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Evidence on Presence of Adaptive Market Hypothesis in Nepal Stock Exchange

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Abstract

In recent years, the argument on capital market efficiency has shifted to alternative forms of the hypothesis. This research examines one of such alternatives, the Adaptive Market Hypothesis (AMH) with an aim to offer a framework for testing the dynamic notion of market efficiency. Using the Nepal Stock Exchange (NEPSE) monthly return index over the period of recent 16 years (from 2003 to 2019). This research divides the whole sample into 12 subsamples of 5 years moving window. The statistical tools used in this research are linear and non-linear tests for independence and dependence for stock returns. The finding of the linear tests shows that NEPSE Index consists of AMH while nonlinear tests have mixed results. McLeod Li test and Engle LM test for whole subsamples show that the market is efficient but one of the prominent non-linear BDS tests shows that the market moves from efficiency to inefficiency and inefficiency to efficiency which supports AMH. The result of the study is supposed to be useful not only for the investors but also for the financial regulators.

***Keywords**: Efficient market hypothesis, Random walk hypothesis, Adaptive market hypothesis, Nepal stock exchange, Capital markets.*

1. Introduction

Efficient Market Hypothesis (EMH) is a proposition made by Fama (1970, 1991). The hypothesis states that stock price movements are impossible to predict in the short term and the new information affects prices almost immediately. It means stock price reflects all the available information about the value of the firm. The major reason for changes in price is due to the entrance of new information in the market. Hence, all the new information related to security is absorbed in price immediately and makes the stock price walk unpredictably (Ahmad & Shahid, 2018). Hence, "*there is no reason to believe that price is too high or too low, security prices adjust before an investor has time to trade on and profit from a new piece of information*" (Clarke & Jandik, 2001).

The assumption is that investors in the market are rational, and all information is available in the public domain. Based on this assumption, it is impossible for assets to be mispriced and there is no way to earn excess profits by using the available information. Fama (1970), categorized three levels of market efficiency, the weak form (historical sequences of prices), the semi-strong form (publicly available information), and the strong form (all information, both public and private, is priced into stocks) efficiency. EMH also claims that all investors are rational, skilled, and can analyze the flow of new information but in real practice majority of common investors are not financial experts (Clarke & Jandik, 2001).

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Over the past few decades, some behavioral theories are gaining support. "*Practical investment and academic studies have acknowledged the existence of investment behavioral biases that lead to irrational decision-making*" (Ahmad et al., 2017).

Both the EMH and behavioral theories are moving forward with contrasting as well as complementing arguments. In the finance literature, the weak form of the EMH has become the most widely empirically tested form of the hypothesis. After numerous tests being done to examine its validity, no one has reached a consensus which has led to a division among academics either defending EMH or favoring the behavioral biases (another extreme of looking and analyzing the market based on investors' psychology) that might influence the financial markets (Dhankar & Shankar, 2016).

To settle those two schools of thought, a prominent different framework suggested by Lo (2004, 2005) proposed the adaptive market hypothesis (AMH) and argued that the impact of the competition, mutation, reproduction, and natural selection formulates pressures on financial institutions and market participants. It determines the efficiency of markets and the waxing and waning of investment strategies (Xiong et al., 2019).

However, several studies on different stock markets have shown that the price does not follow a random walk (MacKinlay, 1988). In the case of Nepal, NEPSE has not followed the random walk rather it suffers from the problem of thin trading as a result further study is necessary to determine its nature (Dangol, 2012). Further, Dangol (2016) stated that the random walk hypothesis is strongly rejected for all stock price indexes as well as the sensitivity index on the Nepal Stock Exchange. Meanwhile, Nepalese investors believed in the existence of weak form and semi-strong form of market efficiency, whereas they rejected the existence of strong form market efficiency.

In the case of Nepal, it has been more than two and half decades of establishment and functioning of the Nepal Stock Exchange. However, extant literature about the behavior of Nepalese investors shows that the financial literacy in Nepal is inadequate (Dhungana & Devkota, 2021; Thapa & Nepal, 2015). Investors often park their money in stock without any fundamental or technical analysis but by speculation. The study shows that most investors do not study the market properly rather they follow rumors. Lo (2004) professed that the traditional investment framework is inconsistent, not wrong but incomplete. According to that study, in a stable environment, stable investment policies are suitable and in a dynamic environment, dynamic investment policies are suitable. The current environment is not stable rather it is highly dynamic. Recently, the market capitalization of the Nepal stock exchange has exceeded the GDP of the country (Nepal Stock Exchange, 2021). Hence, it is wise to adapt to the changing market condition.

When the market is adaptive, technical, and fundamental analysis could be carried out for future investment. It would thus necessitate a focus on active portfolio management. Lo (2004) also admits that because of the dynamic nature of risk premium and volatilities, adaptive portfolio policies could be favorable. There are several practical implications that AMH offers risk-reward relationship, that is, due to the stock market situations and demographics of investors in the environment, risk premium varies over time (Urquhart & Hudson, 2013).

The AMH implies more complex market dynamics, with cycles as well as trends, panics, manias, bubbles, crashes, and other phenomena that are routinely witnessed in natural market ecologies (Lo, 2004). At times, investment strategies will also perform well in certain environments and perform poorly in other environments. The classic theory of EMH explains that a certain level of expected returns can be achieved simply by taking enough degree of risk. Numerous researchers have provided the evidence that AMH suggests that the risk/reward relation varies through time, and that is a better way of attaining a reliable level of expected returns to adapt to changing market conditions (Khuntia & Pattanayak, 2018; Urquhart & Hudson, 2013; Urquhart & McGroarty, 2016). AMH has a clear implication for all financial market participants; survival is the only objective that matters. There are many other practical insights and potential breakthroughs that can be derived from the AMH as we shift our mode of thinking in financial economics from the physical to the biological sciences (Lo, 2004).

