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# Random Walk Hypothesis: Evidence from Market Efficiency of the Zimbabwe Stock Exchange

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**Abstract:** ***This study examined whether the share prices of companies listed on the Zimbabwe Stock Exchange follow the Random Walk Hypothesis. The research was motivated by the fact that investors are interested in knowing whether past share prices have a propensity to forecast future share prices. The period covered by the research was January 2014 to December 2014. The main objective of the study investigated the possibility that share prices follow the Random Walk Hypothesis. The data was analysed using the Chi-square Test, the Runs Test and the Auto-correlation Test. The findings showed that changes in share prices on the ZSE refute the Random Walk Hypothesis. The study concluded that share price shifts follow some pattern or trend and that historical price changes can be used to predict future price movements. The study also concluded that the ZSE provides an opportunity for investors to create wealth as they take advantage of its weak-form inefficiency.***

**Keywords:** Zimbabwe Stock Exchange, Efficient Markets, Random Walk Hypothesis, Adaptive Markets Hypothesis, Weak-form inefficiency

## 1. Introduction

For many years, researchers in finance portrayed considerable interest in modelling share price behaviour and testing existing models. The product of their research efforts include the Random Walk Hypothesis (RWH) developed by Kendall (1953) and Fama (1965) who hypothesized that stock price movements are irregular and past prices are of no use in predicting future movements. According to Hin Yu Chung (2006), in statistical terms, the RWH test independence assuming that stock prices move randomly, follow a constant autoregressive pattern of order 1 and has unit roots showing very little or no correlation. Mabhunu (2004), concluded that studies on the RWH have resulted in various theoretical models and statistical analysis. However, notwithstanding the knowledge that has been accumulated so far from other stock markets on the RWH, the model still needs to be empirically tested on the ZSE.

Dupernex (2007) asserts that the acceptance of the RWH has since long been considered a basis for the EMH. The current stock price is an unbiased predictor of the future stock price allowing for a random error term. If today is period t, then the stock price in period t + 1 will be a game of chance implying that past information have no predictive capacity and that no abnormal returns can be continuously earned trading on past data in an efficient market.

As market efficiency increase, so does randomness and unpredictability of future share prices. In its greatest form of efficiency, a market's share price forms stochastically having a zero average change in price hence the path that future prices will follow is purely unexpected. Market efficiency manifests in three different ways which consists of weak, semi-strong and strong form. Weak form market efficiency exist when the existing stock prices reflect all factual data encompassed in past share prices. This means that adjustment of share prices to capture historic data is automatic. This implies that it is of no use to study both past share prices and technical analysis. In other words, no investor will have an advantage over others based on a study of past share price behaviour.

The validity of the theory or otherwise, is the basis for the use or refutation of technical analysis for forecasting share price behaviour by investors on stock markets. According to Xie (2011), the rejection of the RWH is due to chance or results from errors in the models used to test the hypothesis. This study therefore seeks to test the RWH using a different model from the ones that were previously used to test the model on the performance of the ZSE.

Insights from the concept of adaptive efficiency by Lo (2011, 2005a, 2005b) and Lim and Brooks (2006) as cited in the works of Nyangara and Mazviona (2013) justify the need to continuously test the RWH on the ZSE. The argument is that markets alternate between efficiency and inefficiency as opposed to the earlier claim of progressive market efficiency. This is because markets respond to changes in the economic, legal, political, technological, environmental and institutional variables.

Numerous researchers have studied the subject of market efficiency to determine if movement of share prices exhibit some random behaviour. Osborne (1959) established that changes in share prices happen in an accidental fashion. Another research by Dyckman and Morse (1986) reveal that the random behaviour relates to the direction and magnitude of the subsequent change in price at a chosen time in response to information existent at that particular time. This means that if a different time period is considered, results of the test may also vary i.e. the magnitude and direction of

share price change is not static since the determinant variable, information is dynamic. This provides another dimension from which to support this study. Despite past findings from ZSE market efficiency studies, it makes sense to investigate the RWH for the current period chosen for the study since the current period relate to current information which is different from the information that was available when other studies were done. It follows that the magnitude and direction of the deviation in share prices cannot remain the same hence there is a chance that the form of market efficiency may change as well.

The study is valuable to regulatory authorities, academia, stock brokers, and investors among other stakeholders of the ZSE. It shall particularly enlighten investors on whether they can employ technical analysis to predict future prices of shares from past share prices. The research provides an appraisal of capital market performance in an emerging economy. It also aids investors as they plan and structure their portfolios.

The current research seeks to specifically examine whether the ZSE is efficient in the weak form or not. This research therefore seeks to investigate the behaviour of share prices, whether they follow the Random Walk Hypothesis and hence determine whether present share prices are a function of past share prices. The main objective of this research is to determine the existence or non-existence of serial correlation on the ZSE using index and share price data of firms listed on the ZSE. This will be used as the basis for drawing conclusions on the efficiency of the ZSE and the basis for rejecting or accepting the usefulness of technical analysis to investors as they try to use trading strategies to consistently earn abnormal returns or profits.

This research work was limited to firms listed on the ZSE from 10 sectors, the mining index and the industrial index. These sectors are agriculture, retail, investment holding, conglomerate, food, beverages, telecommunications, financial, property and mining. The data and views shall be collected from these selected firms and be used in the analysis to determine whether share prices follow the Random Walk Hypothesis model. Market Efficiency literature has become extremely extensive and therefore the study only discusses the fundamental issues of weak form market efficiency as examined through the RWH. For the implementation of the study share price and index data was collected for the period January 2014 to December 2014.

