THE THEORY OF RANDOM WALK AND STOCK PRICE BEHAVIOR OF NEPALESE COMMERCIAL BANK

BY

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RECOMMENDATION

CERTIFICATION

We, the undersigned certify that we have read and hereby recommend for the acceptance by the School of Management, Tribhuvan University, a Graduate Research Project (GRP) report submitted by Shrijana Tripathi entitled, “The Theory of Random Walk and stock price behavior of commercial bank” in a partial fulfillment of the requirements for the award of Master of Business Administration of Tribhuvan University.

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DECLARATION OF AUTHENTICITY

I, Srijana Tripathi declare that this GRP is my own original work and that it had fully and specifically acknowledged wherever adapted from other sources. I also understand that if at any time it is shown that I have significantly misinterpreted material presented to SOMTU, any credits awarded to me on the basis of that material may be revoked.

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Srijana Tripathi

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ABBREVIATIONS

ADF	Augmented Dickey Fuller
BSE	Mumbai Stock Exchange
CD	Confidence Distribution
CHL	Chile
COL	Columbia
CSD	Cross Sectional Dependence
DJIA	Dow Jones Industrial Average
DJIMA	Dow Jones Islamic Market Indices
DSE	Dhaka Stock Exchange
EMH	Efficient Market Hypothesis
E-views	Electronic Views
EU	European Union
FX	Forex
FY	Fiscal Year
IMF	International Monetary Fund
US	United States
NEPSE	Nepal Stock Exchange
NSE	National Stock Exchange
NRB	Nepal Rastra Bank
SEBON	Securities Board of Nepal
SEC	Securities Exchange Center

EXECUTIVE SUMMARY

The concept of random walk was first developed by Bachelier in 1900. According to random walk theory, stock price changes have the same distribution and are independent of one another. As a result, it assumes that a stock price or market's historical movement or trend cannot be utilized to forecast its future movement. The efficient market hypothesis (EMH) had its genesis in the random walk theory of the movement of security prices. The basic idea of emh was it is impossible to "beat the market “or “outperform” in the market. Stock market is said to be efficient if the stock return series follow random-walk behavior where historical sequence of returns are irrelevant in predicting future stock prices leading a market to be efficient in weak-form. Because of the widespread availability of public information, any information that may be utilized to forecast stock performance is already represented in the stock price today. As a result, in an efficient market, it is impossible for an investor to consistently outperform the market and achieve abnormal profits.

This paper examines the stock price behavior of Nepalese commercial bank using random walk model. The objective of the research is to access the stock price behavior of Nepalese Commercial Bank. Apart from that investigate price distribution patterns of Nepalese Commercial Bank., identify whether the successive prices are correlated of one another or not, access the existence of a unit root in the daily price time-series. The study period spanned from 2010 to 2020. The data has the daily frequency. The national level “A” class bank which is listed in NEPSE and hasn’t gone for merger/acquisition after 2011 and which has not been remained de-listed for a long period of time is included in sample. Most of the companies chosen as sample consist of trading history of 10 years. The distribution of 12 sampled bank were first, analyzed using descriptive statistics like mean, max, min, standard deviation, skewness, kurtosis and Jarque-Bera test with data of period 2011 to 2020. Besides these, unit root test, run test and autocorrelation test were also applied to test the random walk behavior of share price of commercial bank.

The mean daily return of majority companies is positive which indicates that bank return involves low risk. This may have happened due to market size, technology, information and attitude of investors towards the risk. The study gives the mixed result regarding the randomness of stock price of commercial bank in Nepal. Auto-correlation test shows that share price of NBB, EBL and KBL as random and are efficient in weak

form. Run test shows randomness of all share of commercial bank except EBL and NABIL. When tested with unit root test all of them were not random. Hence, the result is contradictory with different random walk tools. Same result can be seen for Nabil bank with all three test. Share price of Nabil is not random i.e. it is not efficient in weak-form. This means that investors can predict future price by using technical analysis and gain abnormal profit. Excess returns can be earned by using investment strategies based on historical share prices. These evidences of different result for all other bank shows that testing market efficiency is a continuous process and should be tested at different time-intervals. Further research is needed on the topic of random walk hypothesis (RWH) in Nepalese stock market. In order to develop a more comprehensive study on random walk model, future research should cater overall index and all other indices. Different techniques can provide different outcomes. As a result, future research should use additional statistical tools to investigate the RWH and EMH

CHAPTER I
INTRODUCTION

1.1 Background

Bachelier (1900) first developed the idea of efficient market and uses the random walk model for stock prices behavior. He developed a theory that speculative prices follow random walks on the assumption of zero expectation of gain. After Bachelier (1900), further investigation on security prices behavior advanced but slowly. The concept of security prices following a random walk is connected to that of the Efficient Market Hypothesis (EMH). The efficient market hypothesis (EMH) had its genesis in the random walk theory of the movement of security prices that appeared in literature in the late 1950s. The concept of efficient market hypothesis was developed by financial economist Eugene Fama in early 1960s. The basic idea of emh was it is impossible to "beat the market "or "outperform" in the market. According to the Efficient Market theory, a stock's price will reflect all available information in an active market with a large number of well-informed investors. Fama (1970) surveyed the idea of an informational efficient capital market and explain that "A market in which prices always "fully reflects" available information is called "efficient". Stock market is said to be efficient if the stock return series follow random-walk behavior where historical sequence of returns are irrelevant in predicting future stock prices leading a market to be efficient in weak-form. Because of the widespread availability of public information, any information that may be utilized to forecast stock performance is already represented in the stock price today. As a result, in an efficient market, it is impossible for an investor to consistently outperform the market and achieve abnormal profits.

Fama (1970) contended that markets to be efficient at three levels, depending on what information was reflected in pricing. They are: weak form efficiency, semi-strong form efficiency and strong form efficiency. The stock price accurately reflects previous prices and returns in weak form, public information which is known to all market participant is reflected in stock price in semi-strong form and in strong form both public and private information is reflected in stock price. After two decades of publication of market efficiency literature in 1970, Fama (1991) proposed to change the categories of market efficiency, namely tests for return predictability instead of weak-form tests, event studies instead of semi-strong-form tests and test for private information instead of strong-form tests.

When Biratnagar Jute Mill and Nepal Bank Limited floated their shares to the general public for the first time, Nepal's capital market was born. The primary market grew at a rapid pace at first. It was a good source of business capital. Nepal's stock market is small in comparison to its GDP, illiquid and risky, and has little impact on the country's economy. Most of the companies listed with exchange belong to banking, finance and insurance companies. Only few companies from trading, hotel, manufacturing and aviation sectors, information technology, construction sectors are listed with the exchange. Investors' confidence and trust is low due to stock market volatility, inadequate information, lack of understanding financial market and instruments and treated as 'non fair game'. The weak institutional mechanisms, insufficient market makers and brokers were some major limitations of Nepalese capital market. Currently we can observe the scenario where the primary market is oversubscribed and secondary is lacking of investors. On the basis of literature review and observation on present status of capital market in Nepal, the stakeholders of whole capital market should be concerned with the areas such as a good tax policies, development and improvement in infrastructure, elimination of restriction on foreign portfolio investment, training and developments to regulating body and professionals, proper coordination between regulatory body and all stakeholders of financial intermediaries. Likewise, Closer coordination and collaboration with other stakeholders like the government, NRB, Insurance Board and NEPSE is of paramount importance as they together are responsible for promoting, diversifying and modernizing the capital market. NEPSE has 26 companies listed under commercial bank group, 17 in development bank group, 17 companies in finance company group, 29 companies in insurance group, 40 companies in hydropower group, 50 micro-finance companies, 7 companies in manufacturing and processing group, 4 in hotel and tourism group, 2 in trading, 5 in investment and remaining three in other group as of august 11, 2021. In the secondary market, companies are organized into 13 categories, including mutual funds. Commercial banks have the highest stake of the secondary market among the 13 groups. Despite the fact that there are 27 commercial banks in operation, Rastriya Banijya Bank has yet to issue ordinary shares. The overall market capitalization of the 26 listed commercial banks was Rs. 1351.37 billion as of March 2021. These banks' securities are traded on the secondary market, with a total of 2 billion 888 million 791 thousand

862 shares. Based on their total share price, banks account for 38.39 percent of the entire market capitalization. As more percent of total market capitalization is concentrated on Commercial Banks, this group significantly affects the overall NEPSE index. The major focus of this thesis is to examine the weak form efficiency of the Efficient Market Hypothesis (EMH) of commercial bank over the period of 2011- 2020. To examine the EMH, some appropriate tests are identified for use in this thesis. They are: The Autocorrelation test, Run test and Unit Root Test.

1.2 Problem statement

In terms of securities valuation and price behavior, there have traditionally been two theories: technical analysis theory and intrinsic value analysis theory. In a nutshell, the technical analysis (chartist) theory proposes that by plotting the market price of shares over time on a chart (hence the title chartist theory), one can identify the certain pattern. According to the fundamental analysis hypothesis, a stock's market value is determined by intrinsic or fundamental elements such as earnings, dividends, growth potential, debt equity mix, and so on. Investors pay technical and fundamental experts for their services as security analysts. The advice of a technical or fundamental analyst would be worthless in a totally efficient market.

There are numerous empirical research on share price behavior or market efficiency. The classical patterns of technical analysis were initially demonstrated by Roberts (1956). Moore (1964) found that the prices of US stocks follow random walk. The study conducted by Worthington and Higgs (2003b) on sixteen European developed markets concluded a mixed result. Only few countries follows the random walk and are efficient. Jarrett and Kyper (2005) examined market efficiency of United States and provides the evidence that the US stock markets show characteristics of a random-walk and thus, they are efficient in the weak-form. Narayan and Narayan (2007) examine market efficiency of G7 countries and found consistent with the efficient market hypothesis.

The above studies provide evidences of market efficiency in the developed markets. On the contrary, Worthington and Higgs (2003a) report all seven Latin American stock markets reject the presence of random walks. These evidences show that testing market efficiency is a continuous process and should be tested at different time-intervals. Nisar & Hanif (2012) examined the weak form of efficient market hypothesis on the four major stock exchanges of South Asia where none of the four major stock markets of south-Asia follows Random-walk. Ali, Naseem, and Sultana (2013) examined Random walk and Weak Form Efficiency of capital markets of Pakistan, India, Srilanka and Bangladesh constituted as SAARC countries and concluded that none of capital markets is characterized by Random walk and hence are not Weak form Efficient. Puah, Wong, and Sen Liew (2013) surveyed data on gross revenue and capital expenditures to examine the validity of REH in Malaysian manufacturing business expectations. Empirical results indicated that the manufacturers' expectations are being irrationally constructed in terms of gross revenue predictions but comply with REH properties in the case of capital expenditures forecasts. Onwukwe and Ali (2018) evaluated the insurance sector of Nigeria Stock Exchange and found that it doesn't follow random walk. Hence these evidences show that testing market efficiency is a continuous process.

The Nepalese stock market is still in its infancy. As a result, it is conceivable for a few people to manipulate the pricing of securities and engage in unethical behavior. To address these flaws, the government established the Securities Board of Nepal (SEBO/N) as an apex regulatory body with the mission of facilitating the orderly development of a dynamic and competitive stock market while maintaining its credibility, fairness, efficiency, transparency, and responsiveness. As an organized stock exchange market for exchanging securities, Nepal Stock Exchange Ltd. (NEPSE) created new policies, rules, and regulations to ensure the smooth operation of the market. Despite this, the Nepalese stock market appears to be 'underdeveloped,' and stock market efficiency may be suspicious for a variety of reasons. As a result, a study of the Nepalese stock market is required in order to determine its "efficiency" or "inefficiency" in terms of share pricing utilizing secondary and primary data. Efficient market hypothesis has become a controversial subject due to empirical results against market efficiency in various stock markets.