The market shows different patterns of stock return probability based on different market situations which are highly relevant to investigate how patterns of stock return likelihood have varied over time in a Nepalese context. Such predictability of the market will explore whether smart investors can exploit profit-making opportunities. Hence, the rationale of the below-mentioned question below is to know whether the Nepalese market is fully efficient or partly efficient or inefficient or varying efficient, that is adaptive.

Does the Nepalese stock market follow the Adaptive Market Hypothesis (AMH)?

This study examines whether the stock market of Nepal (NEPSE) behaves according to the nature of the Adaptive Market Hypothesis. For this purpose, batteries of linear and nonlinear independence of daily stock price movements have been tested from 2003 to 2019.

As extent literatures have shown that traditional strict sense of EMH is unrealistic, evolving efficiency is possible and realistic. Hence AMH has the ability to describe such efficiency and capture the reforms and changes in the market. So, this study investigates and provides useful inputs for the formulation of stock market development plans.

Hence, the specific objectives of this study are:

- To examine the various stages of efficiency of the Nepalese Stock Market.
- To test AMH on the Nepalese Stock Market.

Due to rapid changes in the business condition of the market, it is very difficult to capture the real status of the market and make clear investment decisions. So, in this context study of AMH plays a vital role in understanding the market and making perfect investment decisions. According to the classical EMH, a certain level of expected returns can be achieved simply by taking enough degree of risk, but AMH implies that because the risk/reward relation varies through time, a better way to achieve a consistent level of anticipated returns is to adapt to changing market conditions. Due to the unavoidable trend of the market dynamics (cycles or trends) which is routinely witnessed in the market ecology, AMH would be the best fit in this situation rather than EMH (Bernstein, 1999).

The findings of this study are expected to be useful for institutional investors like mutual funds, pension funds, insurance companies, banks, financial institutions, etc. Besides, the findings also guide the individual investors who are keen to explore the possibilities of fundamental and technical analysis. On the other hand, those banks and financial institutions who lend against financial instruments can also use the findings of this research as a reference to understand the predictability of the value of their collateral such as financial instruments. Thus, it is strongly believed that the study bridges the gap of lacking literature that has explored the dynamics of the financial market in Nepal. Additionally, policymakers can also have references over the market behavior to strengthen their policy formation processes. The organization of the article includes an introduction, followed by the literature review, methodology, findings, and discussion & conclusion.

2. Literature Review

The Adaptive Market Hypothesis (AMH) is a newly proposed theory that combines principles of the Efficient Market hypothesis (EMH) and Behavioral Finance. According to Lo (2004), the price reflects as much information as dictated by the combination of environmental conditions and the number and nature of market participants (such as pension funds, retail investors, market makers, hedge-fund managers, etc.) in the economy (ecology). As a result, the investment strategies undergo cycles of profitability and losses, as the business conditions and a number of competitors change (Árendáš & Chovancová, 2015). In other words, market efficiency is not static, but it is evolving in different stages as higher efficiency, lower efficiency, or inefficiency. AMH is supported by the results of various studies. Ito and Sugiyama (2009) find that time-varying market inefficiency in the US. Todea et al., (2009) examine linear and non-linear tests on six Asian capital markets, period of 1997 to 2008. They found that the degree of market efficiency varies over time. It is episodic. Kim et al. (2011) tested the Dow Jones Industrial Average (DJIA) returns from 1900 to 2009 and found strong evidence of time-varying return predictability. The study used two autocorrelation tests (variance ratio and portmanteau) and a generalized spectrum test on moving subsamples window. The researcher found that return predictability has been smaller during economic bubbles than in normal times and that return predictability is associated with stock market volatility and economic fundamentals. Hence, there is no return predictability during market crashes, while economic and political crises are associated with a high degree of return predictability. The study also uses regression analysis to fix how the return predictability over time is related to changing market and economic conditions.

Smith (2012) tested AMH on fifteen European emerging stock markets, along with the three developed markets Greece, Portugal, and the UK. The researcher used rolling window variance ratio tests for the data from February 2000 to December 2009. They found that each of the eighteen markets provides evidence of the time-varying nature of return predictively which is consistent with AMH. Lim et al., (2013) use two most recently developed data-driven tests, namely the automatic portmanteau Box–Pierce test (AR) and the wild bootstrapped automatic variance ratio (WBAVR) test on three major US stock indices using rolling window and found that time-varying nature of predictable patterns is consistent with the adaptive markets hypothesis. They also stated that markets must go through periods of efficiency and inefficiency. Urquhart and Hudson (2013) tested AMH in the US, UK, and Japan share market using linear autocorrelation, runs, and variance ratio tests and found that AMH is valid for the three markets. Katusiime et al., (2015) empirically investigate market efficiency and trading rule profitability of the Ugandan foreign exchange market (UFEM) for the period of 1994 to 2012. They found that UFEM is characterized by weak-form inefficiency and time variation in market efficiency is consistent with AMH. Urquhart and McGroarty (2016) test AMH in four of the world's largest stock markets, namely the S & P500, FTSE100, NIKKEI225, and EURO STOXX 50 using daily data from January 1990 to May 2014. The study uses variance ratio test as well as nonlinear BDS test to fixed-length moving sub-sample window of two years. The researcher found that return predictability fluctuates over time in each market. Thus, an investor needs to view each market independently since the predictability of these markets varies over time along with market conditions. Developed stock markets are found to be more efficient than emerging markets (Lim & Brooks, 2011). The researcher found that the degree of market efficiency varies through time in a cyclical fashion. Trung and Quang (2019) tested AMH in two main Vietnamese stock exchanges, namely HSX and HNX by automatic variance ratio test (AVR), the automatic portmanteau test (AP), the generalized spectral test

(GS), and time-varying autoregressive (TV-AR) approach. They found that both markets validate AMH. The principle outline of AMH proposed by Lo (2005) is as follows

1. Individuals act in their own self-interest.
2. Individuals make mistakes.
3. Individuals learn and adapt.
4. Competition drives adaptation and innovation.
5. Natural selection shapes market ecology.
6. Evolution determines market dynamics.