**The Random Walk Model**

According to Prakash, Ajaya and Menezes (2012), the fundamental principle behind the Random Walk Hypothesis model are that consecutive changes in prices of specific stocks are individual securities are autonomous for a given period and that the actual price fluctuates randomly around the intrinsic value and the theoretical value. Therefore the random walk model address the question on whether future stock prices can be determined from past prices. The concept of a random walk explains a stochastic occurrence where consecutive changes in the price of a stock are independent and follow a normal distribution. That being the case, share price at time t, $P_t$ moves according to the following model:

$$P_t - P_{t-1} = e_t \quad (1)$$

For this study $P_t$ = share price in period t, $e_t$ is a stochastic component whose mean is zero and is taken autonomously at each time interval hence every change in P is stochastic as well. Allowing the model to drift by a constant *a*, at every point in time we have.

$$P_t = P_{t-1} + e_t + a \quad (2)$$

This shows that the general direction of the process depends on whether the constant *a* is negative or positive.

An attempt to test the RWH for share prices of companies listed on the ZSE was made by the researchers by examining the hypothesis that there is no pattern to consecutive price movements, that is, movements in share prices exhibit autonomous behaviour.

**1.1 Background of Study**

The Zimbabwe Stock Exchange consists of 64 listed firms, of which 60 are actively trading whilst four are suspended. Investment in any one of the 60 listed companies is represented by physical share certificates issued in the name of the investor. In other markets the physical share certificates have been replaced electronic share registers. Listed stocks are openly traded by the public at the stock exchange through stockbrokers. This means that they can change hands from one investor to the next as facilitated by the exchange. The market prices of these stocks rise and fall as market forces come into play. These prices are generally determined by the forces of demand and supply of a particular stock on that particular day. When buying a stock the investor anticipates that the price will go up. However there is no guarantee that this will happen, since the stock price can also fall. However it is desirable that the price rises above the purchase price as this means that the investor would have made a profit on his investment. The opposite becomes true when the price drops.

Generally, the stock prices go up when demand for buying that stock is high, and goes down when there is pressure from investors to sell. Investors want to take advantage of this volatility to make money out of the stock market. The ZSE is very critical as a platform for linking individual companies and investors to facilitate mobilisation of long term capital.

The main objectives of the study are:
To examine the veracity of the RWH for share prices of firms listed on the ZSE.

To examine the veracity of the RWH for the Mining and the Industrial Indices on the ZSE.

The RWH is a widely accepted test for efficiency of stock markets. This test can be applied to both companies and indices. Given a share price walks in a random fashion, then it is presumed that no investor can continuously make supernormal returns from their investments. Such conditions will only prevail in equilibrium when shares assume their

correct values. Refutation of the RWH means that an economy's capital prices are distorted.

The hypothesis to be tested are stated below
$H_0$: The share prices on the ZSE follow the Random Walk Hypothesis.
$H_1$: The share prices on the ZSE do not follow a Random Walk Hypothesis.

Abundant research on the RWH has been done in developed economies. Nevertheless, a significant number of researchers are shifting their attention to test the model on emerging markets as well. This is due to the critical role that efficient markets have played in promoting the expansion of the financial sector and economic development. Market efficiency leads to fair distribution of economic capital. Better economic policies, both macro and micro may also be set which facilitate suitable corporate agreements.

## 2. Research Models

Predicting the performance of stock markets can be done using two main approaches which gave birth to modern financial theory. These are:

**a) The Random Walk Hypothesis**
The RWH is considered part of the EMH and most researchers who want to test the EMH, test the RWH. A good comprehension of how prices are set in competitive capital markets establish this relationship. The RWH was developed by Kendall (1953) building on the work of the early 20th century writer Bachelier. Kendall used a sample of 22 indices and collected weekly stock market data in series. His analysis led to the conclusion that it is impossible for anyone to consistently predict stock market performance. His findings show that stock prices are a nomadic series. Osborne (1959) produced similar work where he noted that stock prices are ever moving. Roberts (1959) did further research on the RWH and made the same conclusion further explaining that price changes that are not random are insignificant to the extent that it is difficult to exploit them and make profit. This implies that both technical analysis and fundamental analysis can never assist an investor as strategies for earning returns above what the market offers as later explained by Fama in (1965). In this work, Fama propounded the idea of independence in successive share prices. If they are independent the RWH is substantiated but if they are dependent, the RWH is refuted.

The majority of studies on the Random Walk Hypothesis model focussed on developed economies, where majority of the share prices follow the random walk. Developed financial markets as a whole have proved that they follow either the Random Walk Model or weak-form efficient market hypothesis (EMH).

**b) Efficient Market Hypothesis model (EMH) (Jenson 1978; Samuelson 1965).**
The EMH propose that present stock prices is a fair and true reflector of the full set of information known about firm value. EMH address most basic and interesting subjects in finance on the cause for price fluctuations in capital markets and how they fluctuate. It presents introduction of new information as the most determinant of share price fluctuations. Fama (1970) was the first researcher to use the term Efficient Market after a thorough review of both empirical and theoretical literature complemented by an empirical study of stock prices all of which made it apparent that markets are efficient.

Explaining the EMH in one of his books, Fama (1976) posits that market efficiency relates to quick and unbiased incorporation of new information into existing prices to give current prices. That being the case, all existing information at any particular moment, whether known or unknown, is instantaneously assimilated into the current security price. As a result, it is out of wrong motives that investors believe that securities are overvalued or undervalued. Those who expect security prices to increase in the future believe they are currently undervalued hence they buy them. Those who expect securities to sell cheap in the future believe that they are currently overvalued hence they sell them. Their hope is to outdo the market and take home above average returns.

Nevertheless, dealers, financial managers, brokers and investors need to understand the consequences of market efficiency. The case in efficient markets is that securities are always accurately priced since prices change to reflect new information well before investors could execute trades based on that information at a profit regardless of how fast the investors react to the new information. Prices adjust as new information appear.

Researchers made a comprehensive review of most previous studies that tested the Random Walk Hypothesis on various markets around the world.