There are some empirical research on share price behavior or market efficiency in Nepalese context. GC (2010) studied daily Nepse index and seven sectorial indices and found all the sector inefficient. Dangol (2010), Dangol (2011), Amgain and Shrestha (2011) has done the study for overall nepse index where dangol found market as an inefficient but amgain and Shrestha explained that the Nepalese stock market is efficient. The reason for varying result could be due to the use of different data analytical tools and techniques. This evidences show that testing market efficiency is required at different time interval with different tools. Dahal (2018) has conducted the study from 2005-2016 for nine sub-indices and conclude the mixed results. Commercial bank was inefficient during the study period but it was observed that level of efficiency is rising in the coming years than before. (Bam, Thagurath and Shrestha (2018) analyzed the random behavior of stock price of Nepalese Commercial Banks by using run test, serial correlation and run tests and martingale random walk hypothesis under heteroscedasticity assumption of standard error. They reported that the proposition of Random Walk Hypothesis (RWH) in Nepalese stock markets does not hold true. Dhungana (2020) made daily observation of Nepse, Float, Sensitive, sensitive float index and BSE Sensex and concluded the mixed result. Risal and koju (2021) analyzed daily return of Nepse index and found stock market is inefficient in weak form. Most of the study is conducted for the nepse as overall which gives aggregate and mixed result. Nepalese capital market is highly supported by financial sector including banks and financial institutions and insurance companies in raising public finance. Shares of Nepalese commercial banks are heavily traded in the stock market and, therefore, these shares play a key role in the determination stock exchange indicators. The rising pace of growth of capital market in Nepal has provided the doors for utilization of money for corporate sectors. Capital markets and banks coexist, and they are the most important external finance sources for individuals, businesses, and governments. They not only transfer and distribute risks across the economy, but also mobilize and channel savings. Therefore, the study of bank and financial institutions is of great relevance. Specifically, this study deals with the following issues:

- Whether the prices of Nepalese commercial bank show any systematic patterns or are they indistinguishable from those of random walks?
- Do stock prices of commercial bank over the period display random phenomenon? Whether the successive prices are correlated of one another?
- What is the nature of stock price distribution of commercial bank in Nepal? Do the stock price conform to the normal distribution?
- Whether there is existence of a unit root in the time-series or not?

1.3 Objectives

Financial sector plays a key role in bringing dispersed savings together for capital formation. Stock market as a part of financial market aids in the mobilization of funds for economic sustainability, provides a foundation for real-economy growth, which includes the nation's main infrastructure development. Nepalese securities market is still in its infancy and its continued development is essential. Commercial bank shares are a prominent part of the securities market in Nepal, and the price behavior of commercial bank shares influences the Nepal Stock Exchange index. The rapid development of Nepal's capital market has created new opportunities for corporate sectors to access financing. It is well acknowledged that Nepal has a wealth of human and natural resources to exploit, but it also suffers from a lack of financial resources. Therefore the purpose of this paper is to determine how share price of Nepalese commercial banks behave. The outcomes of the study are likely to benefit investors and policymakers by allowing them to increase efficiency. The existence or absence of the random walk in stock price is examined using 12 sampled commercial bank from 2011 to 2020. The general objective of the study is to assess the stock price behavior of Nepalese Commercial Bank. Do the stock price of Nepalese Commercial Banks follow random walk or not.

The specific objectives of the study are as follows:

- To investigate price distribution patterns of Nepalese Commercial Bank.
- To identify whether the successive prices are correlated of one another or not.
- To assess the existence of a unit root in the daily price time-series.

1.4 Hypothesis

It is essential to test hypothesis with various types of data, markets, indices, and time periods. Although most of the world's equity markets have been studied for weak-form market efficiency, the results vary from one study to the next due to changes in methodology, data frequency, and study timeframe. GC (2010) studied daily Nepse index and seven sectorial indices using run test, unit root test, GARCH model, variance ratio and autocorrelation test and found all the sector inefficient. The study discarded the pre-determined hypothesis that stock market is efficient and return series follow random-walk. Similarly the study conducted by Chaudhuri (1991), Bhatta (2010), Haque, Liu and Nisa (2011), Alsayed (2016), Fernando and Gunasekara (2018) was not consistent with the assumption that share price changes are independent and return series follow random walk. On the contrary Dickinson and Muragu (1994) examined 30 actively traded companies in Kenya, Amgain and Shrestha (2011) examined daily return of Nepse index, Worthington and Higgs (2009) examined Australian stock market and concluded that they follow random walk and are efficient in weak-form.

Pradhan and KC (2010) examined weekly return of Nepse and 26 highly traded stock and found that random walk hypothesis is true for less frequently traded stocks but not with highly traded stocks. Therefore form above evidences it can be said that the results vary from one study to the next due to changes in methodology, data frequency, and study timeframe. Testing market efficiency is a continuous process and should be tested at different time-intervals. In Nepalese context, there have been limited study for the Random Walk (RW), which is why this research is being carried out. The following hypothesis is formulated for the study:

H01: Stock price of Nepalese commercial bank follows a random walk for the study period.

H02: Stock price series of Nepalese commercial bank follow a normal distribution.

H03: There is no serial correlation between the stock prices of Nepalese commercial bank.

H04: There is unit root in the stock price series of Nepalese commercial bank.

If the above mentioned null hypothesis is accepted, it will be consistent with the assumption of the random walk and are weak form efficiency and vice-versa. Investors can predict future price by using technical analysis and gain abnormal profit.

1.5 Scope and significance

According to Worthington and Higgs (2009) The presence (or absence) of a random walk has important implications for investors and trading strategies, fund managers and asset pricing models, and capital markets and market efficiency. Nepalese capital market is highly supported by financial sector including banks and financial institutions and insurance companies in raising public finance. Shares of Nepalese commercial banks are heavily traded in the stock market and, therefore, these shares play a key role in the determination stock exchange indicators. The rising pace of growth of capital market in Nepal has provided the doors for utilization of money for corporate sectors. Capital markets and banks coexist, and they are the most important external finance sources for individuals, businesses, and governments. They not only transfer and distribute risks across the economy, but also mobilize and channel savings. Therefore, the study of bank and financial institutions is of great relevance.

Even though we live in an era of powerful communication technology, one way to understand the Nepalese stock market is that the price formation process may slowly transmit information. Furthermore, the contradictory result of the random walk hypothesis indicate a lack of intensive market regulation, and hence a regulatory shift could be beneficial. The stock price efficiency of commercial bank is necessary to make sound investment decisions. As a result, bias will be avoided, and saving and investments will be encouraged. Investors prefer to invest in a market that is efficient, meaning that stock prices adapt promptly to all available information. According to Fama (1965; 1970), in an efficient market, investors cannot generate extraordinary profits since they trade at their fair value. Investors, regulators, market makers, and policymakers will benefit from the findings of this thesis.

1.6 Limitations

- This study studies the random walk behavior of stock price of Nepalese commercial bank. The study includes only 12 commercial bank because of non-availability of data for other bank that goes for merger/acquisition. Bank that goes for merger after 2011 has been excluded from the study.
- This study is concerned with studying weak form of market efficiency as explained by Noble Lauriat Eugene Fama (1970). It doesn’t analyze semi strong and strong form of efficiency due to lack of popular testing methodology.
- It uses data of daily price return of commercial bank only from the period of 2011 to 2020. Individual observation for the listed company could also be taken for further research. Weekly and monthly data could be taken.
- Among the three procedures given by Worthington and Higgs to test random walks only two method has been used. Parametric serial correlation coefficient and the nonparametric runs and unit root test is used. Other study methods could have been included for more validity of the result.

1.7 Structure

This research paper is categorized into five sections. Each chapter focuses on a different component of the report as a whole. The first chapter contains an introduction that highlights the important issues to be investigated and considers the following: introduction, statement of the problem, research objectives, testable hypothesis, and significance of the study, study limitation and outline of study. Chapter two include the review of related literature, articles, journals, reports conducted by experts and researchers relating to weak-form of market efficiency in global and Nepalese context.

It also include the theoretical frameworks and the research gap. The methodological aspect of the study are discussed in Chapter 3, which includes the variable specification, population and sample, sample selection, research design, data sources, data types, data analysis tools, and software employed. The fourth chapter discusses data analysis and outcomes interpretation. Finally, chapter five concludes the main findings and future implication of research. Within the framework of the established theoretical structure, it links the obtained data with the problem domain and research questions in a logical and reasonable way.

CHAPTER II
RELATED LITERATURE AND THEORETICAL FRAMEWORK

2. Review of literature

The main objective of this thesis is to examine the stock price behavior of Nepalese Commercial Bank. It is important to discuss the theoretical aspect of the efficient market hypothesis in order to achieve this. This chapter summarizes the pertinent literature on random testing and market efficiency testing. The research examines the stock market and its efficiency in the context of different countries. This chapter compiles relevant and existing research on market efficiency (particularly empirical) in both developed and developing nations that attempts to understand stock market randomness and efficiency to date. This chapter is divided into five parts. The first section deals into the topic of market efficiency. The second section deals with the origins and evolution of the efficient market hypothesis. The third section discusses market efficiency viewpoints. The historical history of the efficient market hypothesis is explained in these parts, as well as the research environment. The fourth one explains the empirical research conducted on market efficiency on Nepalese and International context and the last talk about the research gap.

2.1 Theoretical background

2.1.1 The theory of random walk

The Random Walk Theory, often known as the Random Walk Hypothesis, is a stock market mathematical model. The theory's proponents think that the prices of securities in the stock market follow a random walk. According to the Random Walk Theory, the price of each stock in the stock market follows a random walk. The Random Walk Theory also assumes that the price movement of one security is independent to the price movement of another security. Jules Regnault, a French mathematician turned stock dealer, authored "Calcul des Chances et Philosophie de la Bourse" or "The Study of Chance and the Philosophy of Exchange" in 1863. Regnault's work is regarded as one of the first attempts to employ advanced mathematics in stock market analysis. Another French mathematician, Louis Bachelier, was influenced by Regnault's work and wrote a paper named "Théorie de a Spéculation" or "Theory of Speculation." This paper is recognized with laying the groundwork for the application of mathematics and statistics in the stock market. Paul Cootner, an American financial economist, released a book called "The Random Character of Stock Market Prices" in 1964. It influenced later studies such as Burton Malkiel's "A Random Walk Down Wall Street" and Eugene Fama's "Random Walks in Stock Market Prices," which are both considered classics in the field of financial economics.

Because it is difficult to foresee the movement of stock prices, it is also impossible for a stock market investor to outperform or "beat" the market in the long run, according to the Random Walk Theory. It suggests that an investor cannot outperform the market without taking on a significant amount of additional risk. As a result, an investor's ideal plan is to invest in a market portfolio, which is a portfolio that closely resembles the entire stock market and whose price reflects perfectly the movement of the prices of each asset in the market. The failure of most money managers to regularly outperform the broader market has led to the formation of an ever-increasing number of passive index funds, according to a flurry of recent performance studies. In addition, it appears that a growing percentage of investors believe in the benefits of index investing. According to Vanguard and Morningstar data, index funds received a historic inflow of more than $235 billion in 2016.

2.1.2 The concept of market efficiency

Market efficiency, according to Fama (1965), is attained when "the price of a security effectively represents all available information in the market." As a result, no single investor will benefited as everyone has access to the same information that the market has represented in the price. The stock market is weak-form efficient when subsequent stock price changes and price movements are independent (Fama, 1970). Thus, in order to explore weak-form market efficiency, the randomness of stock returns, which is the foundation of the Random Walk (RW) theory, should be examined.

Furthermore, “a market following a RW is consistent with equity being adequately priced at an equilibrium level. In other words, there is no arbitrage opportunity providing excess over equilibrium profits,” according to Fama (1970). If stock prices are not characterized by a RW, a temporary component dominates the return-generating process, and future returns can be forecasted partly by the past sequence of returns. Market efficiency is a desirable characteristic that enhances capital price and availability, attracts foreign investment, and increases domestic savings.

Fama (1970) investigated the concept of an informational efficient capital market and defined it as follows: “A market in which prices always “fully reflect” available knowledge is considered “efficient.” In general, “the theory of efficient markets” is concerned with whether prices “fully reflect” available information at any given time. The definition emphasizes the importance of information in incorporating stock prices following the release of new market data. According to the EMH, stock prices reflect all available information and are very close to their intrinsic values. The EMH stated mathematically by Fama (1970) in the following equations:

$E(P_{j,t+1} | \Phi_t) = [1 + E(r_{j,t+1} | \Phi_t)]P_{jt}$…………… (1)

Where, E is the expected value operator; P_{jt} is the price of security j at time t; $P_{j,t+1}$ is Price of Security j at time t+1 (including reinvestment of any intermediate cash income from security); $r_{j,t+1}$ = One period percentage return $(P_{j,t+1}-P_{jt})/P_{jt}$; Φ_t is a general symbol of whatever set of information assumed to be "fully reflected" on share price at time t;and the tildes indicate that $P_{j,t+1}$ and $r_{j,t+1}$ are random variables at t.

$Z_{j,t+1} = r_{j,t+1} - E(P_{j,t+1} | \Phi_t)$………………… (2)

$E(Z_{j,t+1} | \Phi_t) = 0$ ………………… (3)

Where $Z_{j,t+1}$ is the unexpected (or excess) return of security j at time t+1, the difference between the observed return, $r_{j,t+1}$, and the expected return based on the information set Φ_t. Defining market efficiency in this way has two important implications, such as (1) an investor cannot use Φ_{t-1} to earn nonzero abnormal returns, and (2) in an efficient, when a new information item is added to the information set, Φ, its revaluation implications for P_{jt} is instantaneously and unbiased impounded into the current market price.

Fama (1970) contended that markets to be efficient at three levels, depending on what information was reflected in pricing. They are: weak form efficiency, semi-strong form efficiency and strong form efficiency.