In this context, AMH can be said to revolve around three main processes of heuristics development, learning, and an adaptation process of decision making whose combined impact on financial institutions that help to determine market efficiencies and the waxing and waning of investment products, industries, and even individual and institutional fortune. Based on the above literature following hypothesis has been developed.

H1: The stock return of NEPSE crosses the different stages of efficiency.

H2: Stock returns of NEPSE follow the hypothesis of AMH.

In Nepal, several studies have been done on market efficiency. Dangol (2010) used the variance ratio test and found that the random-walk hypothesis is strongly rejected for weekly indices of the observed and corrected returns. It indicates investors have opportunities to predict future prices and earn abnormal returns. Pradhan and Upadhyay (2011) used a parametric test for independence and a non-parametric test for randomness and this study does not support the independence assumption of the random walk model. To our knowledge, the study about the pattern of stock return predictively on different market conditions from the AMH lens has not been done previously.

This study, therefore, examines whether the Nepalese stock market is in the process of evolution as explained by the Adaptive Market Hypothesis. As the market grows, it is expected to acquire more financial literacy, helping to develop the adaptive nature of investors towards a more efficient market. When an investor understands the nature of the market, it benefits the investor. This research would address whether the adaptive market hypothesis provides a better description of the behavior of the emerging stock market. It is a new approach to explaining investment behavior in emerging stock markets such as Nepal.

3. Research Methodology

The current study adopted the positivist approach to explore and investigate the problem. Empirically research design is used to study the evolving efficiency of the stock market of Nepal. Time series data are used to study the movement of the stock price in the given time. This study uses the induction method to formulate hypotheses which are in turn tested applying batteries of the test. The data used in this study are secondary and complete historical time series monthly adjusted stock prices of the NEPSE Index. The data is taken from Nepal Stock Exchange Ltd. This study has observed the dependency and independency of returns in that period through linear and nonlinear tests. In this study, the monthly adjusted stock price return from the NEPSE index has been taken as an individual time series variable.

3.1 Data Analysis

For the empirical test, this study uses monthly adjusted closing prices of the NEPSE Index from the period of 1st August 2003 to 1st July 2018 with a total of 180 monthly data points. To capture changing efficiency or evolving nature of the stock market, this research divides the whole sample into five-yearly subsamples moving windows 2003-2008, 2004-2009, 2005-2010, 2006-2011, 2007-2012, 2008-2013, 2009-2014, 2010-2015, 2011-2016, 2012-2017, 2013-2018, 2014-2018.

This study uses stock market returns as an individual time, series variable. The all share price index is based on the market prices of all stocks listed with the NEPSE. Monthly market returns r_t are calculated from the price indices as follows.

$$(r_t) = ln\left(\frac{P_t}{P_{t-1}}\right)$$

Where P_t represents price index at period t, P_{t-1} represents the price index at period t-1. Empirically, logarithmic returns are more likely to be normally distributed which is a prior condition of standard statistical techniques (Strong, 1992).

3.2 Methods for Testing the Validity of AMH

The AMH asserts that markets evolve because of events and structural change, adapt and market efficiency varies in degree at different times (Lo, 2005). It is unrealistic to expect perfectly efficient/inefficient markets due to the behavior bias as per the EMH (Khuntia & Pattanayak, 2018).

The market is adaptive if the following behavior exists in the market:

The market has gone through at least three different stages of efficiency. That is, the market has either been efficient, inefficient, and then efficient again, or inefficient, efficient, and inefficient again (Urquhart & Hudson, 2013).

If the market is efficient, the returns are independent, hence, it follows the random walk hypothesis. If returns are inefficient, the returns are dependent, and it rejects the hypothesis of the random walk as returns are independent. Besides that, if returns are dependent then further test is required, whether returns are linear dependent or non-linear dependent. To capture the dependency and independency of returns, linear and nonlinear tests are suitable. This research uses three linear tests such as Autocorrelation test, runs test, and variance ratio tests.

3.3 Autocorrelation Test

Autocorrelation is a characteristic of data that shows the degree of correlation between the values of the same variables over successive time intervals. This implies there is a pattern such that values in the series can be predicted based on preceding values in the series. Autocorrelation means data is correlated with itself. It is used in investigating the independence of random variables in a series. If autocorrelations are found then returns are not independent, that is returns are dependent.

Autocorrelation (ρ_k) occurs:

When the covariance and correlations between different disturbances are not all non-zero (i.e., $Cov(\in_i, \in_j) = \sigma_{ij}$ for all $i \neq j$, where $\in_t$ is the value of the disturbance in the ith observation). The auto covariance at leg k is defined as

$$\gamma_k = E(u_t, u_{t-k}), k = 0, \pm 1, \pm 2 \ldots$$

At zero lag, we have constant variance

$$\gamma_0 = E(u_t^{\,2}) = \sigma^2$$

The autocorrelation coefficient at leg s is defined as

$$\rho_k = \frac{E(u_t, u_{t-k})}{\sqrt{var(u_t)var(u_{t-k})}} = \frac{\gamma_k}{\gamma_0}, k = 0, \pm 1, \pm 2, \ldots$$

Assume that ρ_k and γ_k are symmetrical in k. These coefficients are constant over time and depend on length of lag S. The autocorrection between the successive terms (u_2 and u_1), … (u_n and u_{n-1}) gives the autocorrelation of order 1, that is ρ_1. Similarly, the autocorrelation between (u_3 and u_1), (u_4 and u_2) … (u_n and u_{n-2}) gives the autocorrection of order 2, that is ρ_2.

3.4 Runs Test

The Wald–Wolfowitz runs test, is a non-parametric statistical test that checks a randomness hypothesis for a two-valued data sequence. It does not require returns to be normally distributed. In the stock market, a run test of randomness is applied to know if the stock price of a particular company is behaving randomly, or if there is any pattern. A run is a succession of identical symbols, positive (+) denoted by P and Negative (-) denoted by N. So, a run is a sequence of positive and negative returns.