**Evidence from Developed Stock Markets**
Kendall (1953), Fama (1970) and many other researchers focussed their studies on first world countries where their empirical evidence show that developed financial markets are efficient in the weak form. However, another class of researchers give contradicting conclusions (Poterba and Summers, 1989), yet they provide no evidence of successful use of technical analysis in predicting future stock prices. As a consequence stock exchanges in developed economies exhibit weak form efficiency.

Voluminous literatures are available on studying the behaviour of share prices over time. The subject still receives substantial attention. Couple of prominent studies have been reviewed in this research. Using several correlation tests Kendall (1953), Moore (1962), Cootner (1962) and Fama (1965), support the Random Walk Hypothesis. According to these studies it was established that, autocorrelation coefficients calculated for consecutive movements in stock prices incredibly approach zero, implying that the successive changes in prices are independent. Zhu (1998) through panel unit root tests for G-7 countries arrived at the same conclusion that stock price changes are independent. Narayan and Smith (2006) found strong support for the RWH for 15 countries in Europe.

On the other hand, several autocorrelation tests refute the RWH (Lo and McKinlay, 1999; Fama, 1995, 1976; Fama and French, 1988). Some studies occupy the middle of the continuum giving mixed findings. Zivot and Andrew (1992) found that stock prices of 10 countries out of 18 countries are weak form inefficient, whereas the remaining 8 are efficient.

**Evidence from Developing Stock Markets**

Evidence from developing countries contradicts that from developed markets. Stock market research evidence from Latin America and Asia shows different findings. Tests of the RWH on Bombay Stock Exchange by Sharma and Kennedy (1977) show that successive stock prices are independent. On the other hand, research studies on Shanghai and Shenzhen stock markets and Less Developed Countries (LDCs) stock markets reject the RWH, (Groenwold et al, 2003; Mookerjee and Yu, 1999; Errunza and Losq 1985). However, Urritia (1995) provided mixed evidence for Argentina, Brazil, Chile and Mexico. Results from the Runs Test validate the RWH while the variance ratio test results reject it. Tabulated below are some of the researches done on emerging markets.

**Table 2.1:** RWH evidence from emerging market economies

| Country | Stock Exchange | Researchers | Year | Conclusion |
|---|---|---|---|---|
| Malaysia | Kuala Lumpur Stock Exchange | Mun et al<br>Branes | 2008<br>1986 | Rejected the RWH |
| Sri Lanka | Colombo Stock Exchange | Wickremasinghe<br>Abeysekera | 2007<br>2001 | Rejected the RWH |
| Bangladesh | Dhaka Stock Exchange | Hossain<br>Ahmad<br>Mobarek &Keasey | 2004<br>2002<br>2000 | Rejected the RWH |
| India | Mumbai Stock Exchange | Gupta & Basu<br>Udyog<br>Poshakwale | 2007<br>2004<br>1996 | Rejected RWH |
| Pakistan | Karachi Stock Exchange | Irfan et al<br>Chakraborty<br>Hussain, | 2010<br>2006<br>1996 | Rejected the RWH |

Source: Vitali and Mollar (2010)

It can be seen, from Table 2.1 above, that research activity on emerging markets started around the 1900s and increased in the 2000s. Here are some research evidence from developing markets in the Middle-East, part of Europe and part of Africa. Smith and Ryoo (2003) found that stock markets in Slovakia, Poland, Hungary and the Czech Republic are weak form efficient. However, for the same stock markets in the same countries, conclusions made by Gilmore and MacMaanus (2003) reject the RWH. Likewise Gandhi et al, (1980) refuted the RWH based on conclusions made from a study done on the Kuwait Stock Exchange. Studies by Dahel and Labaas (1999) showed that stock markets in Saudi Arabia, Oman and Bahrain are weak-form inefficient except for Kuwait stock exchange.

Stock markets in Turkey, Morocco, Jordan, Israel and Egypt produce evidence that contradicts the RWH with the exception of Israel's Tel Aviv Stock Exchange, (Omran and Farrar, 2005) from statistical analysis of sequential stock price data. Al-Khazali, Ding and Pyun (2007 tested the RWH on North African and Middle Eastern stock markets. They employed two methods which are Variance Ration test for non-parametric data by Wright (2000) and the runs test used when data follows a binomial distribution. They manipulated the share price data to correct for limited trading activity on the markets (where the orders executed on the market are too small such that they do not accommodate large trades) and found out that the stock prices follow a random walk.

Empirical research in Africa on stock markets is still shallow in comparison to other developing economies. Tests of the RWH on the Johannesburg Stock Exchange (JSE) prove that the stock market is efficient in the weak form, (Thomson and Ward, 1995). Further research work on the JSE confirm earlier findings on weak-form efficiency, while they rejected the null hypothesis for other stock markets in Africa, (Simons and Laryea, 2005; Jefferis and Smith, 2005; Smith, Jefferis and Ryoo, 2002; Magnusson and Wydick, 2002). Some additional evidence from Smith (2008), Mollah (2007) and Appiah-Kusi and Menyah (2003) reinforce prior conclusions that a majority of African stock markets are not weak-form efficient. Researcher used a number of different methodologies; both statistical and non-statistical. Among other methods, variance ration tests were a common statistical methodology.

