z*(q)	*-2.206	*-2.450	*-2.353	*-2.294	-1.731	-1.944	-1.871	-1.821	-1.328	-1.469	-1.390	-1.353
Other	VR(q)	0.488	0.249	0.125	0.063	0.480	0.247	0.125	0.062	0.518	0.251	0.124	0.064
	Z(q)	*-24.736	*-19.384	*-14.284	*-10.285	*-17.899	*-13.864	*-10.184	*-7.338	*-16.314	*-13.538	*-10.015	*-7.196
	Z*(q)	*-2.074	*-1.996	*-1.972	-1.960	-1.505	-1.452	-1.444	-1.442	-1.460	-1.472	-1.447	-1.427

Notes: The table presents results of the variance ratio tests of daily market returns series on the corrected data of Nepal Stock Exchange (NEPSE). Variance ratios are given for overall market returns series as well as for nine other sectors returns series for full sample study period from July 17, 2000 to July 15, 2010 and the two sub-periods. Estimates of VR(q) – variance ratio, Z(q) – test statistic for null hypothesis of homoskedastic increments random-walk, Z*(q) - test statistic for null hypothesis of heteroskedastic increments random-walk are reported. Asterisk (*) indicates Z(q) and Z*(q) significance at 5 per cent level. Sampling intervals (q) are in days.

Table 4: Variance Ratio Tests of Weekly Stock Returns (Corrected Data)

Indices	Statistics	Overall Period (2000 July 17 – 2010 July 15)				First Half Period (2000 July 17 – 2005 July 16)				Second Half Period (2005 July 17 – 2010 July 15)			
		q = 2	q = 4	q = 8	q = 16	Q = 2	q = 4	q = 8	q = 16	q = 2	q = 4	q = 8	q = 16
Overall	VR(q)	0.450	0.251	0.120	0.064	0.481	0.248	0.125	0.067	0.433	0.258	0.123	0.069
	Z(q)	*-12.427	*-9.040	*-6.715	*-4.801	*-8.304	*-6.432	*-4.732	*-3.391	*-9.026	*-6.306	*-4.717	*-3.365
	Z*(q)	*-7.005	*-5.660	*-4.778	*-3.781	*-3.828	*-3.310	*-2.862	*-2.360	*-6.102	*-4.710	*-3.866	*-2.946
Commercial Banking	VR(q)	0.472	0.256	0.116	0.064	0.496	0.256	0.118	0.068	0.452	0.262	0.119	0.068
	Z(q)	*-11.925	*-8.979	*-6.753	*-4.800	*-8.065	*-6.365	*-4.769	*-3.387	*-8.720	*-6.276	*-4.737	*-3.369
	Z*(q)	*-5.946	*-5.034	*-4.456	*-3.520	*-3.413	*-3.059	*-2.774	*-2.218	*-5.882	*-4.627	*-3.838	*-2.942
Development Banking	VR(q)	0.511	0.248	0.131	0.072	0.493	0.276	0.132	0.079	0.523	0.246	0.135	0.075
	Z(q)	*-10.166	*-8.360	*-6.105	*-4.381	*-6.764	*-5.162	*-3.913	*-2.792	*-7.589	*-6.408	*-4.653	*-3.344
	Z*(q)	*-4.767	*-4.547	*-3.908	*-3005	-1.623	-1.538	-1.567	-1.531	*-4.488	*-4.308	*-3.563	*-2.640
Finance	VR(q)	0.391	0.216	0.104	0.064	0.447	0.235	0.119	0.068	0.407	0.226	0.109	0.068
	Z(q)	*-13.756	*-9.462	*-6.843	*-4.803	*-8.853	*-6.543	*-4.768	*-3.387	*-9.425	*-6.580	*-4.793	*-3.369
	Z*(q)	*-4.996	*-4.033	*-3.509	*-2.795	*-2.691	*-2.388	*-2.152	-1.747	*-4.236	*-3.448	*-2.963	*-2.326
Insurance	VR(q)	0.460	0.232	0.125	0.062	0.414	0.225	0.124	0.060	0.555	0.258	0.147	0.067
	Z(q)	*-12.188	*-9.267	*-6.684	*-4.811	*-9.383	*-6.626	*-4.736	*-3.417	*-7.075	*-6.310	*-4.589	*-3.370
	Z*(q)	*-4.266	*-3.769	*-3.246	*-2.671	*-2.924	*-2.442	*-2.135	-1.770	*-3.786	*-3.730	*-2.954	*-2.401
Hydropower	VR(q)	0.457	0.242	0.125	0.074	N.A.	N.A.	N.A.	N.A.	0.457	0.242	0.125	0.074
	Z(q)	*-6.671	*-4.977	*-3.633	*-2.586	N.A.	N.A.	N.A.	N.A.	*-6.671	*-4.977	*-3.633	*-2.586
	Z*(q)	*-4.772	*-4.008	*-3.231	*-2.431	N.A.	N.A.	N.A.	N.A.	*-4.772	*-4.008	*-3.231	*-2.431
Hotel	VR(q)	0.554	0.230	0.125	0.066	0.618	0.209	0.121	0.070	0.511	0.252	0.133	0.070
	Z(q)	*-10.072	*-9.300	*-6.681	*-4.792	*-6.105	*-6.764	*-4.754	*-3.379	*-7.771	*-6.361	*-4.661	*-3.361
	Z*(q)	*-2.215	*-2.491	*-2.306	*-2.107	*-3.121	*-3.512	*-2.551	-1.870	-1.263	-1.285	-1.268	-1.260
Trading	VR(q)	0.447	0.230	0.127	0.064	0.469	0.252	0.137	0.068	0.445	0.227	0.128	0.067
	Z(q)	*-12.486	*-9.290	*-6.661	*-4.801	*-8.491	*-6.394	*-4.667	*-3.387	*-8.825	*-6.569	*-4.688	*-3.371
	Z*(q)	*-2.325	*-2.120	-1.903	-1.711	*-3.337	*-2.973	*-2.677	*-2.409	-1.816	-1.656	-1.478	-1.326
Manufacturing	VR(q)	0.531	0.239	0.121	0.063	0.552	0.245	0.120	0.064	0.501	0.218	0.131	0.065
	Z(q)	*-10.600	*-9.188	*-6.708	*-4.809	*-7.172	*-6.461	*-4.760	*-3.401	*-7.943	*-6.652	*-4.675	*-3.378
	Z*(q)	-1.787	-1.869	-1.801	1.762	-1.558	-1.681	-1.625	-1.579	*-4.141	*-4.120	*-3.280	*-2.657
Other	VR(q)	0.486	0.256	0.136	0.065	0.490	0.244	0.146	0.069	0.510	0.289	0.123	0.068
	Z(q)	*-11.613	*-9.975	*-6.597	*-4.797	*-8.159	*-6.469	*-4.621	*-3.383	*-7.792	*-6.047	*-4.714	*-3.366
	Z*(q)	*-2.116	*-2.027	*-1.984	-1.959	-1.456	-1.432	-1.377	-1.386	-1.654	-1.576	-1.577	-1.475