Weak form efficiency

The Weak Form of the Efficient Market Hypothesis, in which the information set Φ_t is taken to be solely the information contained in the past price history of the market as of time t. This includes past series of stock prices and indexes. If stock market in the form of weak efficiency, the technical analysis does not provide excess returns.

Semi-strong form efficiency

The Semi-Strong Form of the Efficient Market Hypothesis, in which Φt is taken to be all information that is publicly available at time t. This includes the history of past prices as well as all publicly available information about assets' returns, i.e. all disclosures, announcements and reports, which are available to all market participants. All such information is reflected in the current price of the assets. If stock market in the form of semi-strong efficiency, the fundamental analysis does not provide excess returns.

Strong form efficiency

In addition to the above, the Strong Form of the Efficient Market Hypothesis, in which Φt is taken to be all information known to anyone at time t. It includes all privately available information on the assets, i.e. information proprietary to particular investors, analysts and managers. If stock market in the form of strong efficiency, the insider information does not provide excess returns.

After two decades of publication of market efficiency literature in 1970, Fama (1991) proposed to change the categories of market efficiency, namely tests for return predictability instead of weak-form tests, event studies instead of semi-strong-form tests and test for private information instead of strong-form tests. If market efficiency is present, it is difficult to expect above average returns because market cannot be 'bear'. Most economists, on the other hand, argue that markets are efficient since they are filled with investors who are constantly taking risks in the hopes of making a significant profit. This would not be the case if markets were efficient. However, with the introduction of the internet, information has become more freely available to investors, resulting in a significant rise in market efficiency. As a result, markets may become more efficient as a result of technological advancements.

Random walk theory states that market prices are random and impossible to forecast. The theory complements market efficiency and makes it more difficult for people to locate opportunities to generate substantial returns from their investments. If prices were unpredictably fluctuating, investors would be gambling. The concept of market efficiency permits stock investors to make rational decisions because taking advantage of market irregularities would likely be the only method to achieve above-average profits. Although irregularities usually go away with time, there is usually a window of opportunity to capitalize on them. In other word, most economists believe that market will never be totally efficient but investors will always have a chance to profit.

The RWH is, in reality, the foundation of weak-form market efficiency. It claims that stock prices are unpredictable and cannot be anticipated using historical data (Fama, 1995). Fama's (1965, 1970) proposed this theory, which has been adopted by financial economists, researchers, and practitioners. He further points out that the RWH is an independence test that is based on the premise that stock prices can be identified by a white-noise process, a stable first-order autoregressive pattern, a unit root process, or a low correlation dimension. Such criteria may be used to distinguish between market efficiency and perfection.

Indeed, the terms "efficient market" and "perfect market" are frequently interchanged. It's important to highlight, however, that there's a difference between an efficient market and a perfect market, with the latter having more stringent criteria. All parties are assumed to be rational in such a market and have instant access to all relevant information without paying fees. A perfect market is further distinguished by the absence of transaction costs, divisible assets, a large number of investors, free entry and exit, perfect knowledge, and no investor attachment. Butler and Malaikah (1992) argue that emerging stock markets are inefficient due to thin trading, market size, market regulations, trading expenses, market participants' nature, and the fact that different members may have conflicting information. A perfect market is an efficient market by definition, but an efficient market does not always imply a perfect market.

2.1.3 The Inception and growth of the efficient market hypothesis

Bachelier (1900) is credited as being the first to propose the efficient market hypothesis. The random walk in security prices is demonstrated and modelled by him. Samuelson (1965), on the other hand, establishes a theoretical basis for the random walk. Several academics have since tested the random walk hypothesis, finding considerable support for the concept that sequential price swings are independent. Fama (1970) studies the EMH and concludes that a market is efficient if prices fully represent all available information. He said that market efficiency requires three things: a) no transaction costs, b) all parties have free access to all relevant information, and c) the current stock price should reflect all available information. Shareholders cannot gain additional returns or beat the market based on available information if these conditions are met.

In addition, he proposes three types of efficient market hypotheses. All known information about prior prices is already reflected in prices in weak-form Efficiency. This form declares that historical price data cannot be utilized to forecast future price movements, and that technical analysis will not assist in obtaining abnormal gains. In In semi-strong form, public information is already represented in the stock price abnormal returns cannot be achieved. Finally, a market is said to be strong-form efficient when stock prices react quickly to all types of information (previous, public, and inside information) and investors are unable to profit abnormally. According to Fama (1970 and 1995) and other scholars, if the stock market is semi-strong efficient, it is also weak-form efficient. Furthermore, if the stock market is strong form efficient, it implies that it is also semi-efficient and weak- form efficient. If the weak form of the EMH is rejected, the semi-strong and strong forms of the EMH are also rejected.

2.2 Empirical evidence on efficient market hypothesis

This section is concerned with the previous research work done by the different scholars. More specially, the chapter includes the review of foreign research, review of Nepalese research and review of Journals and articles.

The weak-form of the efficient market hypothesis is tested to see how well historical results can be predicted. It means that future returns cannot be predicted using historical data since present returns are assumed to contain all of the information contained in history data. In other words, if stock price movements cannot be forecast based on past returns, a market is termed inefficient in its weak form. Changes in stock returns are independent and random, according to statistics. Researchers have been developing and testing models of stock price behavior for many years. The theory of random-walking is one major paradigm that has emerged from the research (Fama, 1965). Fama (1991) has broadened the scope of testing for return predictability beyond the predictability of previous returns to include seasonal in returns and forecasting abilities of factors such as dividends, firm size, and/or interest rates. A plethora of studies were devoted to testing the validity of the weak-form of the EMH, following Fama's theory and thorough empirical works of efficient capital markets.

2.2.1 Nepalese review

Study	Methodology	Data Period	Data interval	Findings
GC (2010)	Run test, unit root test, GARCH model, variance ratio and autocorrelation test	2003-2009	Daily Nepse index and seven sectorial indices	Rejects the presence of random walk and hence inefficient weak form market.
Pradhan and KC (2010)	Serial correlation and run test	2005-2008	Weekly return of Nepse and 26 highly traded stock	Random walk hypothesis is true for less frequently traded stocks but not with highly traded stocks.
Dangol (2010)	Unit root test ((Augmented Dickey-Fuller and Philip Perron test), Normality test	July 14, 2000 - January 14, 2010	Daily market return of Nepse	Stock market is inefficient in daily returns series. Historical movements in stock prices can be used to predict their future movements
Bhatta (2010)	Auto-correlation and run test	1995-2005	Daily, weekly and monthly return of Nepse index and return of 30 listed companies	Stock prices in Nepal are not moving independently confirming the Nepalese stock market is not weak form efficient.

Dangol (2011)	Variance ratio test	2003-2010	Daily market return of Nepse, Sensex and Nifty	Nepalese market is inefficient whereas Indian stock market is efficient in weak form.
Amgain and Shrestha (2011)	Unit root test	17 July 2003 – 5 May 2011	Daily return of Nepse index (1810 observation)	Support the weak form of efficient market hypothesis.
Dangol (2012)	Normality (Skewness, kurtosis ,Jarque Bera), Variance-ratio test, run test	September 2006- May 2010	Daily return of All share price index (ASPI), Sensitive index (SI)	Random walk hypothesis doesn't hold true.
Dangol (2016)	Normality test (Skewness, kurtosis, jarque bera), serial correlation coefficient	July 2000- July 2010	Daily, weekly return of Nepse and nine sectorial indices Auto-regressive model	Problem of thin trading for observed data set whereas corrected data (using moving average model, auto-regressive model) shows market is efficient and follows random walk.
Dahal (2018)	Normality, unit-root, Variance-ratio test, run test, autocorrelation, Primary research (percentage, scale/rank)	2005 - 2016 and two sub-period (2005-2010, 2011-2016	Daily market return of Nepse and nine sub-indices	There exists the weak form efficiency for development bank, hotel, manufacturing and trading and

				inefficient in other five sectors. Level of efficiency is rising in the coming years than before.
Dhungana (2020)	Variance ratio test	2015-2020	Daily observation of Nepse, Float, Sensitive and sensitive float index	Result is consistent with the hypothesis for Nepse index whereas it doesn't hold true for other index.
Dhungana (2020)	Serial correlation coefficient, runs tests, Augmented Dickey-Fuller, Phillips Perron unit root tests and multiple variance ratio tests.	2015-2020	Daily return of Nepse and BSE Sensex	Serial correlation and variance ratio test explores the Nepalese stock market follows the random walk and the stock market is weak form of efficient. But the runs test and unit root test explores the Nepalese stock market does not follow the random walk.
Risal and koju (2021)	Normality, autocorrelation,, run and unit root test ((ADF) test and (PP) test)	Jan 2010-Dec 2019	Daily return of Nepse index	Stock market is inefficient in weak form. Generate abnormal market return through use of technical analysis

2.2.2 International review

Study	Country	Period	Methodology	Data	Findings
Sharma and Kennedy (1977)	India, U.K. and U.S.	1963-1973	Run test, Spectral analysis	Monthly indices	Both run tests and spectral analysis confirmed the random walk movement of stock indices for all the three stock exchanges.
Jegadeesh (1990)	U.S.	1929-1982	Cross-sectional regression, Serial correlation	Monthly returns on individual securities on the basis of size.	Reject the hypothesis that the stock prices follow random walks.
Chaudhuri (1991)	India	1988-1990	Serial correlation test, Run test	Daily return of 93 actively traded shares of Bombay Stock	Not efficient in weak form.
Groenewold and Kang (1993)	Australia	1980-1988	Autocorrelation, unit root, regression equation	Monthly stock price indices.	Efficient Market Hypothesis is accepted.
Dickinson and Muragu (1994)	Kenya	1979-1988	Serial correlation test, Run test	Weekly returns of 30 actively traded companies	Majority of stock is efficient in weak form.
Cheung and Coutts (2001)	Hong Kong	1985-1997	Variance ratio test	Daily indices	It follows random-walk behavior.

Moustafa (2004)	United Arab Emirates	2001-2003	Normality test, Run test	Daily prices of the 43 individual stocks in UAE	The empirical results support the weak-form EMH of UAE stock market.
Lucey and Segot (2005)	Middle East countries	1998-2004	Unit root test (KPSS), Variance ratio test	Daily indices	Turkish and Israeli markets follow random walk behavior.
Rahman and Hossain (2006)	Bangladesh	1994-2005	Normality tests, Run test, Autocorrelation test, ARIMA model	Daily stock returns for 33 companies and two daily indices	Dhaka stock market of Bangladesh is not efficient in weak-form.
Gupta and Basu (2007)	India	1991-2006	Unit root test (ADF, PP and KPSS tests)	Daily indices of the Nifty and Sensex	Both markets are not weak form efficient.
Sunde and Zivanomoyo (2008)	Zimbabwe	1998-2006	Augmented-Dickey Fuller (ADF) tests	Monthly return of Zimbabwe Stock Exchange	Do not follow a random walk. Past prices has influence in the determination of future prices and provided an opportunity for out-performance.
Marashdeh and Shrestha (2008)	UAE	2003-2008	Unit root test (ADF and PP)	Daily indices	Follows a random walk.
Uddin, and	Bangladesh	2001-2008	Unit root test (ADF)	Daily indices and daily	DSE is not efficient in weak

Khoda (2009)				prices of 23 individual Pharmaceutical companies	form and DSE does not follow the random walk model.
Worthington and Higgs (2009)	Australia	1958-2006 1875-2005	Serial correlation, Runs tests, Unit root tests, Variance ratio tests	Daily and monthly returns of indices	Monthly stock returns follow a random walk, but daily returns do not because of short-terms autocorrelation in returns.
Charles and Darne (2009)	China	1992-2007	Multiple variance ratio tests	Daily return	Class B shares for Chinese stock exchanges do not follow the random walk hypothesis whereas Class A shares seem more efficient.
Puah, Wong and Liew (2011)	Malaysia	1978-2007	Co-integration test, unbiasedness test, Serial correlation	Daily return of 270 manufacturing companies	The rejection of RWH reveals that the Pakistani stock prices are not Weak Form Efficient.
Haque, Liu and Nisa (2011)	Pakistan	2000-2010	Normality, run, variance ratio, unit root test and auto-correlation test	Weekly return of KSE – 100	Pakistani stock prices are not Weak Form Efficient. Current stock prices are helpful in predicting the future prices. This may benefit the

					investors to yield some arbitrage benefits and abnormal profits.
Hou and Sun (2014)	China and Cana da	1997-2006, 2007-2009, 2010-2013	Run test, variance ratio test, serial correlation test, ARMA model	Daily closing price of Toronto and shanghai stock exchange	No clear conclusion regarding which market is more efficient than the other. Period 2 and 3 support the weak form efficient for both index.
Alsayed (2016)	Dubai	1996-2012	Auto-correlation ,run test, unit root test and variance ratio test	Daily return of four Dow Jones Islamic market indices (DJIMI) Asia/Pacific, developed, emerging and global.	Do not follow a random walk and are not efficient in the weak-form.
Parulekar (2017)	India	2004-2016	Run and auto-correlation test	Monthly return of selected companies from five different sector (IT), Fast (FMCG), (CG), (Auto) and (Pharma))	Stock returns are not efficient in extreme short term. However, they could be efficient in medium to long term period of more than a month.