The expected (mean) number of runs and variance in a run test of randomness is calculated by the following formula

$$E(u) = \frac{2PN(P+N)}{(P+N)} + 1$$

Variance, $\sigma^2 = \frac{2PN(2PN-P-N)}{(P+N)^2(P+N-1)}$.

3.5 Variance Ratio Test

Mackinlay and Lo (1988) proposed the variance ratio test which is capable of distinguishing between several interesting alternative stochastic processes. The variance ratio test is based on the statistical property that if a stock price follows a random walk, then the variance of the k^{th} period return is equal to k times the variance of the one-period return. Using the single variance ratio denoted by VR (k).

Let r_t denote an asset return at time t, where t=1, 2, 3, T. Then the variance ratio for r_t with holding period k is

$$VR(k) = \sigma_k^{\,2}/k\sigma^2$$

Where, ${\sigma_k}^2 = variance(r_t + r_{t-1} + \cdots + r_{t-k+1})$ is the variance of k- period return.

Hence $VR(k) = 1 + 2\sum_{j=1}^{k-1}\left(1 - \frac{j}{k}\right)\rho(j)$

Where, $\rho(j)$ is the autocorrelation of r_t of order j

3.6 Non-Linear Tests

Non-linear dependence in stock returns has gained much attention in a recent study as it indicates possible dependence when the linear test indicates independence (Kamaiah, 2010). So, this study uses a battery of nonlinear tests to capture the real status of dependency or independency of return. Initially, the linear structure is removed through the pre-whitening model. The residuals of the pre-whitened model were tested through a battery of nonlinear tests, namely the McLeod and Li (1983), (Engle, 1982) and Brock, Dechert, and Scheinman (BDS) (1996) tests.

3.7 McLeod Li Test

McLeod & Li (1983) test is a portmanteau test of nonlinearity. To test for nonlinearity in time series, they proposed the following statistic.

$$Q(m) = \frac{n(n+2)}{n-k}\sum_{k=1}^{m} {r_a}^2(k)$$

$${r_a}^2(k) = \frac{\sum_{t=k-1}^{n} {e_t}^2 {e_{t-k}}^2}{\sum_{t=1}^{n} {e_t}^2} \quad k = 0,1,2 \dots, n-1$$

where ${r_a}^2$ is the autocorrelations of the squared residuals and ${e_t}^2$ is obtained after fitting an AR (p) model to the data in the pre-whitening process.

H0: returns are independent.

If it rejects, then it indicates the presence of ARCH/GARCH non-linear effects in the data. The presence of the ARCH effect implies the underlying time series returns are efficient.

3.8 BDS Test

Broock et al. (1996) developed a portmanteau test for time-based dependence in a series, popularly known as BDS (named after its authors, Broock, Dechert, & Scheinman). It is a powerful and most used non-parametric test for nonlinear predictability in time series analysis. The correlation integral is the probability that any pair of points is within a given distance $' \in '$ apart in phase space. Consider a return seriesx_t, t =1, 2, …T and having m-history $x_t m = (x_t, x_{t-1}, \dots\ x_{t-1+m})$, the correlation integral at consecutive point m can be estimated as

$$C_{m,\in} = \frac{2}{T_m(T_{m-1})}\sum m \leq s \sum t \leq TI({x_t}^m, {x_s}^m; \in)$$

With $T_m = T - m + 1$ and $I({x_t}^m, {x_s}^m; \in)$ being an indicator of a function, which takes 1 if $x_t - x_{t-1} \leq \in$ or 0, otherwise. The estimation of the joint probability of independence of x_t is

$$PR(|x_t - x_s| < \in, |x_t - x_{t-1}| < \in, \dots |x_{t-1+m} - x_{s-1+m}| < \in)$$

Brock et al. (1996) showed that

$$W_{m,\in} = \sqrt{T}\,\frac{C_{m,\in} - C_{1,\in^m}}{S_{m,\in}}$$

Where $C_{m,\in}$ and $C_{1,\in^m}$ is probability equaling $PR(|x_t - x_s| < \in)^m$ while $S_{m,\in}$ stands for the standard deviation of $\sqrt{T}\left(C_{m,\in} - C_{1,\in^m}\right)$. $W_{m,\in}$ is BDS, which tests the null hypothesis that return series are independent. This hypothesis is rejected when the P-value of the BDS is significant at 5%, implying non-linear dependence or market inefficiency. This test is a measure of the nonlinear predictability of the sample.

3.9 ARCH-LM Test

Engle (1982) proposed Lagrange Multiplier (LM) test to detect ARCH disturbances. The residuals of the AR (p) model are tested for heteroscedasticity. The Engle LM statistic is computed from an auxiliary test regression, which is

$$e_t{}^2 = a_0 + \sum_{i=1}^{p} a_i e_{t-1}{}^2 + V_t$$

where e is the residual from the pre-whitened AR (p) model.

4. Results

This section aims to present the outcomes from the proposed methods and the relationships of the variables of interest. This section analyzes and interprets the result of the empirical research.

4.1 Descriptive Statistics

Descriptive statistics gives the summary of the variables used for this study. It is a form of univariate analysis which shows the number of observations, mean, standard deviation, minimum and maximum values of the variables.

Table 1: Descriptive Statistics of Monthly Return for the NEPSE Stock Indices

Sample Period		Obs.	Minimum	Maximum	Mean	S.D.
Full sample		180	-0.2394	0.25	0.00986	0.07135
2003	2008	60	-0.2394	0.1767	0.02556	0.06299
2004	2009	60	-0.2394	0.1767	0.0184	0.0763
2005	2010	60	-0.2394	0.1767	0.00859	0.08428
2006	2011	60	-0.2394	0.1767	-0.00205	0.08432
2007	2012	60	-0.2394	0.25	-0.00768	0.08704
2008	2013	60	-0.1563	0.25	-0.01056	0.07372
2009	2014	60	-0.1123	0.25	0.00614	0.06961
2010	2015	60	-0.1098	0.25	0.01162	0.06505
2011	2016	60	-10.98%	25.00%	0.02735	0.0662
2012	2017	60	-10.98%	23.59%	0.02359	0.06811
2013	2018	60	-10.98%	23.59%	0.01456	0.0731
2014	2019	48	-0.10977	0.23589	0.00445	0.07457

The descriptive analysis shows that volatility measured in terms of standard deviation is largest in sub-sample of 2007 to 2012. This is intuitive as it was the time around which Nepal was undergoing a transformation from constitutional monarchy towards institutionalizing the federal republic. Also, it was a period of uncertainty following the first constitutional assembly election. Furthermore, the mean return is also negative in the same period. Meanwhile, in other periods the return appears positive. Similarly, the full sample of 16 years shows the positive average return of 0.00986.