An overview of empirical studies available from African equity markets are tabled below:

**Table 2.2:** An overview of empirical studies available from African developing countries

| Country | Conclusion | Author(s) |
|---|---|---|
| Kenya | Stock prices follows the RWH | Magnusson and Wydick, 2002; Dickinson and Muragu 1994 |
| | Stock prices do not follow the RWH | Smith 2008; Jefferis and Smith 2005; Appiah-Kusi and Menyah , 2003; Smith, Jefferis and Ryoo,2002, |
| Nigeria | Stock prices follows the RWH | Jefferis and Smith 2005; Appiah-Kusi and Menyah , 2003; Magnusson and Wydick, 2002; Olowe, 1999 |
| | Stock prices do not follow the RWH | Smith 2008; Smith, Jefferis and Ryoo,2002 |
| Egypt | Stock prices follow the RWH | Lagoarde-Segot and Lucey, 2008; Jefferis and Smith 2005 |
| | Stock prices do not follow the RWH | Smith 2008; Al-Khazali, Ding and Pyun, 2007; Simons and Laryea, 2005; Appiah-Kusi and Menyah , 2003; Smith, Jefferis and Ryoo,2002; Mecagni and Sourial , 1999 |
| Mauritius | Stock prices follows the RWH | Jefferis and Smith 2005; Appiah-Kusi and Menyah , 2003; Magnusson and Wydick, 2002 |

| | | |
|---|---|---|
| | Stock prices do not follow the RWH | Smith 2008; Simons and Laryea, 2005; Smith, Jefferis and Ryoo,2002; Bundoo,2000 |
| Ivory Coast | Stock prices follows the RWH | Appiah-Kusi and Menyah , 2003; Magnusson and Wydick, 2002 |
| | Stock prices do not follow the RWH | Smith 2008 |
| Ghana | Stock prices follows the RWH | Appiah-Kusi and Menyah , 2003; |
| | Stock prices do not follow the RWH | Smith 2008; Simons and Laryea, 2005; Magnusson and Wydick, 2002 |
| South Africa | Stock prices follows the RWH | Simons and Laryea, 2005; Jefferis and Smith 2005; Appiah-Kusi and Menyah , 2003; Magnusson and Wydick, 2002; Smith, Jefferis and Ryoo,2002 |
| | Stock prices do not follow the RWH | Smith 2008 |
| Morocco | Stock prices follows the RWH | Jefferis and Smith 2005; Magnusson and Wydick, 2002 |
| | Stock prices do not follow the RWH | Smith 2008; Lagoarde-Segot and Lucey, 2008; Al-Khazali, Ding and Pyun, 2007; Appiah-Kusi and Menyah , 2003; Smith, Jefferis and Ryoo,2002 |
| Botswana | Stock prices follows the RWH | Appiah-Kusi and Menyah , 2003; Magnusson and Wydick, 2002 |
| | Stock prices do not follow the RWH | Smith 2008; Mollah 2007; Smith, Jefferis and Ryoo,2002 |
| Swaziland | Stock prices follows the RWH | Appiah-Kusi and Menyah , 2003 |
| | Stock prices do not follow the RWH | Smith 2008; Smith, Jefferis and Ryoo,2002 |
| Tunisia | Stock prices do not follow the RWH | Lagoarde-Segot and Lucey, 2008, Al-Khazali, Ding and Pyun, 2007 |

Source: Vitali and Mollar (2010)

Mixed results are available on most African stock markets as shown above. In some instances, researchers made different conclusions on market efficiency in the same period maybe because of different methods used. Furthermore, some stock markets were found to alternate from efficiency to inefficiency in different periods. However, generalisations can be made for some countries. The South African stock market is more efficient in the weak form while Tunisia is a weak-form inefficient market.

### 2.3 Focussed Literature Review

The stock market is one investment option where firms' shares are publicly bought and sold. The stock prices are largely driven by forces of demand and supply which influence the upward or downward movement of prices on a daily basis. From empirical research, it has been ascertained that financial markets are central drivers of economic growth and significantly contribute to economic welfare of entire world. Without exception, the ZSE can fuel growth in the Zimbabwean economy as long as sufficient players have sufficient capital to invest on the bourse.

The ZSE links business owners to public investors. The ZSE is a formal platform for the legal buying and selling of shares and stocks of listed companies. It stimulates trust in financial markets by public investors especially if it attains market efficiency. Investors will be assured of positive yields from invested stocks and shares. In accordance with the ZSE Act, that is what the stock market is mandated to do.

**Table 2.3:** Previous Studies on Zimbabwe Stock Exchange Market Efficiency

| Author(s) and Year | Period Covered | Conclusions |
|---|---|---|
| L. Chikoko & W. Muparuri (2013) | Feb 2009 to Jan 2012 | Weak-form inefficient |
| D. Nyangara and B. W. Mazviona (2012) | 2009 Feb to 2012 June | Weak-form inefficient |
| P. Jecheche (2012) | 08/01/2010 to 29/07/2011 | Weak form efficient |
| T. Sunde & J. Zivanamoyo (2008) | Jan 1998- Nov 2006 | Weak-form inefficient |
| C. Mlambo and N. B. Biekpe (2007) | 02 Jan 1997 to 31 May 2002 | Weak form efficient |
| G. Smith 2008 | January 2000 to September 2006 | Weak-form inefficient |
| K. Jefferis and G. Smith 2005 | early 1990s to June 2001 | Weak-form inefficient |
| J. Appiah-Kusi and K. Menyah , 2003 | 1992 to 1998 | Weak-form inefficient |
| M. A. Magnusson and B. Wydick, 2002 | various periods ending in 1998 | Weak-form inefficient |
| G. Smith, K. Jefferis and H. Ryoo,2002 | January 1990 - August 1998 | Weak-form inefficient |
| J. Zivanomoyo (2011) | January 1994 to November 2002 | Weak-form inefficient |

A number of researches (more than 10) were done on the ZSE to test the RWH as shown in Table 2.3 above. A majority of these studies concluded that the ZSE is inefficient in the weak form except two studies by Mlambo and Biekpe in 2007 and Jecheche in 2012. This evidence seem to suggest that the ZSE is sometimes weak-form efficient though it appears that it is weak-form inefficient most of the time.