Arora and Singh (2017)	India	2009-2011	Augmented Dickey and Fuller (ADF) test, ARMA model and GARCH model.	5-minute interval return data for the Nifty 50 and top 10 frequently traded stocks	Non-existence of the weak form of efficiency.
Fernando and Gunasekara (2018)	Colombia	2010-2015	Normality, run, unit root an auto-correlation test	Daily market closing index values of (All Share Price Index) ASPI of CSE	CSE is not weak form efficient.

2.3 Research gap

There are some empirical research on share price behavior or market efficiency in Nepalese context. GC (2010) studied daily Nepse index and seven sectorial indices and found all the sector inefficient. Dangol (2010), Dangol (2011), Amgain and Shrestha (2011) has done the study for overall nepse index in same time frame where dangol found market as an inefficient but amgain and Shrestha explained that the Nepalese stock market is efficient. The reason for varying result could be due to the use of different data analytical tools and techniques. This evidences show that testing market efficiency is required at different time interval with different tools. Dahal (2018) has conducted the study from 2005-2016 for nine sub-indices and conclude the mixed results. Commercial bank was inefficient during the study period but it was observed that level of efficiency is rising in the coming years than before. (Bam, Thagurath and Shrestha (2018) analyzed the random behavior of stock price of Nepalese Commercial Banks by using run test, serial correlation and run tests and martingale random walk hypothesis under heteroscedasticity assumption of standard error. They reported that the proposition of Random Walk Hypothesis (RWH) in Nepalese stock markets does not hold true. Dhungana (2020) made daily observation of Nepse, Float, Sensitive, sensitive float index and BSE Sensex and concluded the mixed result. Risal and koju

(2021) analyzed daily return of Nepse index and found stock market is inefficient in weak form. Most of the study is conducted for the nepse as overall which gives aggregate and mixed result. Therefore the researcher has taken into account data for ten years to understand the behavior of the share pricing of Nepalese Commercial Bank over the past decade that is 2010 to 2020. Moreover both parametric and non-parametric test has been applied to identify the share pricing behavior of the Nepalese Commercial Bank. This study will add to literature study of stock market efficiency including data of more than a decade and applying both parametric and non-parametric test.

CHAPTER III
RESEARCH METHODS

This chapter includes research design, population and sample of the study, nature and sources of data, specification of model, variable specification, data and data analysis tools. Short-term movements and market returns will not reflect any pattern when markets are efficient, as evidenced by the literature analysis in Chapter three. As a result, when modeling tools fail to detect a pattern in market returns, the returns are assumed to be random. In order to discover patterns in time series data, researchers have utilized a variety of methodologies. Regression and exponential smoothing methods assume that returns are unrelated from one period to the next. In addition, there have been several statistical methods provided in the literature to examine the random walk hypothesis. The literature also demonstrates that there is a lengthy tradition of depending on specific kind of statistical tests first, and then moving on to more powerful types of tests. In addition, the literature has indicated some of the strategies that should be used in this thesis. The autocorrelation test, two different unit root tests (the Augmented Dickey-Fuller (ADF) (1979) test, the Phillips-Perron (PP) (1988) test and the Run test (Bradley, 1968). These test procedures are used to look at the random walk hypothesis.

3.1 Research design

The study follow a descriptive research design with the analytical approach. The study seeks to access the stock price behavior of Nepalese Commercial Bank employing unit root test, run test and autocorrelation test. In order to achieve the research objectives various statistical computer software program are employed. Specifically, the Electronic Views, also called E-Views, Microsoft Excel and SPSS are employed to perform the run test, unit root test and autocorrelation to analyze the collected data. For time series analysis, data set of daily closing price of bank is retrieved from NEPSE's official website. Regarding the use of tools autocorrelation test, two different unit root tests (the Augmented Dickey-Fuller (ADF) (1979) test and the Phillips-Perron (PP) (1988) test) and the Run test (Bradley, 1968) is used. These test procedures are used to examine random walk hypothesis and, as a result, market efficiency of listed commercial bank in their weak version. The reasons for choosing the above test methodologies are as follows: first, the random walk hypothesis states that there is no correlation between price trends over time, which can be tested statistically using an autocorrelation test like the Ljung and Box (1978) test; second, the RWH states that the return series must be stationary, which can be tested using various unit tests. Third, in some emerging make there may arise infrequent trading and in such case the efficient market hypothesis cannot be evaluated using autocorrelation, hence the Run Test of Randomness can be employed instead.

At first, normality and descriptive statistics are employed to determine whether or not the data are regularly distributed. For the observations, descriptive statistics such as the Arithmetic Mean, Median, maximum, minimum, Skewness, and Kurtosis are used. The Jarque- Bera test has been used to determine whether data is normal. Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test are applied for the unit root test to examine the stationarity. Furthermore, autocorrelation test and run test are employed to examine the random walk hypothesis and hence the market efficiency in the weak form.

3.2 Population and sample

NEPSE consist of the overall index, ten sub-sector indices (i.e., commercial banking, development banking, finance, insurance, hydropower, hotel, trading, manufacturing, micro-finance and other group indices), sensitive index, float index and sensitive-float index. Listed commercial banks is the population of the study whereas selected 12 (NBL, ADBL, NABIL, SCB, SBI, NBB, EBL, KBL, LBL, CZBIL, PCBL and SRBL) banks are sample. The sample is based on the following criteria:

- The bank should be listed in NEPSE.
- The bank should be national level “A” class bank.
- The bank which goes for merger/acquisition after 2011 is excluded.
- The bank that has remained de-listed for a long period of time is excluded.
- Most of the companies chosen as sample consist of trading history of 10 years.

Hence there are 12 banks fulfilling all this criteria. Nepal Investment bank and Himalayan bank is excluded because of their merger agreement. The listed companies along with their operation date and number of observation is provided in appendix 1 and 2 respectively. Dangol (2010), Bhatta (2010), Dangol (2016), Dahal (2018), Risal and Koju (2021) conducted the study with time frame of 10 years. Similarly, Dickinson and Muragu (1994) in Kenya, Haque et.al (2011) in Pakistan, Hou and Sun (2014) in China and canadian market conducted the random walk behavior using 10 years' time frame. The findings also shows that the study conducted for longer period shows a concrete result in compared to that of shorter time frame. The length of time series can vary, but are generally at least 20 observations long, and many models require at least 50 observations for accurate estimation McCleary et al. (1980). More data is always preferable, but at the very least, a time series should be long enough to capture the phenomena of interest. To qualify for selection, the company must have given rise to a minimum of sixty observations to ensure viability of the goodness-of-fit tests (Bhatta, 2010). Here, the observation of all bank is above 1900 and the study includes the time period of 10 years' time series data to access the randomness of stock price of commercial bank.

3.3 Nature and sources of data

The data is quantitative in nature. For time series analysis, data set of daily closing price of bank is retrieved from NEPSE's official website (www.nepalstock.com.np). As stock prices react slowly to new information, it's necessary to look at returns over long time periods to gain a whole picture of market inefficiency (Fama, 1998). Therefore the data includes return of every trading day from 2011 to 2020.

3.4 Specification of model

In the early treatments of the efficient markets model, the statement that the current price of a security "fully reflects" available information was assumed to imply that successive price changes (or more usually, successive one-period returns) are independent. In addition, it was usually assumed that successive changes (or returns) are identically distributed. Together the two hypotheses constitute the random walk model. Formally, the model says, Fama (1970)

$f(r_{j,t+1} \| \Phi_t) = f(r_{j,t+1})$ ………………………………..(1)

which is the usual statement that the conditional and marginal probability distributions of an independent random variable are identical. In addition, the density function f must be the same for all t.

Expression (1) of course says much more than the general expected return model. For example, if we restrict expected return model by assuming that the expected return on security j is constant over time, then we have

$E(\tilde{r}_{j,t+1} \| \Phi_t) = E(\tilde{r}_{j,t+1})$.

This says that the mean of the distribution of $r_{j,t+1}$ is independent of the information available at t, Φ_t, whereas the random walk model in addition says that the entire distribution is independent of Φ_t. it is best to regard the random walk model as an extension of the general expected return or "fair game" efficient markets model in the sense of making a more detailed statement about the economic environment. The "fair game" model just says that the conditions of market equilibrium can be stated in terms of expected returns, and thus it says little about the details of the stochastic process generating returns. A random walk arises within the context of such a model when the environment is (fortuitously) such that the evolution of investor tastes and the process generating new information combine to produce equilibrium in which return distributions repeat themselves through time.

The random walk hypothesis states that the future path of the price level of a security is no more predictable than the path of a series of cumulated random numbers (Fama, 1965). In statistical terms, the hypothesis states that successive price changes are independent, identically distributed random variables so that future price changes cannot be predicted from historical price changes. Mathematically, this model may be expressed in a number of ways but the simplest model is:

$$P_t = P_{t-1} + \varepsilon_t$$

Where, P_t is the price of the stock at time't' ,P_{t-1} is the price of the stock in the immediately preceding period and ε_t is a random error. This study employed two traditional models namely, autocorrelation test and runs test to test the random walk hypothesis in Nepalese stock market.

3.5 Variables specification

Daily closing price of 12 listed companies are selected to check the robustness of market returns. The initial time periods vary from company to company but usually run from 2011 to 2020. The final date is the same for all companies, but the initial date varies.

3.6 Data

The study used stock returns as an individual time-series variable. The natural log of the relative price has been computed for the daily intervals to produce a time series of continuously compounded returns, such that:

$$Rt = \ln\left(\frac{Pt}{Pt-1}\right) * 100$$

where Pt and Pt-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, Dahal 2016, Dangol 2016).

Further, there are three main reasons for using changes in log price rather than simple price changes:

- First, the change in log price is the yield, with continuous compounding, from holding the security for that period (Bhatta, 2010).
- Second, Moore (1964) has shown that the variability of simple price changes for a given stock is an increasing function of the price level of the stock. The study indicated that taking logarithms seems to neutralize most of this price level effect.
- Third, for changes less than ±15 percent the change in log price is very close to the percentage price change, and for many purposes it is convenient to look at the data in terms of percentage price changes.

3.7 Data analysis tools

To assess random walks, Worthington and Higgs (2009) proposed three different procedures. They are the parametric serial correlation coefficient and the nonparametric runs test (RW1), the Augmented Dickey-Fuller, Phillips-Perron, and Kwiatkowski, Phillips, Schmidt, and Shin unit root tests for non-stationarity as a necessary condition for a random walk (RW2) and multiple variance test statistics for random walks under varying distributional assumptions (RW3). Fama (1965) used runs tests to examine whether price changes were likely to be followed by more price changes of the same sign.

To examine random walk, the study uses parametric serial correlation tests and non-parametric runs tests and unit root test among the three techniques. Most studies (Worthington and Higgs (2004), GC (2010), Pradhan and KC (2010), Bhatta (2010), Alsayed (2016), Dangol (2016), Dahal (2018), Risal and Koju (2021) have used serial correlation to examine the random walk behavior of stock prices. Serial correlation coefficient test is a widely employed procedure that tests the relationship between returns in the current period and those in the previous period. If no significant autocorrelations are found then the series are assumed to follow a random walk. Second, the runs test determines whether successive price changes are independent and unlike the serial correlation test of independence, is non-parametric and does not require returns to be normally distributed (Worthington and Higgs, 2009). Sunde and Zivano moyo (2008), Worthington ang higgs (2009), Alsayed (2016), Arora and Singh (2017), Fernando and Gunasekarab (2018) has used unit root test to examine randomness in the stock return. The daily stock returns series are tested for the presence of unit root in the log of the index using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP), i.e., tests of the stationarity of the series. The acceptance of null hypothesis implies the existence of a unit root or non-stationarity of stock return series. It is the indication of presence of the characteristics of random walk and weak form efficiency of the market and vice-versa.

3.7.1 Normality and descriptive statistics

There are various assumptions upon which various statistical methods are based; one crucial assumption is normality of data that a random variable is normally distributed. Speaking to EMH, this presumes that if stock prices are in random fashion then its distribution should conform to normal distribution. To put it differently, if changes in indices pursue the normal distribution the series can be called random (Ali, Naseem ,&Sultana,2013). Many researchers conveniently implicit normal distribution without any empirical evidence or test but normality becomes critical especially when this assumption is dishonored and any given interpretation and deduction cannot be reliable or valid. Normality of data can be examined by two ways: Graphical method and Numerical methods. Graphical methods envisage the Distributions of random variables or the differences between the given empirical distribution and a theoretical distribution. On the other hand, Numerical methods give summary of statistics such as skewness and kurtosis, or by conducting statistical tests for normality. Furthermore, Descriptive statistics for the observations includes the Arithmetic Mean, Median, Range, Variance, Skewness, and Kurtosis. As normality tests seek either given set of data keeps similarity to the normal distribution or not. So the null hypothesis is thus that the given set of data is similar to normal distribution , thus a small p-value will leads us to nonnormal distribution of data. Jarque- Bera test have been employed for testing the normality of data (Dahal, 2018). The hypothesis for the normality test is as follows:

H0: Stock returns series of bank follow a normal distribution.