4.2 Linear Test Results

Table 2 shows the test result for linear correlation tests of five-yearly subsamples for the NEPSE index. The first two columns represent the start date and the end date of the subsamples. The third column represents the result of the autocorrelation-portmanteau test for white noise, while the fourth column shows the z-statistic for the non-parametric runs test. The last four columns show that variance-ratio for k equals 2, 4, 8, and 16.

Table 2: Linear Test of Return of NEPSE Index

Start year	End year	Autocorrelation	Runs	VR			
		Portmanteau (Q) statistic	Z-Statistics	2	4	8	16
Full sample		61.7152**	-2.54**	0.562***	0.36***	0.157***	0.107**
2003	2008	36.1508	-0.78	0.494***	0.451*	0.179*	0.321
2004	2009	65.6809***	-1.3	0.548***	0.564	.219*	0.504
2005	2010	57.0543***	-0.26	0.526***	0.511*	0.216*	0.494
2006	2011	62.4702***	-1.82*	0.565***	0.514*	0.231	0.53
2007	2012	34.9446	-0.78	0.5***	0.316**	0.242	0.547
2008	2013	17.2305	0	0.537***	0.305**	0.207*	0.299
2009	2014	22.1778	-1.04	0.553***	0.318**	0.230*	0.35
2010	2015	27.0452	-0.26	0.595***	0.352**	0.235	0.351
2011	2016	35.9722	-2.08**	0.791	0.47*	0.351	0.593
2012	2017	41.9291**	-2.86***	0.78	0.422**	0.282	0.525
2013	2018	25.5654	-1.82*	0.658**	0.351**	0.242	0.441
2014	2019	13.0486	-0.88	0.588**	0.300**	0.243	0.283

* Represents significant at 10%, ** Represents significant at 5%, ***Represents significant at 1%.

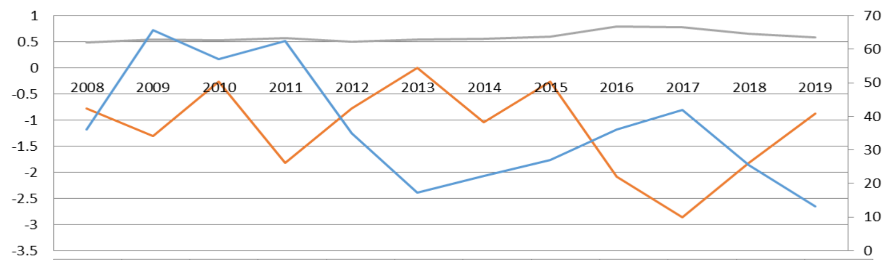
The result of autocorrelation runs, and variance ratio test are documented in table 2, which also contains the autocorrelation coefficients of the full sample and 12 sub-samples of five years moving window for monthly returns of the index. The optimum lag of four was observed for the subsamples of 2003-2008, 2004-2009, 2005-2010, 2006-2011. However, an optimum lag of one was observed for the full sample 2003-2019.There was zero lag for the subsample 2007-2012, 2008-2013, 2009-2014,2010-2015, 2011-2016, and 2014-2019. Stock returns were linearly independent in those periods where optimum lag was found zero. The results showed that the full sample of the NEPSE Index possessed the first-order autocorrelation. Its positive and significant value indicated that stock returns were dependent on past historical prices. It showed that in the long-run stock returns were predictable. The result of the first subsample 2003-2008 was not significant while subsequently three subsamples 2004-2008, 2005-2010, 2006-2011 strongly had fourth-order autocorrelation. However, 2012-2017 was significant at first-order autocorrelation. The rest seven subsamples 2007-2012, 2008-2013, 2009-2014, 2010-2015, 2011-2016, 2013-2018, and 2014-2019 indicated no significant autocorrelation, implying stock returns were linearly independent during this period. Hence according to the autocorrelation test, overall results suggest that the NEPSE index is an adaptive market.

The runs test is used most frequently to test the randomness in data. The test results for the NEPSE full sample along with subsample 2006-2011, 2011-2016, 2012-2017, 2013-2018 are all negative and significant, indicating that the observed number of runs is significantly fewer than the expected number of runs to be random. Therefore, for these periods, the null hypothesis that returns followed a random walk was rejected. Hence in these periods, returns of stock were linearly dependent. However, in 2003-2008, 2004-2009, 2005-2010, 2007-2012, 2008-2013, 2009-2014, 2010-2015, and 2014-2018 the returns are independent as z-values indicated their insignificance. These results implied that the NEPSE index stock returns fluctuated over time between being dependent and independent, supporting the AMH.

The result of the variance ratio test for the full sample showed that there was a mean reversion between returns for all four tested k’s since the variance-ratio statistic was significantly less than one and significant at 1%. The variance ratio test result of subsample analysis in table-2 showed that for k =2, eight subsamples 2003- 2008, 2004-2009, 2005-2010, 2006-2011, 2007-2012, 2008-2013, 2009-2014, 2010-2015 and last two subsamples 2013-2018 and 2014-2018 had variance ratio statistics less than one with almost all subsamples being statistically significant at 1%. However, subsamples 2011-2016 and 2012-2017 were not significant for almost all k’s. Hence almost every subsample rejected the null hypothesis of independence for k= 2, 4 however, not for k=8, 16. This meant that the stock market switched from dependency to independency; that is inefficiency to efficiency. So, a very interesting pattern has been found from the VR test that Present returns are influenced by recent past returns not for longer past returns. So, returns are predictable based on a short period of time not based on a longer period. Hence variance ratio test supported the first stage of AMH for stock returns.