Critique and Evidence against the Random Walk Hypothesis
Some research evidence and evidence from investment analysts dispute the RWH with the support of both theoretical and empirical analysis. Malkiel. Burton, a popular advocate of the universal acceptability of EMH showed some reservations commenting on stock markets in developing economies. He refuted the EMH for the Chinese stock markets; the Shenzhen and Shanghai through empirical analysis. Nevertheless, he still maintained that US stock market exhibit no significant evidence of stock price manipulation.

A research paper by Andrew Lo and Craig Mackinlay in the late 1990s, challenged the EMH arguing that random walks in stock prices never happened and they will never be there.

They compiled all evidence that was available by then into a research paper to lend academic credence to their argument. Initially, the world of academia took time to accept the idea of non-random walk. After two years, the work started to be considered with further research done (Canegrati, 2008; Eitelman and Vitanza, 2008; Lo and Craig 2002, Brown 2002; Fromlet, 2001) to reinforce the idea of non-random walk of stock prices.

Candidates of Keynesian economics and the Adam Smith School who argue for irrational behaviour by investors reject the EMH. Among other strong opponents are Warren Buffet, Michael Green and Mathew Bishop. They believe that good fund managers and investment analysts can outperform the market due to skill as opposed to mere luck as proposed by the EMH. What is known as irrationality in the behaviour of investors have consistently earned positive returns for such investors in several cases.

## 3. Research Methodology

### 3.1 Sample Population

The ZSE is divided into two sectors which are Mining and Industrial. According to the Zimbabwe Stock Exchange Booklet May Overview (2012) the Industrial sector is further divided into ten sectors which are Agriculture, Financial, Insurance, Food, Beverages, Telecommunications, Conglomerate, Investment Holding, Property and Retail. The researchers chose at least one firm to represent each of the 10 sectors which are actively trading. In addition the researchers used the Mining and Industrial Indices. Stock price return data for this study consists of daily closing price quotations for the period January 2014 to December 2014.The firms chosen from each respective sector are listed in the Table 3.1 below.

**Table 3.1:** Firms from the different sectors in the survey that were used in the study

| No | Firm | Sector |
|---|---|---|
| 1 | Ariston | Agriculture |
| 2 | OK Zimbabwe Ltd | Retail |
| 3 | Barclays | Financial |
| 4 | Innscor | Conglomerate |
| 5 | Dairiboard | Food |
| 6 | Delta | Beverages |
| 7 | Econet | Telecoms |
| 8 | Rio Zim | Mining |
| 9 | Dawn Properties | Property |
| 10 | Old Mutual | Insurance |

Source: Zimbabwe Stock Exchange May Overview 2012

### 3.2 Sources of Data

A variety of sources provided data for the study. Secondary data was collected from a mixture of financial journals, working papers, textbooks and the internet. Share price data and index data used for this study was obtained from FBC Securities' database.

### 3.3 Methods of Data Analysis

The Null Hypothesis was tested according to Elton and Gruber (1975) using the revised version of the RWH which can be tested.

$$\ln P_t = \ln P_{t-1} + e_t \quad (3)$$

Where E ($e_t$) = 0, Cov (et, $e_{t-s}$) = 0, all s = 0 if the random walk is true

$P_t$ is value of a stock in period t and $e_t$ is a series of residuals.

From equation (3) above a change of subject of formula will give $e_t$ as:

$$\ln \frac{Pt}{Pt-1} = e_t \quad (4)$$

The Elton and Gruber model only investigate linearity of logarithmic changes in prices. In addition, the testable form of the RWH may destroy the heteroskedasticity property of present and past share prices resultantly leading to a stationary series. By design, logarithmic transformations help convert non-stationary data to stationary data. This is because non-stationary data is difficult to work with due to spurious regression.

According to Chaudhuri (1991) if simple price $\frac{Pt-Pt-1}{Pt-1}$ changes are considered, the variability of little movements in a share price series increasingly depend on the level of prices, (Moore, 1964). This would make the distribution of the historical price changes unstable, thereby violating the assumption of stationarity of price series.

Multiple literature sources support logarithmic transformations because

a) Transforming by taking logarithms share price changes compounds the value of the daily returns
b) Transforming help to even out effects of level of prices on the series since the ultimate size of price changes depends on level of prices.
c) change of logarithmic prices approximate percentage price change for small movements in stock prices

If a series is to satisfy The Random Walk Model it should satisfy the two important statistical properties of normality and independence.

#### 3.3.1. Test for Normality

**Chi-squared Test**

Normality in the distribution of data is a basic requirement when using statistical tests on parametric data. Prior to the application of statistical tests, it should be verified that parametric data is normally distributed. Due to this important property, parametric tests are more authoritative as compared to non-parametric tests. For similar sample sizes, very small variability in data can be easily detected through parametric tests if data is normally distributed. Similarly, changes in smaller samples can be easily identified using parametric tests yet the counterpart non-parametric tests cannot do this. The Chi-squared Test is employed in this study to verify the normality assumption.

It is generally accepted that the Chi-squared Test is able to properly fit data unlike other normality tests like the Kolmogorov- Smirnov Test. Hence it has attracted wide

usage. Based on such properties, the Chi-squared Test was considered appropriate for this study. With limited data points, the Kolmogorov- Smirnov Test can be comfortably used since the Chi-squared Test is inappropriate for such circumstances.

### 3.3.1 Independence Tests

After testing for normality, it becomes necessary to test for independence. When a test passes Chi-squared Test, it does not automatically follow that the data is not serially correlated. Fama (1965) points out that stochastic independence is an indispensable property in market efficiency studies as it is the basis for refuting or validating the RWH. If independence is detected in a stock price series, the RWH is upheld yet if successive changes in prices are dependent, the RWH is repudiated. RWH tests are premised on the assumption that a series of stock returns is normally distributed. If the series does not conform to this property, its transformed version of logarithms of price changes or differencing will make it a normal series.