H1: Stock returns series of bank do not follow a normal distribution.

If stock returns series follow a normal distribution, it belongs to the assumption of the random-walk model and market is weak form of efficiency.

3.7.2 Autocorrelation

The association among the time series and its own values at different lags is examined by autocorrelation. When the data series have mean reversal, it means that the autocorrelation is negative and accepts the null hypothesis and vice versa. To find out whether the DJIMI returns exhibit serial dependence, this research applies the autocorrelation test developed by Ljung and Box (1978). Ljung and Box (1978) introduced the finite-sample correction that yields a better fit to the χ 2 distribution for small sample sizes:

$$Qlb = \text{n (n + 2)} \sum_{t=1}^{j} \left(\frac{p2(t)}{n-t} \right)$$

where ρ (t) is the estimated autocorrelation coefficients, t is a given lag (t takes the values of 1 to 12 lags) and n is the sample size. If the calculated value of QLB exceeds the critical value of χ 2 with j degrees of freedom, at least one value of ρ(t) is statistically different from zero at the specified significance level. Negative correlations suggest that sequential returns or price changes are inversely correlated, showing that stock prices are possibly drifting towards mean values than drifting away. Whereas, positive correlations suggest that sequential price changes are possibly sustained, indicating that price changes might carry momentum. Fama (1965) recommended one of the most direct and intuitive tests of the random walk for an individual time series are to test serial correlation. If the stock prices exhibit a random walk, the returns of the stocks are uncorrelated at all leads and lags. Serial Correlation coefficient is the most direct and widely used parametric test for testing EMH in weak form. It provides a measure of the relationship between returns in the current period and those in the previous period. Autocorrelation tests determine whether the correlation coefficients are significantly different from zero.

The hypothesis for the auto-correlation test is as follows:

H0: There is no serial correlation between the stock returns.

H1: There is serial correlation between the stock returns.

If null hypothesis is accepted, it will be consistent with the assumption of the random walk hypothesis and hence market is efficient in weak form and if it doesn't market is not efficient in the weak form.

3.7.3 Run test

As a well-known and widely used non-parametric test approach, the run test is able to test and investigate serial dependence in share price movements (randomness), which may not be detected by the parametric auto-correlation test. It is a strong test for proving the random walk model because it is independent of the normality and constant variance of data and ignores the properties of distribution. A run can be defined as a series of price changes of the same sign preceded and followed by the price changes of different sign. The numbers of runs are computed as a sequence of the price changes of the same sign (such as + +, - -, 0 0) (Siegel 1956). Null hypothesis of the test is that successive price changes are independent and random. The null hypothesis of randomness of the daily return series is rejected if the expected number of run is dramatically different from the observed number of runs.

The test statistics for the number of runs is computed as follows:

$E(R) = \frac{2N0N1}{N} + 1$…………… (1)

$V(R) = \frac{2N0N1(2N0N1-N)}{N\hat{}2(N-1)}$…………… (2)

StDev(R) = Sqrt(Var(R))………………… (3)

Where, N = total number of observations; N1 = number of „+‟ symbols; N0 = number of „-‟symbols; R = number of runs. The Z statistics tests the significance of the difference between observed and expected number of runs and it is able to give the probability of difference between the actual and expected number of runs. If the Z value is greater than or equal to ± 1.96, we can reject the null hypothesis at 5% level of significance (Sharma & Kennedy, 1977).

The test statistics Z= R−E(R) StDev (R)…….. (4)

P-value= normsdist(Z)……….(5)

The hypothesis for the run test is as follows:

H0: The observed series is a random series.

H1: The observed series is not a random series.

If null hypothesis is accepted, it will be consistent with the assumption of the random walk hypothesis and hence market is efficient in weak form and if it doesn't market is not efficient in the weak form.

3.7.4 Unit root test

The daily stock returns series are tested for the presence of unit root in the log of the index using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP), i.e., tests of the stationarity of the series. The Augmented Dickey-Fuller (ADF) test makes a parametric correction in Dickey-Fuller (DF) test for higher-order correlation by assuming that the series follows as an AR (p) process. The ADF approach controls for higher-order correlation by adding lagged difference terms of the dependent variable to the right-hand side of the regression. The Augmented Dickey-Fuller (ADF) test has the following three alternative models:

$\Delta Pt=a0+a1t+\beta Pt\text{-}1+ k\ t=1 \quad \delta\Delta Pt\text{-}i+\mathcal{E}t$………………………………………. (1)

$\Delta Pt=a0+\beta Pt\text{-}1+ k\ t=1 \quad \delta\Delta Pt\text{-}i+\mathcal{E}t$…………………………………………... (2)

$\Delta Pt=\beta Pt\text{-}1+ k\ t=1 \quad \delta\Delta Pt\text{-}i+\mathcal{E}t$………………………………………………..(3)

Where Pt, is the stock price index at time t. The first model (equation 1) includes a constant term (αo), a trend term (α1, t), k denotes the number of lagged terms and εt is a white noise disturbance term. The second model (equation 2) includes a constant term (αo) only, and the third model (equation 3) does not include constant and trend terms. To test for stationarity, the null hypothesis is:

H0: $\beta = 0$ (Non-stationary or unit root)

And alternative hypothesis is:

H1: $\beta < 0$ (Stationary or no unit root)

The acceptance of null hypothesis implies the existence of a unit root or non-stationarity of stock return series. It is the indication of presence of the characteristics of random walk and weak form efficiency of the market and vice-versa.

$\Delta Pt=\alpha+\rho Pt\text{-}1+ut$………………………………………….. (4)

The advantage of the PP test is that it is free from parametric errors. In view of this, PP values have also been checked for stationarity. Unlike ADF test, PP test is a non-parametric test therefore is free from parametric errors. PP test was carried out with the same three different models, i.e., (1) with a constant term and a trend term, (2) with only a constant term, and (2) with neither a constant term nor a trend term.

CHAPTER IV
ANALYSIS AND RESULTS

This chapter consists of descriptive analysis of Commercial Banks. It includes empirical tests like run test, unit root test, autocorrelation test and its discussion and analysis drawn from stock market data of commercial bank from year 2011 to 2020. The purpose of this section is to provide the empirical results of random walk test of stock price of Nepalese commercial banks. The analysis consist of: (i) statistical properties of bank returns aimed to identify the distribution character, (ii) results of the parametric test of serial dependence of returns by using autocorrelation function, and (iii) patterns of the price dependence that could not be detected by parametric test using runs analysis and unit root test (a non - parametric test).

4.1 Descriptive statistics

The study initially examined whether stock returns follow a normal distribution or not in order to test the weak form of market efficiency. The premise of the random-walk model is that stock returns series follow a normal distribution; thus, it is considered as the weak form of market efficiency. One of the basic assumptions of random walk model is that the stock returns are normally distributed. As Fama (1965) pointed out that theory of random walk on stock prices is based on two hypotheses: (1) successive price changes in individual security are independent, and (2) the price changes conform to some probability distribution. Table 1 provides the statistical properties of returns. The descriptive statistics contains the number of observations, the mean return for the period and maximum and minimum returns observed for each of the series. It also includes the standard deviations of the returns series to measure the volatility. The third and fourth moments were measured by skewness and kurtosis coefficients and are reported for each return series. Both of these coefficients help to identify the distribution character of the return series. Moreover, Jarque-Bera test is also used to confirm the distribution character of price returns series.

The skewness, kurtosis, and Jarque-Bera statistics are used to test for normality in this study. Descriptive statistics can be used to assess the stock market's informational efficiency. In general, zero skewness and three kurtosis indicate that the observed distribution is normally distributed.

Table 1: Descriptive statistics of individual bank

The return is calculated as the change in the last closing price of a day from the previous days. Logarithm return is calculated. In the table, N represents number of observations and mean, max and min for average, maximum and minimum bank returns respectively for the period. SD stands for standard deviation of the returns. SK is a measure of skewness and KURT represents kurtosis. A random walk test assumes that the return series follow normal distribution characterized by zero skewness and kurtosis value equal to 3. The Jarque-Bera (JB) test of normality is the test of the joint hypothesis that SK and KURT are 0 and 3, respectively. In that case, the value of the JB statistic is expected to be zero. The JB - statistic with * indicates that the distribution is significantly different from normal distribution.

S.N	Bank	N	Mean (%)	Max (%)	Min (%)	SD (%)	SK	KURT	Jarque-Bera
1.	NBL	1923	0.01	18.95	-129.99	3.84	-20.07	683.37	3735240***
2.	ADBL	2380	0.06	9.53	-38.80	2.53	-1.566	28.606	81765.9***
3.	NABIL	2371	0.0	9.53	-31.38	2.51	-2.453	30.88	96167***
4.	SCB	2382	-0.05	9.53	-67.54	2.66	-7.389	183.96	3366424***
5.	SBI	2338	-0.01	9.53	-28.74	2.45	-1.634	22.35	49479.93***
6.	NBB	2300	0.03	9.53	-42.13	2.97	-1.597	24.059	56196.79***
7.	EBL	2371	-0.01	9.53	-57.22	2.76	-5.014	91.31	830094***
8.	KBL	2184	0.01	9.53	-45.00	2.80	-2.108	36.572	122753***
9.	LBL	2281	0.00	9.53	-49.80	2.80	-2.737	47.88	219747***
10.	CZBIL	2375	0.02	9.53	-32.18	2.45	-1.207	19.953	39796.3***
11.	PCBL	2378	0.03	9.53	-27.19	2.54	-1.183	14.897	22443.9***
12.	SRBL	2373	0.02	9.53	-31.97	2.61	-0.964	14.329	20575.8***

*, **, *** denote significant at 10%, 5% and 1%, respectively.

Table 2: Mean return frequency of bank

Mean daily return	No. of bank	Percentage
< 0	3	25%
0-0.05	8	66.67%
0.05-0.10	1	8.33%
Total	12	100%

Table 2 provides frequency distribution of mean daily return of the individual bank. The mean daily return of the majority of the companies (66.67 percent) centered within class interval of 0 to 0.05 percent. While mean daily return of the 25 percent bank is less than zero, 8.33 percent bank lie within the range of 0.05 percent to 0.10 percent return interval. The bank with positive mean returns indicates that bank return involves low risk. This may have happened due to market size, technology, information and attitude of investors towards the risk.

The skewness, kurtosis, and Jarque-Bera statistics are used to test for normality in this study. Descriptive statistics can be used to assess the stock market's informational efficiency. In general, zero skewness and three kurtosis indicate that the observed distribution is normally distributed.

The highest maximum return is observed for NBL (18.95 percent) and all other holds for 9.53 percent. The lowest minimum return was also observed for NBL (-129.99 percent). The fluctuation in stock prices of the listed banks as measured by standard deviation is recorded highest for NBL (3.84 percent) whereas lowest volatility was observed for SBI and CZBIL (2.45 percent). The returns of all banks (100 percent) are negatively skewed. The skewness coefficient in excess of unity is generally taken to be fairly extreme (Chou, (1969)). In a Guassian distribution, one would expect these data to have a kurtosis coefficient of 2.902. Kurtosis generally either much higher or lower indicates extreme leptokurtic or extreme platykurtic (Parkinson, (1987)). The kurtosis coefficient of 683.371 (NBL) lies under the extreme leptokurtic distribution. Generally, the distribution is perfectly normally distributed if skewness and kurtosis coefficients are zero and 3 respectively. Thus, daily return series is not normally distributed. The kurtosis coefficients of all 12 banks are greater than three indicating that the returns on these companies are leptokurtic. The highest kurtosis coefficient is observed for NBL followed by SCB, EBL, LBL, KBL, NABIL, ADBL, NBB, SBL, CZBIL, PCBL and SRBL. Further, the table provides that the Jarque - Bera (JB) statistics for all the return series are significant. The Jarque-Bera statistics for all the bank return series are significant with p-values equal to zero evidenced further that bank daily return series is not normal. The listed commercial bank doesn’t follows the normal distribution, so it doesn’t belong to the assumption of random walk model; hence commercial bank are inefficient in weak form.

4.2 Autocorrelation function test

As explain earlier, autocorrelation test helps to determine whether returns are dependent on their past values. The autocorrelation text is accomplished using market return and individual share prices.