Similarly, lag four can be interpreted in the above format. Lag four represents this month's return is dependent on the last four months' data point.

Figure 1: End-year Linear Test Statistics



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Z-Run	-0.78	-1.3	-0.26	-1.82	-0.78	0	-1.04	-0.26	-2.08	-2.86	-1.82	-0.88
VR(2)	0.494	0.548	0.526	0.565	0.5	0.537	0.553	0.595	0.791	0.78	0.658	0.588
PortmateauQ	36.1508	65.6809	57.0543	62.4702	34.9446	17.2305	22.1778	27.0452	35.9722	41.9291	25.5654	13.0486

To examine the degree of linear dependence, autocorrelation (portmanteau) statistic has increased in the beginning then decreased drastically and again test statistic has decreased the value for some period and finally decreased.

The variance ratio test statistic values stay no less than 0.5 throughout the sample and after 2011 it has increased and finally decreased. The runs Z-statistic fluctuates over time and is negative and insignificant at the start of the sample, then significant and again insignificant, and finally significant. So, the variance ratio, runs test, and autocorrelation test suggest that index return moves towards efficiency.

4.3 Non-Linear Test Results

Table 3: McLeod Li and Engle LM Test Statistics

Date			McLeod Li Test Statistics				Engle LM Test Statistics		
Start	**End**	**AR (p)**	**F(5)**	**F(10)**	**F(15)**	**F(20)**	**Lag(5)**	**Lag(15)**	**Lag(20)**
Full sample		1	0.68	0.68	0.53	0.5	3.468	8.34	10.671
2003	2008	4	0.26	0.22	1.24	0.9	1.429	17.462	19.651
2004	2009	4	0.55	0.64	0.83	0.48	2.33	13.605	14.052
2005	2010	4	0.63	0.56	0.37	0.29	3.32	7.505	9.956
2006	2011	4	0.32	0.21	0.6	0.64	1.738	10.808	16.625
2007	2012	4	0.12	0.2	0.32	0.41	0.679	6.634	12.685
2008	2013	0	NA	NA	NA	NA	NA	NA	NA
2009	2014	0	NA	NA	NA	NA	NA	NA	NA
2010	2015	0	NA	NA	NA	NA	NA	NA	NA
2011	2016	0	NA	NA	NA	NA	NA	NA	NA
2012	2017	1	0.58	0.64	0.4	0.43	3.075	7.781	12.676
2013	2018	1	0.16	0.46	0.26	0.31	0.895	5.407	9.911
2014	2019	0							

* Represents significant at 10%, ** Represents significant at 5%, ***Represents significant at 1%, NA -not available

Results for the nonlinear dependence on the AR filtered stock returns. F (k) is the McLeod-Li statistic that tests the null hypothesis that the increments are identically independently distributed. The Engle LM statistics are calculated up to lags 2, 4, and 6. The McLeod Li Test and Engle LM Test Statistics results are documented in table 3. The result is not significant for each subsample, hence showing that each subsample has nonlinear independence. This indicates that the NEPSE index is efficient during these subsample periods and over the full sample.

The BDS test result is presented in Appendix 1. After finding the optimum lag, an AR filter has been implemented. The result shows that there is strong evidence of significant nonlinear behavior at 0.σ for legs 2, 4 and partial significance at lag 10. Results also show that for 1 σ, 1.5 σ, 2 σ with legs 2, 6, and 10, gradually returns are independent for each subsample and whole samples. Hence nonlinear dependence is present for subsample 2004-2009, 2008-2013, 2011-2016, 2012-2017, and 2014-2019. However, subsamples 2003-2008, 2005-20102006-2011, 2007-2012, 2009-2014, 2010-2015, and 2013-2018 are each almost not significant, showing that returns are independent. Hence BDS test shows that the NEPSE index is non-linear dependent for some subsamples and independent for some subsamples. Hence this test indicates that the market is moving from dependency to independency which is inefficiency to efficiency.

Therefore, out of three non-linear tests, the BDS test is a very powerful test, and it supports the NEPSE index is better described by AMH compared to EMH.

The following figure shows the BDS test carried out throughout various AR filters of 2,6 and 10 lag respectively with the correlational integral computed at the probability of two consecutive returns falling within 1 standard deviation. The result shows that nonlinear dependence is not stable and changes in magnitude throughout sample space.