The test for linear independence of log price changes has been carried out using the Runs Test and Autocorrelation tests. They provide evidence on whether successive stock prices are related or not. Put differently, Auto-correlation tests and the Runs Test investigate if the share price series data exhibit an unpredictable pattern hence determining if the ZSE satisfies the EMH. Autocorrelation tests are most suitable on parametric data while the Runs test is ideal on non-parametric data. However, these two statistical techniques were both employed in this study so that they can complement one another as the weaknesses of one approach are offset by the benefits of using a second approach.

**i) Auto- Correlation Test**

It is a parametric test for detecting non-randomness sometimes inferring from autocorrelation between successive share prices. In other words, the auto-correlation co-efficient is a measure of independence (lack of auto-correlation) between a stock price value at time t and its $k^{th}$ lag. The autocorrelation coefficient of the lagged value k times earlier is estimated by the following expression.

$$r_k = C_k / C_{o1} \quad (5)$$

where;

$C_k = 1/N^{N-K}(P_t - P)(P_{t+k} - P)$ k = 0, 1.....k

$C_k$ - estimates auto-covariance and P measures the expected value of the time series.

Lags used to calculate autocorrelation coefficients take the following values; $1 \leq k \leq 10$. The lags were measured in days to investigate if there is any relationship between a stock price on day t and another price on day t + 1. If the RWH is valid, individual lagged autocorrelation coefficients must be very close to zero and the size and sign of the coefficient ought to follow no discernible pattern.

**ii) Runs Test for the weak form efficiency**

A Runs Test is another commonly used measure for independence in a stochastic process. Nonetheless it differs from the Autocorrelation test in that it is non-parametric implying that it is not premised on the assumption that share prices have a constant variance and that the series follows a normal distribution. It looks for patterns of increasing or decreasing values. To the relationship of sequential price changes, the Runs Test was employed to ascertain how frequent a time series change values in a given direction. More precisely, the Runs Test was used to test serial independence in the share prices hypothesising mutual independence of successive price changes. Acceptance or rejection of the hypothesis will indicate whether the series is random or not. Assuming a random series, the mean number of runs should equal the numerical value of runs observed to detect independence. In this case, randomness implies independence whereas non-randomness in a sign of dependence. The following formula was used.

$Z = R - x/p$

Z = normal variate

R = sum of observed runs

$X = 2\,n_1n_2 + 1/n_1 + n_2$

$\rho = \frac{\sqrt{2}\,n_1n_2\,(2\,n_1n_2 - n)}{n^2(n-1)}$

$n_1$ = sum of positive runs

$n_2$ = sum of negative runs

$n = n_1 + n_2$

The value of Z is taken to be significant if it satisfies the inequality $-1.96 < Z < +1.96$. If Z is significant, then the price series forms in a random manner. If the value of Z falls out of the range given by the above inequality, successive share prices do not follow a random pattern.

**Statistical Packages**

SPSS package was used to aid the analysis of the data

## 4. Data Presentation and Analysis

### 4.1 Findings

Normality tests were done first before the Autocorrelation test and the Runs Test. The Chi-square test for normality produced the results tabulated below from SPSS statistical analysis. In Table 4.1., the Chi-square value is calculated from logarithms of share prices and given in column two for each of the ten companies and indices in column one.

**Table 4.1:** Chi-square values

| *Company/Index* | *Chi-Square Value* | *Degrees of freedom* | *p-value* |
|---|---|---|---|
| Ariston | 184.586 | 11 | .000 |
| OK | 580.311 | 32 | .000 |
| Barclays | 508.765 | 26 | .000 |
| Innscor | 338.661 | 54 | .000 |
| Dairiboard | 361.135 | 33 | .000 |
| Delta | 651.418 | 82 | .000 |
| Econet | 315.582 | 83 | .000 |
| Rio Zim | 403.988 | 17 | .000 |
| Dawn | 400.215 | 14 | .000 |
| Old Mutual | 683.940 | 61 | .000 |
| Industrial | 11.948 | 239 | 1.000 |
| Mining | 148.873 | 143 | .351 |

Source: SPSS

Chi-square critical values are calculated and tabulated in column 3 of Table 4.2 below. If the critical value is greater than the Chi-square value computed above, then the share price series is normally distributed. If it is less than the Chi-square value, the share price series does not conform to a normal distribution.

**Table 4.2:** Chi-square Test for Normality

| No | Firm | $\|\chi^2_{calc}$ | $\|\chi^2_{critical}$ | Remark |
|---|---|---|---|---|
| 1 | Ariston | 184 > | 19.675 | not normally distributed |
| 2 | OK | 580 > | 48.379 | not normally distributed |
| 3 | Barclays | 509 > | 41.923 | not normally distributed |
| 4 | Innscor | 339> | 74.420 | not normally distributed |
| 5 | Dairiboard | 361 > | 49.376 | not normally distributed |
| 6 | Delta | 651 > | 108.629 | not normally distributed |
| 7 | Econet | 316 > | 109.210 | not normally distributed |
| 8 | Rio Zim | 404 > | 30.191 | not normally distributed |
| 9 | Dawn | 400 > | 26.119 | not normally distributed |
| 10 | Old Mutual | 684> | 84.298 | not normally distributed |
| 11 | Industrial | 12 < | 154.320 | normally distributed |
| 12 | Mining | 149> | 148.230 | not normally distributed |

The data for all the firms and Mining Index was found not to be normally distributed, but data for the Industrial index was found to be normally distributed. For firms whose data is normally distributed, Autocorrelation tests are the next logical test to perform to test for independence. For those whose data is not normally distributed, the Runs Test is most appropriate. However, Kendall (1948) and Moore (1962), argued that it is not unusual to assume near normality for the sake of employing both Autocorrelation tests and Runs tests on the same data. This would require a large number of observations. Hence from Kendall and Moore's position, the researchers used both tests for all the sample elements of the study sample. Daily observations for a period of a year were considered large enough.