Autocorrelation function test of individual bank is presented in Table no 3

Table 3: Autocorrelation function test of individual bank

This table presents autocorrelation outcome of daily return of individual banks. The return is computed by taking logarithms of closing prices. The autocorrelation function is a test of stationarity that tests statistical significance of any individual autocorrelation coefficient at certain lag is zero. A zero autocorrelation means the returns in given series are not dependent upon the past return (or lagged values). This confirms the series is non-stationary and thus random. The details auto-correlation coefficient is presented in appendix III.

Bank	Auto-correlation Test
NBL	Insignificant in 1, 2 and 3 lag, and all other coefficient is significant up to 16 lag.
ADBL	All coefficients are significant up to 13 lag and insignificant in 14, 15 and 16 lag.
NABIL	All coefficients are significant up to 16 lag.
SCB	Significant in all lag, except 1 and 6.
SBI	All coefficients are significant up to 16 lag.
NBB	All coefficients are insignificant up to 16 lag.
EBL	All coefficients are insignificant up to 16 lag except lag 4.
KBL	All coefficients are insignificant up to 16 lag.
LBL	All coefficients are significant up to 16 lag.
CZBIL	All coefficients are significant up to 16 lag
PCBL	All coefficients are significant up to 16 lag.
SRBL	All coefficients are significant up to 16 lag.

The auto-correlation coefficient test is a widely employed procedure that tests the relationship between returns in the current period and those in the previous period. If there is no significant autocorrelation found, then the series are assumed to follow a random-walk. The results of autocorrelation test of 12 bank is presented in Table no. 3. The correlation coefficients and the Box-Ljun Q statistic are shown for 16 lags. The P-value for NBL, ADBL, NABIL, SCB, SBI, LBL, CZBIL, PCBL and SRBL is less than alpha 0.01. This shows that there is presence of auto-correlation so we can say that they don't follow the random walk behavior and are inefficient in weak form. For EBL, KBL, and NBB the P-values are greater than alpha and hence we accept null hypothesis. This shows that there is no autocorrelation so we can say that they follow the random walk behavior and are efficient in weak form.

4.3 Runs test of individual bank

The paper has also tested random walk behavior using run test, which is a non-parametric test used for detecting the frequency of the changes in the direction of a time series. Run test provide evidence on the randomness of the price series. Unlike the serial correlation test, it is not affected by any extreme values in the return series. The hypothesis in this test is that the successive price returns on selected bank were random. Dangol (2011) states that the null hypothesis for this test is for temporal independence in the series (or weak-form of efficiency). Returns series are not normally distributed as per Table 1, the presence of structural breaks or outliers in the series can bias the test results. To control for such issues, the runs test is completed using a mean and a median as a base. The latter can yield more reliable results when outliers exist. The Runs Test has been used to see if a index series is random. The runs test is another approach to test and detect statistical dependencies or randomness which may not be detected by the auto-correlation tests. The null hypothesis of the test is that the observed series is a random series. Runs Test is a nonparametric test because no assumption is made about population distribution parameters. This test is used for determining if the order of responses above or below a specified value is random. A run is a set of consecutive observations that are all either less than or greater than a specified value. The number of runs is computed as a sequence of price changes of the same sign. When the expected number of run is significantly different from the observed number of runs, the test rejects the null hypothesis that the daily index return series are random.

A total case denotes the number of observations and total number of runs is a measure of randomness since too many or too few runs indicates dependence between observations. Case less than mean denotes the number of cases below mean, while case greater or equal to mean indicates the number greater than or equal to the mean. It is a positive change when return is greater than the mean, a negative change when the return is less than the mean and zero when the return equals to the mean. The test statistics Z is with its observed significance level. The mean is used as the test value. The test value is used as a cut point to dichotomize the sample. A run is defined as a sequence of cases on the same side of the cut point. The number of runs is a measure of randomness. Too many or too few runs, suggest dependence between observations. A lower than expected number of runs indicates the market's over-reaction to information, while higher number of runs reflect a lagged response to information.

Table 4 : Run test of daily bank return with mean as a base

The table lists statistics associated with the runs test of daily return of listed commercial bank from 2011 to 2020 with mean as a base to test the randomness. Runs test, being a non-parametric test, is a procedure that examines consecutive occurrence of a variable. This variable has only two categories. The runs test classifies values of the variable as being above or below the mean (test value). In the table 'N1' stands for the cases above or equal to mean, 'N0' stands for the cases below mean, 'N' for total number of cases and 'R' for observed number of runs. Any Z-value with *** indicates the significant difference between actual number of runs and observed number of runs indicating that the series is not random at 1% level of significance.

S.N	Bank	Mean (%)	N	N1	N0	R	Z (R)	P-value	R/NR
1.	NBL	0.0086	1923	794	1129	899	-1.615	0.106	R
2.	ADBL	0.0583	2380	1001	1379	1104	-2.397	0.107	R
3.	NABIL	0.0041	2371	1062	1309	1074	-4.13***	0.000	NR
4.	SCB	-0.0516	2382	1226	1156	1164	-1.106	0.269	R
5.	SBI	-0.0149	2338	1188	1150	1128	-1.725	0.084	R
6.	NBB	0.0327	2300	981	1319	1083	-1.840	0.066	R
7.	EBL	-0.0119	2371	1220	1151	1082	-4.25***	0.000	NR
8.	KBL	0.0132	2184	919	1265	1033	-1.431	0.152	R
9.	LBL	-0.0038	2281	1218	1063	1152	0.663	0.507	R
10.	CZBIL	0.0199	2375	994	1381	1110	-1.981	0.048	R
11.	PCBL	0.0259	2378	1043	1335	1137	-1.461	0.144	R
12.	SRBL	0.0239	2373	988	1385	1149	-0.224	0.823	R

*, **, *** denote significant at 10%, 5% and 1%, respectively.

The run test is able to test and investigate serial dependence in share price movements (randomness), which may not be detected by the parametric auto-correlation test. It is a strong test for proving the random walk model because it is independent of the normality and constant variance of data and ignores the properties of distribution. A run can be defined as a series of price changes of the same sign preceded and followed by the price changes of different sign. The numbers of runs are computed as a sequence of the price changes of the same sign (such as + +, - -, 0 0) (Siegel 1956). Null hypothesis of the test is that successive price changes are independent and random. The null hypothesis of randomness of the daily return series is rejected if the expected number of run is dramatically different from the observed number of runs.

The run test shows that the successive return for NABIL and EBL is not independent at 1% percent significant level. There is no evidence for weak-form efficiency. But other remaining ten bank follows the assumption of independent return series indicating that they are efficient in weak-form at 1% level of significance. The return of NABIL and EBL finds the p value is 0.0000 which is less than the 1% level of significant and null hypothesis is rejected which indicates that they do not follow the random walk and the return is weak form of inefficient. Whereas the return of other remaining ten bank follow the random walk and the market is efficient because the p value is higher than the 1% level of significant. So the null hypothesis is accepted.

In the context of Nepal, Bhatta (2010), GC (2010), Dangol (2010), Dangol (2012) and Dhungana (2020) rejected the presence of random walk. Alsayed (2016) reported inefficiency in the weak form. Dahal (2018) rejected the random walk hypothesis of NEPSE and its nine sectors for full study period and other sub-periods where prediction of future price is possible by using technical analysis. Other than that the study results of run tests are also similar to Chaudhuri (1991), Rahman and Hossain (2006), Gupta and Basu (2007), Worthington and higgs (2009, Alsayed (2016), Haque et. al (2011), Hou and Sun (2014) and Parulekar (2017) also reported inefficiency in the weak form. The equity market is said to be efficient, when the return series follow random-walk behavior. Here out of 12, 10 shows that the stock prices are characterized by random-walk. Hence historical sequence of returns are irrelevant in predicting future stock prices and earning abnormal profits.

Table 5 : Run test of daily bank return with median as a base

The table lists statistics associated with the runs test of daily return of listed commercial bank from 2011 to 2020 with median as a base to test the randomness. Runs test, being a non-parametric test, is a procedure that examines consecutive occurrence of a variable. This variable has only two categories. The runs test classifies values of the variable as being above or below the median (test value). In the table 'N1' stands for the cases above or equal to median, 'N0' stands for the cases below median, 'N' for total number of cases and 'R' for observed number of runs. Any Z-value with *** indicates the significant difference between actual number of runs and observed number of runs indicating that the series is not random at 1% level of significance.

S.N	Bank	N	N1	N0	R	Z (R)	P-value	R/NR
1.	NBL	1923	1017	906	950	-0.42552	0.670	R
2.	ADBL	2380	1273	1107	1157	-1.16244	0.670	R
3.	NABIL	2371	1223	1148	1107	-3.220***	0.001	NR
4.	SCB	2382	1216	1166	1162	-1.20865	0.227	R
5.	SBI	2338	1188	1150	1128	-1.72528	0.084	R
6.	NBB	2300	1209	1091	1133	-0.6262	0.531	R
7.	EBL	2371	1220	1151	1082	-4.255***	0.000	NR
8.	KBL	2184	1160	1024	1098	0.396827	0.691	R
9.	LBL	2281	1218	1063	1152	0.663444	0.507	R
10.	CZBIL	2375	1243	1132	1195	0.374102	0.708	R
11.	PCBL	2378	1278	1100	1182	-0.0552	0.956	R
12.	SRBL	2373	1256	1117	1198	0.600421	0.548	R

*, **, *** denote significant at 10%, 5% and 1%, respectively.

The result is similar with run test as mean as a base. The run test shows that the successive return for NABIL and EBL is not independent at 1% percent significant level. There is no evidence for random walk and hence weak-form efficiency. But other remaining ten bank follows the assumption of independent return series indicating that they are efficient in weak-form at 1% level of significance. The return of NABIL and EBL finds the p value is less than the 1% level of significant and null hypothesis is rejected which indicates that they do not follow the random walk and the return is weak form of inefficient. Whereas the return of other remaining ten bank follow the random walk and the market is efficient because the p value is higher than the 1% level of significant. So the null hypothesis is accepted. Run tests with a base of mean and median both rejected the null hypothesis for NABIL and EBL but majority follows the random walk behavior for daily return. Hence they are efficient in weak form.

4.4 Unit root test: of individual bank

Table 6 : Unit root test on the random walk model with constant but no trend

The table shows t-statistics of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests conducted on the daily returns of commercial bank from 2011 to 2020. The test examined stationarity of the daily returns at 1 percent level of significance using a random walk model with constant but no trend.

Bank	ADF		PP	
	Level	Difference	Level	Difference
NBL	-17.2577***	-19.74567***	-42.91392***	-778.50***
ADBL	-35.0962***	-21.54563***	-45.15928***	-546.8833***
NABIL	-34.6419***	-20.13087***	-43.25917***	-339.3549***
SCB	-46.3454***	-19.88514***	-46.31611***	-404.4812***
SBI	-35.2679***	-22..17592***	-44.96849***	-380.5663***
NBB	-45.4866***	-21.10215***	-45.42445***	-2131.916***
EBL	-46.2054***	-20.98834***	-46.14249***	-460.7184***
KBL	-44.5412***	-20.25944***	-44.49731***	-1981.90***
LBL	-43.4336***	-24.34365***	-43.33862***	-405.5644***
CZBIL	-44.6487***	-19.76419***	-44.61598***	-407.5933***
PCBL	-45.6848***	-20.61207***	-45.59934***	-322.5189***
SRBL	-44.9062***	-21.97389***	-44.88698***	-465.5925***

Notes: Test equations for all cases include a constant. The critical values for the ADF and PP tests with intercept are: -3.43(1%); -2.86(5%) and -2.56(10%).For ADF test and PP test hypothesis are: H0: unit root (non-stationary), H1: no unit root (stationary). *, **, *** denote significant at 10%, 5% and 1%, respectively.

Table no.6 shows the stationarity of the daily returns at 1 percent level of significance using a random walk model with constant. All the t-statistics were found to be smaller than Mackinnon’s critical values for both ADF test and PP test at the level and the first difference. Thus, the null hypothesis was rejected. The finding indicates that the daily returns have no unit root. In other words, commercial bank daily return series was stationary, i.e., not random.

Table 7 : Unit root test on the random walk model with constant and trend
The table shows t-statistics of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests conducted on the daily returns of commercial bank from 2011 to 2020. The test examined stationarity of the daily returns at 1 percent level of significance using a random walk model with constant and trend.

Bank	ADF		PP	
	Level	Difference	Level	Difference
NBL	-17.26851***	-19.7515***	-42.89435***	-778.7444***
ADBL	-35.09711***	-21.5412***	-45.15643***	-546.9879***
NABIL	-34.63476***	-20.1269***	-43.24951***	-339.2531***
SCB	-46.34290***	-19.8809***	-46.31209***	-404.3881***
SBI	-35.28534***	-22.1715***	-44.96833***	-380.4628***
NBB	-45.47680***	-21.0990***	-45.41410***	-2140.940***
EBL	-46.20887***	-20.9838***	-46.14598***	-460.5797***
KBL	-44.53370***	-20.2550***	-44.48944***	-1995.447***
LBL	-43.42767***	-24.3382***	-43.33417***	-405.3992***
CZBIL	-44.63950***	-19.7600***	-44.60667***	-407.8607***
PCBL	-45.67547***	-20.6080***	-45.58951***	-322.4232***
SRBL	-44.89682***	-21.9692***	-44.87746***	-465.4009***

Notes: Test equations for all cases include a constant and trend. The critical values for the ADF and PP tests with intercept are: -3.96(1%); -3.41(5%) and -3.12(10%).For ADF test and PP test hypothesis are: H0: unit root (non-stationary), H1: no unit root (stationary).