Notes: The table presents results of the variance ratio tests of weekly market returns series on the corrected data of Nepal Stock Exchange (NEPSE). Variance ratios are given for overall market returns series as well as for nine other sectors returns series for full sample study period from July 17, 2000 to July 15, 2010 and the two sub-periods. Estimates of VR(q) – variance ratio, Z(q) – test statistic for null hypothesis of homoskedastic increments random-walk, Z*(q) - test statistic for null hypothesis of heteroskedastic increments random-walk are reported. Asterisk (*) indicates Z(q) and Z*(q) significance at 5 per cent level. Sampling intervals (q) are in weeks.

Discussions

The Z-statistics are negative in all series in all cases of q. The variance-ratio values of all indices in all cases are below one and they decrease as the interval q increases. It indicates negative serial correlation in the returns and potential mean reversion. In other words, if stock price-returns do mean-reverting, they should be negatively serial-correlated, and the variance ratio should get smaller and smaller than unity as the interval q increases. This type of behaviour is generally observed in emerging financial markets that may suffer a bubble effect (Summers, 1986). But the study results contradict with Urrutia (1995), who found that variance-ratios larger than unity implied positive return autocorrelation in emerging Latin American equity markets. Urrutia (1995) claimed that positive autocorrelations are the indicators of economic growth rather than evidence against the efficient market hypothesis. Thus, the developing Nepalese stock market is not free from bubble effects. According to Rawashdeh and Squalli (2006), return series fit a mean-reverting process; it may suggest abnormally high volatility, overinflated stock prices and frequent market correction from a bubble effect. It indicates that investments in stock market of Nepal may be very risky in the short-run.

Additionally, the evidence of variance-ratios is lesser than one, and it suggests that negative returns autocorrelation in the study tends to disagree with Lo and MacKinlay (1988) who find positive autocorrelation (variance-ratio larger than one) for the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX). Similarly, the results of negative autocorrelation are also contradictory with the study in Australia by Worthington and Hinggs (2009) who found the value of variance-ratio larger than one; it shows presence of positive autocorrelation. But the mean-reverting process of stock returns is documented by Fama and French (1988), and Jegadeesh (1990).