Figure 2: End Sample BDS Statistic at Different Dimensions

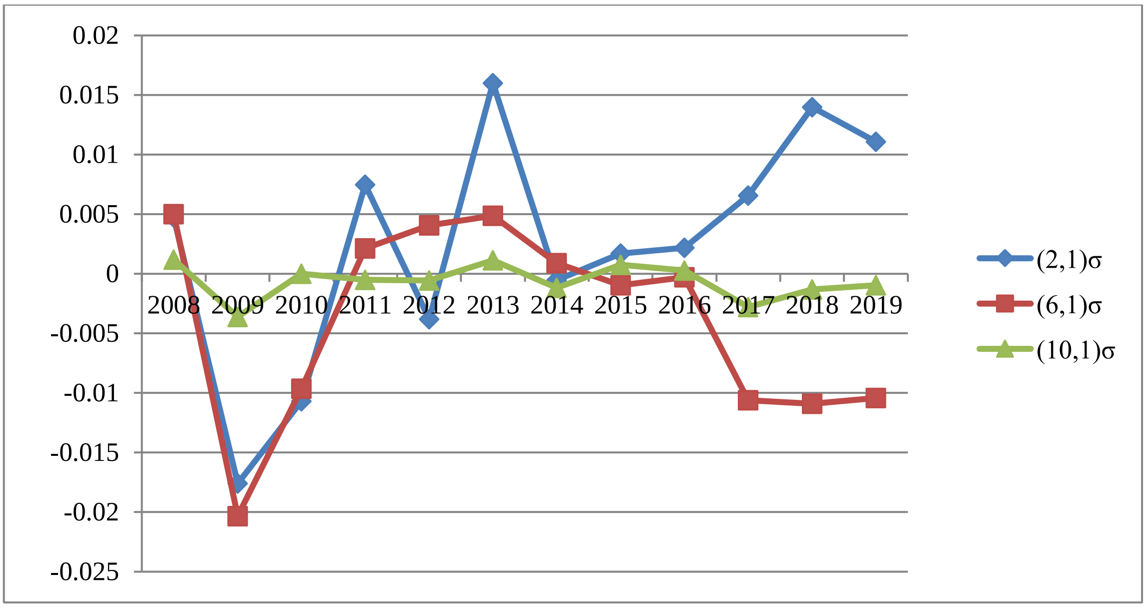


Table 4: Summary Result of Linear and Non- Linear Test

Sample period		Autocorrelation	Runs	Variance Ratio	McLeod-Li	Engle LM	BDS test
Full sample		D	D	D	I	I	D
2003	2008	I	I	D	I	I	I
2004	2009	D	I	D	I	I	D
2005	2010	D	I	D	I	I	D
2006	2011	D	D	D	I	I	D
2007	2012	I	I	D	I	I	I
2008	2013	I	I	D	I	I	D
2009	2014	I	I	D	I	I	I
2010	2015	I	I	D	I	I	I
2011	2016	I	D	I	I	I	I
2012	2017	D	D	I	I	I	D
2013	2018	I	D	D	I	I	D
2014	2019	I	I	D	I	I	D
Class		AMH	AMH	AMH	Efficient	Efficient	AMH

Table 4 shows that the summary results of all linear tests. Variance ratio test shows that NEPSE index return is linearly dependent while at the same time autocorrelation and the run test shows independence in return. In some cases, all these three linear tests show the same result, for example for sample 2006-2011 returns are dependent. Hence results are mixed for the linear tests. Although each test has essentially the same objective of testing linear predictability in price changes, individually autocorrelation test checked for the correlation between returns through the covariance and variance of returns, whereas the runs test examined the positive relationship between returns through a number of changes in the sign of returns compared to the expected number of sign changes.

5. Finding and Discussion

This research has used three major linear tests that are autocorrelation test, runs test, and Variance ratio test. The autocorrelation test measures how much the data set at one point in time influences the data set at a later point in time. This test is a reliable tool for investigating the independence of random variables in a time series. If autocorrelations are found, then returns are not independent. It means returns are dependent on previous returns (lag). Hence, in this case, returns are predictable.

The result of autocorrelation for the full sample (2003 to 2018) is significant as it implies that returns are not independent, so predictable in long run.

In the time frame 2004 to 2009, 2005 to 2010, and 2006 to 2011 returns are not independent. Hence, during these time frames, returns are linearly dependent and predictable. However, from 2007 to 2012 returns are independent which shows the market was efficient. After that from 2012 to 2017 market again was dependent. Hence, returns of the NEPSE index go under periods of efficiency and inefficiency. Therefore, the first alternate hypothesis is accepted.

It is found that in different subsamples, moving windows, in windows 2003 to 2008, 2004 to 2009, 2005 to 2010,2006 to 2011, and 2012 to 2017, auto-correlation test results show that returns are linearly dependent and in other moving windows, returns are independent. But in the runs test and Variance ratio test, results are not consistent with the autocorrelation test. In moving windows 2003 to 2008, 2006 to 2011, 2011 to 2016, and 2012 to 2017 returns are linearly dependent, and, in the rest, moving windows, returns are independent. The result of the Variance ratio test, basically in lags 2 and 4 shows that almost all moving windows returns are linearly dependent. It means returns are influenced by recent past returns.

Hence, the second alternative hypothesis is accepted in some moving window blocks. But in some moving windows null hypothesis fails to reject which means in some moving window returns are independent that is returns are not predictable.

The runs test is used most frequently to test the randomness in data. The runs test results for the NEPSE full sample along with subsample 2006-2011, 2011-2016,2012-2017,2013-2018 are all negative and significant, Therefore, for these periods, the null hypothesis that returns followed a random walk was rejected. Hence in these periods, returns of stock were linearly dependent. However, in 2003-2008,2004-2009,2005-2010, 2007-2012,2008-2013,2009-2014,2010-2015, and 2014-2019 the returns are independent as z-values indicated their insignificance. These results implied that the NEPSE index stock returns fluctuated over time between being dependent and independent, supporting the AMH.

The result of the variance ratio test for the full sample showed that there was a mean reversion between returns for all four tested k's since the variance-ratio statistic was significantly less than 1 and significant at 1%. The variance ratio test result of subsample analysis in table-2 showed that for k=2, 8 subsamples 2003- 2008, 2004-2009, 2005-2010, 2006-2011, 2007-2012, 2008-2013, 2009-2014, 2010-2015 and last two subsamples 2013-2018 and 2014-2019 had variance ratio statistics less than 1 with almost all subsamples being statistically significant at 1%. However, subsamples 2011-2016 and 2012-2017 were not significant for almost all k's. Hence almost every subsample rejected the null hypothesis of independence for k = 2 and4; however, not for k=8 and16. This meant that the stock market switched from dependency to independency; that is inefficiency to efficiency. Hence variance ratio test supported the first stage of AMH for stock returns.

For non-linear independency of stock return, this research has utilized three non-linear tests named McLeod Li test, Engle LM test, and Brock- Dechert-Scheinkman (BDS). In the first two tests result shows that in all sub-sample moving window returns are independent and are not predictable. The third non-linear BDS test which is a more powerful test result shows that in some moving window, returns are independent and in some are dependent which support the second hypothesis too.