*, **, *** denote significant at 10%, 5% and 1%, respectively.

Table no.7 shows the stationarity of the daily returns at 1 percent level of significance using a random walk model with constant and trend. All the t-statistics were found to be smaller than Mackinnon’s critical values for both ADF test and PP test at the level and the first difference. Thus, the null hypothesis was rejected. The finding indicates that the daily returns have no unit root. In other words, commercial bank daily return series was stationary, i.e., not random. Hence it can be concluded that there is no evidence for weak-form efficiency.

Table 8 : Unit root test on the random walk model with neither constant nor trend

The table shows t-statistics of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests conducted on the daily returns of commercial bank from 2011 to 2020. The test examined stationarity of the daily returns at 1 percent level of significance using a random walk model with neither constant nor trend

Bank	ADF		PP	
	Level	Difference	Level	Difference
NBL	-17.26234***	-19.74860***	-42.9231***	-778.9387***
ADBL	-35.07745***	-21.55019***	-45.1851***	-546.8028***
NABIL	-34.64917***	-20.13509***	-43.2688***	-339.4485***
SCB	-46.33854***	-19.88938***	-46.3121***	-404.5851***
SBI	-35.27383***	-22.18068***	-44.9772***	-380.6777***
NBB	-45.49136***	-21.10457***	-45.4297***	-2124.364***
EBL	-46.21436***	-20.99287***	-46.1518***	-460.8522***
KBL	-44.55055***	-20.26416***	-44.5068***	-1971.350***
LBL	-43.44311***	-24..34897***	-43.3496***	-405.8673***
CZBIL	-44.65494***	-19.76851***	-44.6233***	-406.8916***
PCBL	-45.69001***	-20.61645***	-45.6051***	-322.6091***
SRBL	-44.91228***	-21.97858***	-44.8941***	-465.8400***

Notes: Test equations for all cases include a constant and trend. The critical values for the ADF and PP tests with intercept are: -2.56(1%); -1.94(5%) and -1.62(10%).For ADF test and PP test hypothesis are: H0: unit root (non-stationary), H1: no unit root (stationary).

*, **, *** denote significant at 10%, 5% and 1%, respectively.

Unit root test, simultaneously allows testing of the random walk hypothesis. Researchers stated that in “the case of ADF and PP tests, the null hypothesis of a unit root (non-stationary) is tested against the alternative of no unit root (stationary). The existence of a unit root in the time-series indicates that there is a random walk hypothesis, suggesting market efficiency. Test statistics were calculated for all three models for both ADF test and PP test. All the t-statistics were found to be smaller than Mackinnon’s critical values for both ADF test and PP test at the level and the first difference which is shown in Tables 5, 6, and 7. Thus, the null hypothesis was rejected. The finding indicates that the daily returns have no unit root. In other words, commercial bank daily return series was stationary, i.e., not random. Hence it can be concluded that there is no evidence for weak-form efficiency. The study result is also consistent with the prior studies: Sunde and Zivanomoyo (2008) of Zimbabwe, Worthington and Higgs (2009) on Australian market, Alsayed (2016) of Dubai and Arora and Singh (2017). Similarly, in case of Nepal, the current study result is in consonance with Dangol (2010), GC (2010), Dahal (2018) and Dhungana (2020).

4.5 Summary of data analysis

Table 9 : Summary of data analysis

Bank	Auto-correlation Test	Run Test	Unit root Test
NBL	Not Random	Random	Not Random
ADBL	Not Random	Random	Not Random
NABIL	Not Random	Not Random	Not Random
SCB	Not Random	Random	Not Random
SBI	Not Random	Random	Not Random
NBB	Random	Random	Not Random
EBL	Random	Not Random	Not Random
KBL	Random	Random	Not Random
LBL	Not Random	Random	Not Random
CZBIL	Not Random	Random	Not Random
PCBL	Not Random	Random	Not Random
SRBL	Not Random	Random	Not Random

In table no 9, we can observe mixed result regarding the randomness of stock price of commercial bank in Nepal. Different test gives varying result. Auto-correlation test shows that share price of NBB, EBL and KBL as random and are efficient in weak form. Run test shows randomness of all share of commercial bank except EBL and NABIL. When tested with unit root test all of them were not random. Hence, the result is contradictory with different random walk tools. Same result can be seen for Nabil bank with all three test. It shows share price of Nabil is not random i.e. it is not efficient in weak-form. This means that investors can predict future price by using technical analysis and gain abnormal profit. Excess returns can be earned by using investment strategies based on historical share prices. Investors' lack of rationality and herd mentality, unequal information transmission, and accessibility to the general public could be the reasons for inefficiency. In the stock market, weak legislative frameworks, political influence, a smaller number of active investors, a lack of technology-friendly trading also contribute to inefficiency. Investor awareness with equal information accessibility and political stability, an effective legal framework, fully automated online trading and broker license to bank could be the measures to increase efficiency. Furthermore, enhancing efficiency can be achieved through raising investor awareness, making information more accessible, and lowering the cost of trading.

4.6 Major findings

The major findings of the study is explained as below:

- The mean daily return of majority companies (66.67 percent) centered within class interval of 0 to 0.05 percent and 8.33 percent bank lie within the range of 0.05 percent to 0.10 percent return interval which indicates that bank return involves low risk. This may have happened due to market size, technology, information and attitude of investors towards the risk.
- Finding shows that commercial bank doesn't follows the normal distribution, so it doesn't belong to the assumption of random walk model; hence are inefficient in weak form.
- The results of autocorrelation test of NBL, ADBL, NABIL, SCB, SBI, LBL, CZBIL, PCBL and SRBL shows that there is presence of auto-correlation.
- For EBL, KBL, and NBB there is no autocorrelation so they follow the random walk behavior and are efficient in weak form.
- Run tests with a base of mean and median both rejected the null hypothesis for NABIL and EBL but majority follows the random walk behavior for daily return.
- The finding of unit root test indicates that the daily returns have no unit root. In other words, commercial bank daily return series was stationary, i.e., not random.

CHAPTER V
DISCUSSION, CONCLUSIONS AND IMPLICATIONS

This chapter presents the brief summary of the entire study and highlights the major findings of the study. In addition, the major conclusions are discussed in separate section of this chapter which is followed by some implications.

5.1 Discussion

The mean daily return of majority companies (66.67 percent) centered within class interval of 0 to 0.05 percent and 8.33 percent bank lie within the range of 0.05 percent to 0.10 percent return interval which indicates that bank return involves low risk. This may have happened due to market size, technology, information and attitude of investors towards the risk. Finding shows that commercial bank doesn't follows the normal distribution, so it doesn't belong to the assumption of random walk model; hence are inefficient in weak form. The results of this study is consistent with other studies as well. Fama (1965) showed that the distribution of both daily and monthly returns of Dow Jones and New York Stock Exchange (NYSE) indices depart from normal distribution and are negatively skewed, leptokurtic and volatility clustered. Bekaeret (1998) provide evidence that 17 out of 20 emerging countries examined had positive skewness and 19 out of 20 had excess kurtosis, so that normal distribution was rejected for majority of the sample companies. Dangol (2011) showed that the distribution daily returns of Nepse, Sensex and Nifty index depart from normal distribution and are negatively skewed and slightly leptokurtic. Incomparision with Indian stock market Nepalese stock markets has less mean returns with less variance indicating that the Nepalese stock market involves low risk. Dangol (2010), Bhatta (2010), Dangol (2012), Ferando and Gunasekara (2018) concluded the same result. Risal and Koju (2021) concluded positive skewness , slightly leptokurtic of Nepse daily return from period 2010 to 2019.

The results of autocorrelation test of NBL, ADBL, NABIL, SCB, SBI, LBL, CZBIL, PCBL and SRBL shows that there is presence of auto-correlation so we can say that they don't follow the random walk behavior and are inefficient in weak form. For EBL, KBL, and NBB there is no autocorrelation so they follow the random walk behavior and are efficient in weak form. The study result is also consistent with the prior studies:

Chaudhuri (1991) of India, Alsayed (2016) of Dubai and Arora and Singh (2017) and Parulekar (2017) of india. But it contradict with the result of Dickinson and muragu (1994) of Kenya, Haque et.al (2011) of Pakistan. Similarly, in case of Nepal, the current study result is in consonance with GC (2010), Bhatta (2010), Dangol (2016), Dahal (2018), Dhungana (2020) and Rijal and Koju (2021). The run test shows that the successive return for NABIL and EBL is not independent at 1% percent significant level. But other remaining ten bank follows the assumption of independent return series. The return of NABIL and EBL indicates that they do not follow the random walk and the return is weak form of inefficient. Whereas the return of other remaining ten bank follow the random walk and the market is efficient because the p value is higher than the 1% level of significant.

Run tests with a base of mean and median both rejected the null hypothesis for NABIL and EBL but majority follows the random walk behavior for daily return. Hence they are efficient in weak form. In the context of Nepal, Bhatta (2010), GC (2010), Dangol (2010), Dangol (2012) and Dhungana (2020) rejected the presence of random walk. Alsayed (2016) reported inefficiency in the weak form. Dahal (2018) rejected the random walk hypothesis of NEPSE and its nine sectors for full study period and other sub-periods where prediction of future price is possible by using technical analysis. Other than that the study results of run tests are also similar to Chaudhuri (1991), Rahman and Hossain (2006), Gupta and Basu (2007), Worthington and higgs (2009, Alsayed (2016), Haque et. al (2011) , Hou and Sun (2014) and Parulekar (2017) also reported inefficiency in the weak form. The equity market is said to be efficient, when the return series follow random-walk behavior. Here out of 12, 10 shows that the stock prices are characterized by random-walk. Hence historical sequence of returns are irrelevant in predicting future stock prices and earning abnormal profits.

The finding of unit root test indicates that the daily returns have no unit root. In other words, commercial bank daily return series was stationary, i.e., not random. Hence it can be concluded that there is no evidence for weak-form efficiency. The study result is also consistent with the prior studies: Sunde and Zivanomoyo (2008) of Zimbabwe, Worthington and Higgs (2009) on Australian market, Alsayed (2016) of Dubai and Arora and Singh (2017). Similarly, in case of Nepal, the current study result is in consonance with Dangol (2010), GC (2010), Dahal (2018) and Dhungana (2020).

5.2 Conclusions

As per random walk theory, stock price changes have the same distribution and are independent of one another. It assumes that a stock price or market's historical movement or trend cannot be utilized to forecast its future movement. The efficient market hypothesis (EMH) had its genesis in the random walk theory of the movement of security prices. Weak form efficiency, semi-strong efficiency, and strong efficiency are the three categories of efficiency explained by EMH. It is expected that share price of commercial bank to be weak form efficient at least. The equity market is said to be efficient, when the return series follow random-walk behavior. As a result, this thesis is being written in order to better grasp the stock price efficiency of commercial bank. The researcher used the study period from 2011 to 2020. Four tools is used to determine the randomness of the stock price, including the unit root test, run test and autocorrelation test. The study gives mixed result regarding the randomness of stock price of commercial bank in Nepal. Different test gives varying result. Auto-correlation test shows that share price of NBB, EBL and KBL as random and are efficient in weak form. Run test shows randomness of all share of commercial bank except EBL and NABIL. When tested with unit root test all of them were not random. Hence, the result is contradictory with different random walk tools. Same result can be seen for Nabil bank with all three test. It shows share price of Nabil is not random i.e. it is not efficient in weak-form. This means that investors can predict future price by using technical analysis and gain abnormal profit. Excess returns can be earned by using investment strategies based on historical share prices. Investors' lack of rationality and herd mentality, unequal information transmission, and accessibility to the general public could be the reasons for inefficiency. In the stock market, weak legislative frameworks, political influence, a smaller number of active investors, a lack of technology-friendly trading also contribute to inefficiency. Investor awareness with equal information accessibility and political stability, an effective legal framework, fully automated online trading and broker license to bank could be the measures to increase efficiency. Furthermore, enhancing efficiency can be achieved through raising investor awareness, making information more accessible, and lowering the cost of trading.