In the context of Nepal, the market is found inefficient in weak-form as well as non-random returns (Pradhan and Upadhyay, 2006; Bhatta, 2010; Dangol 2010a; Dangol 2010b; Dangol, 2011 & Dangol, 2012). The current study found the market is efficient in weak-form and follow random-walk in the daily returns series using variance ratio test. The current paper showed the more insight and provided evidence for influencing the NEPSE index from thin-trading.

IV. CONCLUSION AND IMPLICATION

This paper examines the random-walk hypothesis in the Nepalese stock market employing variance-ratio. The tests used on two important daily and weekly market indices for all price index and nine sectoral indices. The data should be improved from the problem of thin trading to make further studies in the Nepalese stock market. Since the variance-ratio is less than unity, the random-walk hypothesis for indices is rejected on observed data except overall, insurance and development banking sectors in daily returns. After corrected data employing model of Miller et al. (1994), the Nepalese stock market was found random-walk for overall, and development banking sectors in daily returns. On the contrary, the market is found inefficient in weekly returns series for overall as well as nine sub-sectors in the overall study periods. It indicates that the Nepalese stock market does not have short-term memory.

The Nepalese stock market is efficient in daily returns series suggesting that past movements in stock prices cannot be used to predict their future movements. But, the market can be predicted using the weekly returns series since the market has long-term memory. It provides market players to bring the possibility of earning higher returns than expected using weekly data series. The presence of a random-walk in the stock data has an important implication for portfolio investors, the allocation of capital within an economy and hence overall economic development. It is, therefore, relevant to suggest that there should be an effective regulatory framework and its implementation; and a more effective role by all the stakeholders should be helpful in making the market reflective of a true picture of the economy. Regarding the use of the variance ratio statistic, it can be advantageous for those hypotheses associated with mean reversion. Similarly, the multiple variance ratio can be tested in future studies.

REFERENCES

Bhatta, G. P. 2010. "Does Nepalese Stock Market Follow Random Walk?" *SEBON Journal* 4: 18-58.

Dangol, J. 2010a. "Efficient Market Hypothesis and the Emerging Capital Market in Nepal". In *Efficient Market Hypothesis: Few Empirical Evidences from Nepalese Stock Market*, Kathmandu: Quest Publication

Dangol, J. 2010b. "Testing Random-Walk Behaviour in Nepalese Stock Market." *PYC Nepal Journal of Management* 3: 26-34.

Dangol, J. 2011. "Test of Random-Walk and Stock Market Efficiency in Nepal and India." *MIMT Journal of IT & Management Research* 1: 73-85.

Dangol, J. 2012. "Stock Market Efficiency in Nepal." *Zenith International Journal of Multidisciplinary Research* 2(5): 40-48.

Fama, E. F. 1970. "Efficient Capital Markets: A Review of Theory and Empirical Work." *The Journal of Finance* 25(2): 383-417.

Fama, E. F. 1991. "Efficient Capital Markets: II." *The Journal of Finance* 46(5): 1575-1617.

Fama, E. F. and K. R. French. 1988. "Permanent and Temporary Components of Stock Prices." *Journal of Political Economy* 96(2): 246-273.

Jegadeesh, N. 1990. "Evidence of Predictable Behavior of Security Returns." *The Journal of Finance* 45(3): 881-898.

Lo, A. W. and A. C. MacKinlay. 1988. "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test." *The Review of Financial Studies* 1(1): 41-66.

Miller, M. H., Muthuswamy, J. and R. E. Whaley. 1994. "Mean Reversion of Standard & Poor's 500 Index Basis Changes: Arbitrage-Induced or Statistical Illusion?" *The Journal of Finance* 49(2): 479-513.

Pradhan, R. S. and B. D. Upadhyay. 2006. "The Efficient Market Hypothesis and the Behaviour of Share Prices in Nepal." Retrieved from www.ssrn.com

Rawashdeh, M. and J. Squalli. 2006. "A Sectoral Efficiency Analysis of the Amman Stock Exchange." *Applied Financial Economics Letters* 2: 407-411.

Summers, L. H. 1986. "Does the Stock Market Rationally Reflect Fundamental Values?" *Journal of Finance* 41(3): 591-601.

Urrutia, J. L. 1995. "Tests of Random Walk and Market Efficiency for Latin American Emerging Markets." *Journal of Financial Research* 18(3): 299-309.

Worthington, A. C. and H. Higgs. 2009. "Efficiency in the Australian Stock Market, 1875-2006: A Note on Extreme Long-Run Random Walk Behaviour." *Applied Economics Letters* 16: 301-306.