### 4.3 Runs Test

The hypothesis for the Runs Test has been stated as follows:

$H_{0:}$ the price series was formed in a random fashion (i.e. $H_0$: Share prices of firms on the ZSE follow the Random Walk Hypothesis)

$H_{1:}$ the price series was not formed in a random fashion (i.e. $H_1$: The share prices of firms on the ZSE do not follow the Random Walk Hypothesis)

Significance Level: 5% (1.96)

Decision criterion: If the value of $|Z| > Z_\alpha$ the Runs Test rejects $H_{0.}$ If it falls below, there is no ground for rejecting the null hypothesis.

Given a sufficiently large sample, where the values of $n_1$ and $n_2$ are greater than 10, the standard normal distribution table is used to verify the probability that a test statistic value fall below or above the critical Z score. This means that with 95% confidence, a test statistic whose value exceeds 1.96 shows non-randomness.

The Runs Test output data from SPSS statistical analysis comparing both the test statistic values to the critical values are tabulated in Table 4.1 below.

**Table 4.1:** Runs Test results

| No | Firm | \|Z\|-value | Critical \|Z\|-value | Remark |
|---|---|---|---|---|
| 1 | Ariston | 14.443> | 1.96 | Non-Random/Dependent |
| 2 | OK | 13.440 > | 1.96 | Non-Random/Dependent |
| 3 | Barclays | 14.221 > | 1.96 | Non-Random/Dependent |
| 4 | Innscor | 15.242 > | 1.96 | Non-Random/Dependent |
| 5 | Dairiboard | 14.969 > | 1.96 | Non-Random/Dependent |
| 6 | Delta | 14.989> | 1.96 | Non-Random/Dependent |
| 7 | Econet | 15.369> | 1.96 | Non-Random/Dependent |
| 8 | Rio Zim | 15.047> | 1.96 | Non-Random/Dependent |
| 9 | Dawn | 14.562 > | 1.96 | Non-Random/Dependent |
| 10 | Old Mutual | 14.707 > | 1.96 | Non-Random/Dependent |
| 11 | Industrial | 14.989 > | 1.96 | Non-Random/Dependent |
| 12 | Mining | 14.989 > | 1.96 | Non-Random/Dependent |

The results in Table 4.1 above show that the sequence of the share price data formed in a non-random fashion. This shows that there is a relationship between successive prices in a sequence. This means the share prices of firms on the ZSE do not follow the RWH.

### 4.4 Auto-correlation

To cross check the validity of results from the Runs Test, autocorrelation plots for various lags were constructed. The upper and lower confidence limits were plotted at 95 % confidence levels. The plots indicate that the bars or points (correlation coefficients at each lag) are outside the upper and lower limits implying statistically significant values of correlation coefficients. Statistically significant values provide evidence of non-randomness. The auto correlation diagrams for the firms and the two indices are shown in Figure 4.1 to Figure 4.12 below.