5.3 Implications

Even though we live in an era of powerful communication technology, one way to understand the Nepalese stock market is that the price formation process may slowly transmit information. Furthermore, the contradictory result of the random walk hypothesis indicate a lack of intensive market regulation, and hence a regulatory shift could be beneficial. The stock price efficiency of commercial bank is necessary to make sound investment decisions. As a result, bias will be avoided, and saving and investments will be encouraged. Investors prefer to invest in a market that is efficient, meaning that stock prices adapt promptly to all available information. According to Fama (1965; 1970), in an efficient market, investors cannot generate extraordinary profits since they trade at their fair value. Investors, regulators, market makers, and policymakers will benefit from the findings of this thesis. The following are some of the implications:

- It allows researchers, investors, and practitioners to gain a better understanding of how share price of commercial bank behave and how much efficient they are.
- It helps investors who are interested in investing in share of commercial bank and construct an effective portfolio by allowing them to make reasonable and rational selections.
- It enhances market makers' and regulators' understanding of the performance and characteristics of commercial bank stock.
- When the market fairly values these stocks, it gives investors more confidence to buy/sell more stock. This is attributable to the efficiency of the stock market.
- It's also important for executives of commercial bank. Stock prices in an efficient market take into account the impact of management choices and try to increase shareholder wealth. As a result, managerial choices may be used to track the growth of shareholder wealth.
- This thesis also adds to the present literature on commercial bank investment by gaining a better knowledge of the random walk model in stock prices.

Further research is needed on the topic of random walk hypothesis (RWH) in Nepalese stock market. In order to have develop a more comprehensive study on EMH, future research should cater overall index and all other indices. Different techniques can provide different outcomes. As a result, future research should use additional statistical tools to investigate the RWH and EMH. Future study should also concentrate on the following topics: Anomalies in Nepalese equity markets, market timing and performance, corporate and social responsibility, regulatory and legislative landscape for Nepalese financial markets and institutions, risk management and stability of the Nepalese financial market.

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APPENDICES I

S.N	*Name*	*Operation Date (A.D.)*
1.	Nepal Bank Ltd.	1937/11/15
2.	Agriculture Development Bank Ltd.	1968/01/21
3.	Nabil Bank Ltd.	1984/07/12
4.	Nepal Investment Bank Ltd.	1986/03/09
5.	Standard Chartered Bank Nepal Ltd.	1987/02/28
6.	Himalayan Bank Ltd.	1993/01/18
7.	Nepal SBI Bank Ltd.	1993/07/07
8.	Nepal Bangladesh Bank Ltd.	1994/06/06
9.	Everest Bank Ltd.	1994/10/18
10.	Kumari Bank Ltd.	2001/04/03
11.	Laxmi Bank Ltd.	2002/04/03
12.	Citizens Bank International Ltd.	2007/04/20
13.	Prime Commercial Bank Ltd.	2007/09/24
14.	Sunrise Bank Ltd.	2007/10/12
15.	Century Commercial Bank Ltd.	2011/03/10
16.	Sanima Bank Ltd.	2012/02/15
17.	Machhapuchhre Bank Ltd.	2012/07/09*
18.	NIC Asia Bank Ltd.	2013/06/30*
19.	Global IME Bank Ltd.	2019/09/04*
20.	NMB Bank Ltd.	2019/09/28*
21.	Prabhu Bank Ltd.	2016/2/12*
22.	Siddhartha Bank Ltd.	2016/7/21*
23	Bank of Kathmandu Ltd.	2016/7/14*
24.	Civil Bank Ltd.	2016/10/17*
25.	Nepal Credit and Commerce Bank Ltd.	2017/01/01*
26.	Rastriya Banijya Bank Ltd.	2018/05/02*
27.	Mega Bank Nepal Ltd.	2018/05/13*

Source: Nepal Rastra Bank

*Joint operation date after merger.

List of bank and number of observations

Bank	*Number of observations*
NBL	1923
ADBL	2380
NABIL	2371
SCB	2382
SBI	2338
NBB	2300
EBL	2371
KBL	2184
LBL	2281
CZBIL	2376
PCBL	2378
SRBL	2373

APPENDICES III

In this table, the joint hypothesis that all the autocorrelation coefficients up to certain lags are simultaneously equal to zero is tested by using Ljung-Box Q-statistic. Any autocorrelation coefficient with * indicates the significant value indicating that the series is stationary (non-random) up to that lag.

	NBL			*ADBL*			*NABIL*		
Lag	*AC*	*Q-stat*	*Prob.*	*AC*	*Q-stat*	*Prob.*	*AC*	*Q-stat*	*Prob.*
1	0.031	1.843	0.175	0.073	12.724 ***	0.000	0.112	29.876 ***	0.000
2	-0.014	2.203	0.332	-0.052	19.138 ***	0.000	-0.053	36.581 ***	0.000
3	-0.030	3.912	0.271	-0.032	21.534 ***	0.000	-0.032	39.005 ***	0.000
4	0.080	16.124 ***	0.003	-0.018	22.305 ***	0.000	-0.014	39.463 ***	0.000
5	0.096	33.855 ***	0.000	-0.011	22.614 ***	0.000	-0.042	43.560 ***	0.000
6	0.041	37.088 ***	0.000	0.021	23.715 ***	0.001	-0.001	43.562 ***	0.000
7	-0.001	37.089 ***	0.000	0.012	24.084 ***	0.001	0.051	49.679 ***	0.000
8	0.002	37.097 ***	0.000	0.007	24.206 ***	0.002	0.026	51.317 ***	0.000
9	0.015	37.534 ***	0.000	-0.004	24.248 ***	0.004	-0.024	52.681 ***	0.000
10	0.018	38.155 ***	0.000	-0.021	25.284 ***	0.005	-0.026	54.237 ***	0.000
11	0.007	38.259 ***	0.000	0.037	28.528 ***	0.003	0.020	55.208 ***	0.000
12	-0.008	38.372 ***	0.000	0.002	28.537 ***	0.005	-0.009	55.396 ***	0.000

13	-0.013	38.683***	0.000	-0.002	28.543***	0.008	-0.030	57.479***	0.000
14	0.020	39.498***	0.000	-0.004	28.575	0.012	0.002	57.486***	0.000
15	0.018	40.096***	0.000	0.018	29.349	0.014	0.016	58.078***	0.000
16	-0.011	40.312***	0.001	0.006	29.438	0.021	-0.030	60.174***	0.000

Note: K: Number of lags, AC: Autocorrelation, Q-Stat: Ljung-Box Q Statistics, ***, **, * significant at 1%, 5%, and 10%, respectively.

In this table, the joint hypothesis that all the autocorrelation coefficients up to certain lags are simultaneously equal to zero is tested by using Ljung-Box Q-statistic. Any autocorrelation coefficient with * indicates the significant value indicating that the series is stationary (non-random) up to that lag.

	SCB			*SBI*			*NBB*		
Lag	AC	Q-stat	Prob.	AC	Q-stat	Prob.	AC	Q-stat	Prob.
1	0.051	6.215	0.013	0.073	12.332***	0.000	0.052	6.278	0.012
2	-0.052	12.736***	0.002	-0.064	21.905***	0.000	-0.004	6.310	0.043
3	-0.005	12.792***	0.005	0.009	22.082***	0.000	-0.015	6.821	0.078
4	0.024	14.210***	0.007	0.071	34.054***	0.000	-0.036	9.825	0.043
5	-0.016	14.854	0.011	-0.003	34.080***	0.000	0.005	9.883	0.079
6	-0.009	15.033	0.020	0.012	34.401***	0.000	0.008	10.036	0.123
7	0.051	21.308***	0.003	0.057	42.002***	0.000	0.011	10.331	0.171
8	0.024	22.682***	0.004	0.002	42.010***	0.000	-0.041	14.128	0.078

9	-0.013	23.068***	0.006	-0.051	48.006***	0.000	-0.015	14.667	0.101
10	-0.020	24.009***	0.008	0.006	48.099***	0.000	-0.029	16.568	0.084
11	0.055	31.250***	0.001	0.039	51.748***	0.000	0.038	19.970	0.046
12	-0.006	31.325***	0.002	-0.045	56.61***	0.000	0.022	21.115	0.049
13	-0.034	34.051***	0.001	-0.038	59.983***	0.000	0.002	21.125	0.070
14	-0.016	34.686***	0.002	-0.013	60.386***	0.000	0.034	23.864	0.048
15	0.026	36.260***	0.002	0.058	68.209***	0.000	0.008	23.995	0.065
16	-0.009	36.439***	0.003	-0.008	68.369***	0.000	0.021	24.993	0.070

Note: K: Number of lags, AC: Autocorrelation, Q-Stat: Ljung-Box Q Statistics, ***, **, * significant at 1%, 5%, and 10%, respectively.

In this table, the joint hypothesis that all the autocorrelation coefficients up to certain lags are simultaneously equal to zero is tested by using Ljung-Box Q-statistic. Any autocorrelation coefficient with * indicates the significant value indicating that the series is stationary (non-random) up to that lag.

	EBL			*KBL*			*LBL*		
Lag	AC	Q-stat	Prob.	AC	Q-stat	Prob.	AC	Q-stat	Prob.
1	0.052	6.353	0.012	0.047	4.893	0.027	0.094	20.157***	0.000
2	-0.035	9.207	0.010	-0.042	8.784	0.012	-0.023	21.399***	0.000
3	-0.020	10.165	0.017	-0.006	8.876	0.031	-0.043	25.654***	0.000

4	-0.040	13.885***	0.008	-0.014	9.292	0.054	-0.058	33.470***	0.000
5	-0.005	13.937	0.016	0.011	9.548	0.089	-0.081	48.310***	0.000
6	0.023	15.184	0.019	-0.006	9.634	0.141	-0.049	53.788***	0.000
7	0.031	17.439	0.015	0.032	11.925	0.103	0.006	53.870***	0.000
8	0.014	17.924	0.022	0.032	14.232	0.076	0.042	57.933***	0.000
9	-0.019	18.776	0.027	-0.006	14.317	0.111	-0.031	60.139***	0.000
10	-0.020	19.732	0.032	-0.024	15.625	0.111	0.027	61.871***	0.000
11	0.015	20.283	0.042	0.001	15.627	0.156	0.070	73.010***	0.000
12	-0.021	21.289	0.046	-0.014	16.063	0.188	0.021	73.981***	0.000
13	-0.019	22.190	0.052	-0.046	20.712	0.079	-0.006	74.051***	0.000
14	0.011	22.486	0.069	-0.012	21.033	0.101	0.004	74.088***	0.000
15	0.020	23.486	0.074	-0.004	21.071	0.135	-0.013	74.449***	0.000
16	0.010	23.708	0.096	0.034	23.602	0.099	-0.044	78.912***	0.000

Note: K: Number of lags, AC: Autocorrelation, Q-Stat: Ljung-Box Q Statistics, ***, **, * significant at 1%, 5%, and 10%, respectively.

In this table, the joint hypothesis that all the autocorrelation coefficients up to certain lags are simultaneously equal to zero is tested by using Ljung-Box Q-statistic. Any autocorrelation coefficient with * indicates the significant value indicating that the series is stationary (non-random) up to that lag.

	CZBIL			*PCBL*			*SRBL*		
Lag	AC	Q-stat	Prob.	AC	Q-stat	Prob.	AC	Q-stat	Prob.
1	0.087	17.986***	0.000	0.065	9.911***	0.002	0.081	15.415***	0.000
2	-0.022	19.101***	0.000	-0.051	16.114***	0.000	-0.037	18.659***	0.000
3	-0.012	19.426***	0.000	-0.008	16.249***	0.001	-0.038	22.169***	0.000
4	-0.020	20.361***	0.000	-0.011	16.542***	0.002	0.016	22.770***	0.000
5	-0.013	20.793***	0.001	0.003	16.566***	0.005	0.008	22.934***	0.000
6	0.040	24.626***	0.000	0.010	16.820***	0.010	0.023	24.244***	0.000
7	0.032	27.023***	0.000	0.043	21.324***	0.003	0.063	33.763***	0.000
8	0.029	28.984***	0.000	0.009	21.534***	0.006	0.004	33.797***	0.000
9	-0.016	29.565***	0.001	-0.063	31.053***	0.000	-0.019	34.633***	0.000
10	-0.011	29.864***	0.001	-0.024	32.427***	0.000	0.008	34.770***	0.000
11	0.002	29.874***	0.002	0.033	35.012***	0.000	0.017	35.446***	0.000
12	0.000	29.874***	0.003	-0.023	36.317***	0.000	-0.011	35.740***	0.000
13	0.021	30.954***	0.003	-0.025	37.867***	0.000	0.010	36.003***	0.001
14	-0.032	33.462***	0.002	0.011	38.153***	0.000	0.017	36.671***	0.001
15	-0.023	34.774***	0.003	0.024	39.539***	0.001	0.030	38.776***	0.001

16	-0.015	35.339***	0.004	-0.005	39.591***	0.001	0.015	39.289***	0.001

Note: K: Number of lags, AC: Autocorrelation, Q-Stat: Ljung-Box Q Statistics, ***, **, * significant at 1%, 5%, and 10%, respectively.