Finally, in some subsamples of moving window, the market is efficient and in some subsamples it is inefficient. This suggests that returns are predictable in one period and not predictable in other. From this, we can infer that market efficiency can be coexisting with the efficiency of the market. EMH and market efficiency can co-exist in an intellectually consistent manner.

In the context of Nepal, during 2005-2011, there was serious political instability, as in 2006 constitution was not drafted. At the same time, the market could not be confident about the government. The impact of this situation is reflected in the stock market too. Autocorrelation and runs test is matching for the full sample. The result of both tests shows that returns are dependent on the full sample size. It indicates that the Nepalese stock market has long-term memory (Dangol, 2010). VR (2), VR (4), and VR (8) also have almost similar pattern, indicating that for the small-time frame as the lag become larger, returns moving from dependency to independency, that is inefficiency to efficiency. It indicates that Nepal stock market is moving towards efficiency. But VR (16) supports an inefficient market. The reason is that for the full sample the data point is very large having 180 monthly data points compared to one subsample moving window having only 60 monthly data points. So, in long run, returns are dependent, that is long memory is found in stock return (Volos & Siokis, 2006). McLeod Li test and Engle test are congruences in all periods of moving window. This is a big question for the Nepalese stock market that returns are independent, implying the market is efficient in all time frames, which is not possible in the Nepalese context.

6. Conclusion

The research performed the AMH analysis using monthly NEPSE index data from 1st August 2003 to 1st July 2018. Altogether total of 180 monthly adjusted stock price returns have been taken for the study.

The result of the linear test shows that NEPSE stock return moving towards efficiency. There are multiple possible reasons to justify it. Now in the Nepalese market, there are different news portals opened, like merolagani.com, Nepalesepaisa.com, sharesanshar.com, and so on. Multiple Business Schools were opened, which has produced many business graduates in the market. The stock market size has been increasing gradually. Technology has improved substantially and is used on daily basis. Now people are educated and more literate about the system of markets. These might be the reasons for the market gradually becoming efficient compared to previous years.

Out of three nonlinear tests, BDS only advocates that the NEPSE index is adaptive, the other two non-linear tests namely, the McLeod-Li test and Engle LM test, show that the market is efficient that its returns are independent. Hence, according to the McLeod-Li test and Engle LM test, there is no sufficient evidence to prove that NEPSE index returns are nonlinearly dependent in nature, indicating efficiency. This research also examines the degree of nonlinear dependence over time by plotting the BDS test statistic of (2, 1)σ, (6, 1) σ and (10, 1) σ after an AR filter has been implemented. The result shows that the degree of nonlinear dependency does vary over time which supports AMH. Hence the evidence from the linear test support AMH, whereas the non-linear BDS test support AMH.

The result of the study is useful to the individual and institutional investors to make a financial decision. The study also provides insights to the regulators and policymakers for policy formulation. Such policy can facilitate the stock market development. The research can further explore the comparison of South Asian context, use of high-frequency data, and qualitative approach on investor perspective on market adaptiveness.

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Date		AR	2				6				10			
Start	End		0.5σ	1σ	1.5σ	2σ	0.5σ	1σ	1.5σ	2σ	0.5σ	1σ	1.5σ	2σ
Full sample		1	0.003465**	0.005489	0.003061	-0.001109	0.00031***	0.001494	0.002953	-0.011418	-0.00000473**	-2.67E-05	0.010751	0.008015
2003	2008	4	-0.005428	0.00473	0.006534	0.004039	-0.000435*	0.005014	0.003209	0.000826	-4.01E-06	0.001191	-0.007574	-0.045255
2004	2009	4	-0.008122*	-0.017599*	-0.010307	-0.006532	-0.000588**	-0.020327***	-0.041386*	-0.045163	-7.24E-06	-0.00361**	-0.03473**	-0.095151***
2005	2010	4	-0.002569	-0.010689	-0.010337	-0.005893	-0.000474***	-0.009654**	-0.052783***	-0.081955***	-3.41E-06	-0.001804**	-0.038299***	-0.108198***
2006	2011	4	-0.002424	0.00748	0.005147	0.010244*	-0.000323**	0.002125	-0.002024	0.01075	-1.14E-06	-0.000505	-0.008554	-0.010733
2007	2012	4	0.001065	-0.003803	0.005995	-0.00076	-0.000627***	0.004056	0.009849	-0.016436	-2.71E-06	-0.00057	0.013989	0.037188
2008	2013	0	0.008325**	0.016**	0.021895**	0.01385**	0.001571***	0.004879	0.027139	0.061459**	-3.40E-06	0.001134	0.003962	0.034331
2009	2014	0	0.001227	-0.000534	0.00127	-0.003645	0.000154	0.000902	-0.005457	0.01434	-0.00000755**	-0.001181	-0.029119**	-0.052401
2010	2015	0	-0.000358	0.001686	0.005896	0.005122	0.00019	-0.000952	-0.023117	-0.014842	-3.80E-06	0.000747	-0.017561	-0.027629
2011	2016	0	-0.005035**	0.002188	-0.005539	-0.010235	0.000169	-0.000299	-0.013667	-0.023322	-3.40E-06	0.000269	-0.013567	-0.071551
2012	2017	1	0.008531***	0.006568	0.007327	0.000537	-0.000570***	-0.010619	-0.035704**	-0.09051***	-5.52E-06**	-0.002778	-0.028427***	-0.152078***
2013	2018	1	0.000849	0.013988**	0.004818	-0.004938	-0.000648***	-0.010908***	-0.026233	-0.085773***	-2.96E-06	-0.001315**	-0.006034	-0.061405**
2014	2019	0	0.008279**	0.01107	0.00782	-0.001517	-0.000798***	-0.010428**	-0.030921*	-0.035312	-4.04E-06	-0.000963	-0.00428	-0.022985

*Represent significance at 10%.
**Represent significance at 5%.
*** Represent significance at 1%.

Note: The BDS results for nonlinearity in the residuals of the pre-whitening AR model. The first row reports the dimension while the second row documents the dimension by values of the standard deviation of the sample.