#### 4.4.1 Auto-correlation Plots SPSS Output

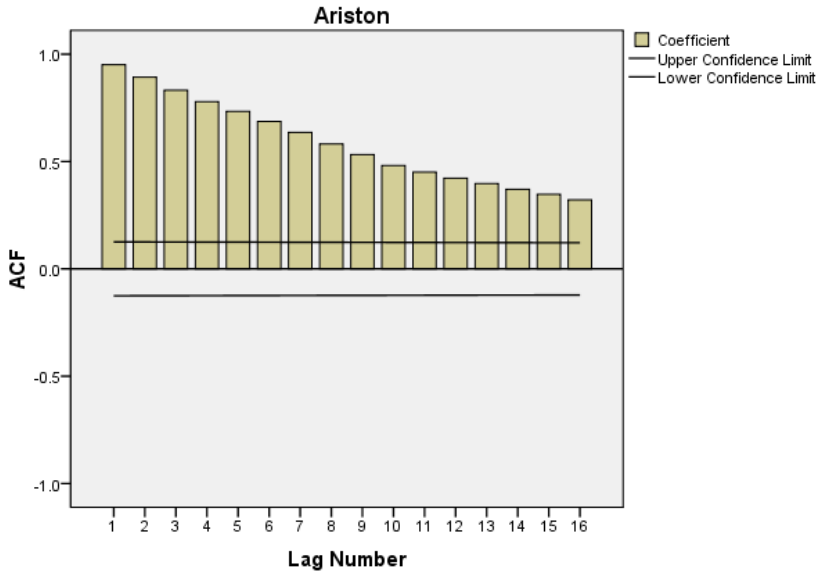


**Figure 4.1:** Auto-correlation Plot for Ariston

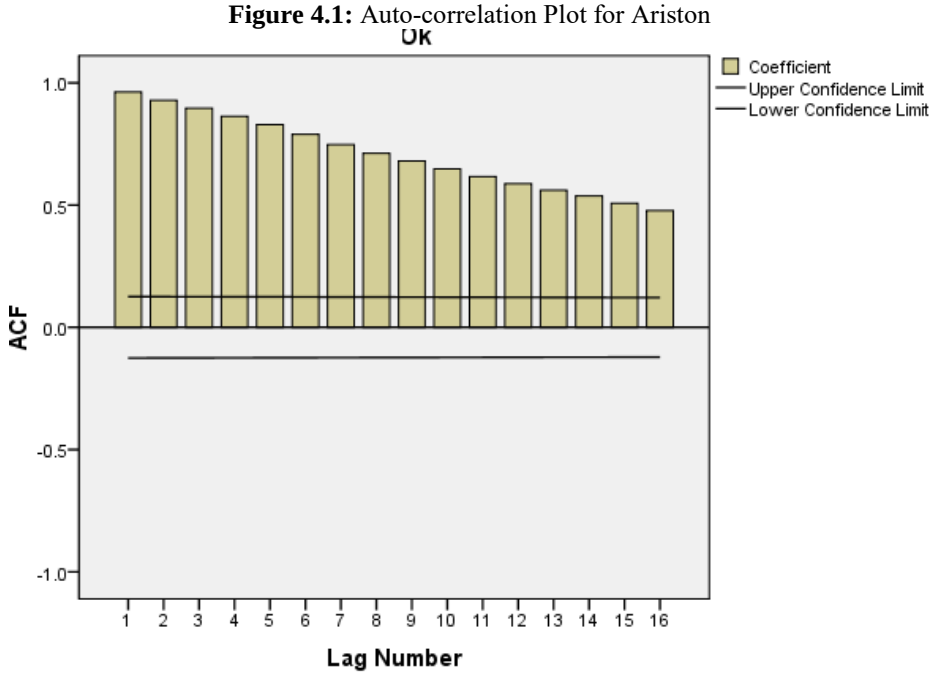


**Figure 4.2:** Auto-correlation Plot for OK

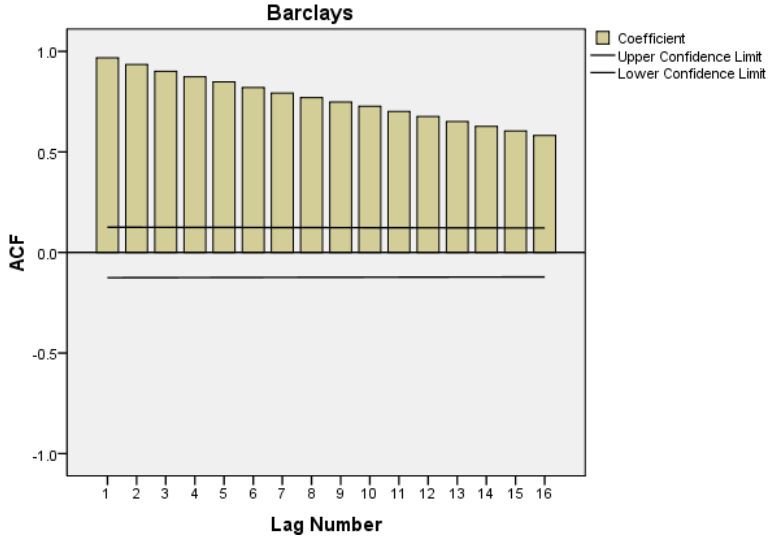


**Figure 4.3:** Auto-correlation Plot for Barclays

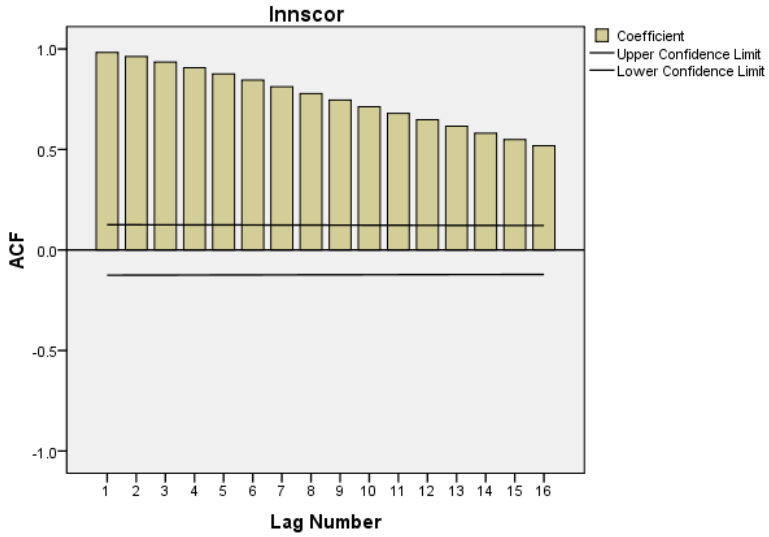


**Figure 4.4:** Auto-correlation Plot for Innscor

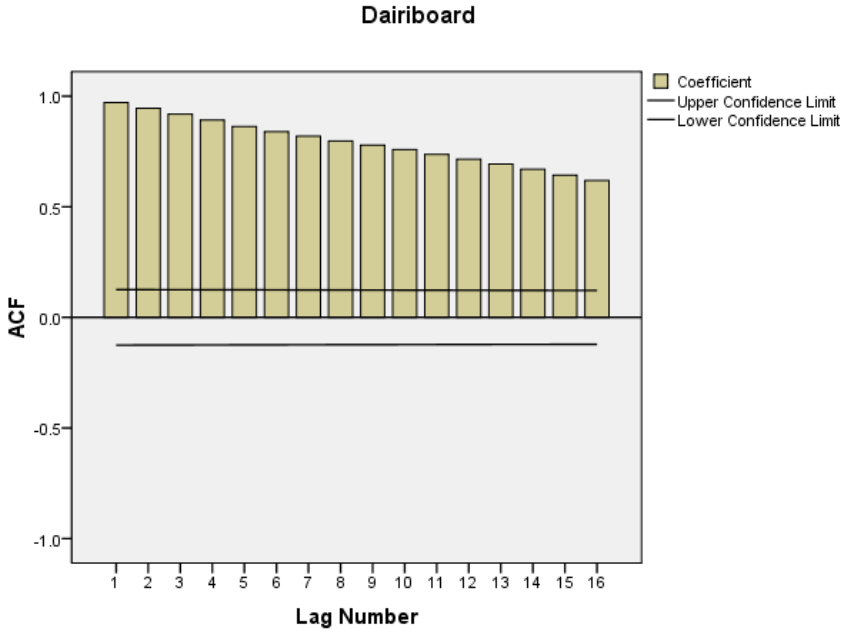


**Figure 4.5:** Auto-correlation Plot for Dairiboard

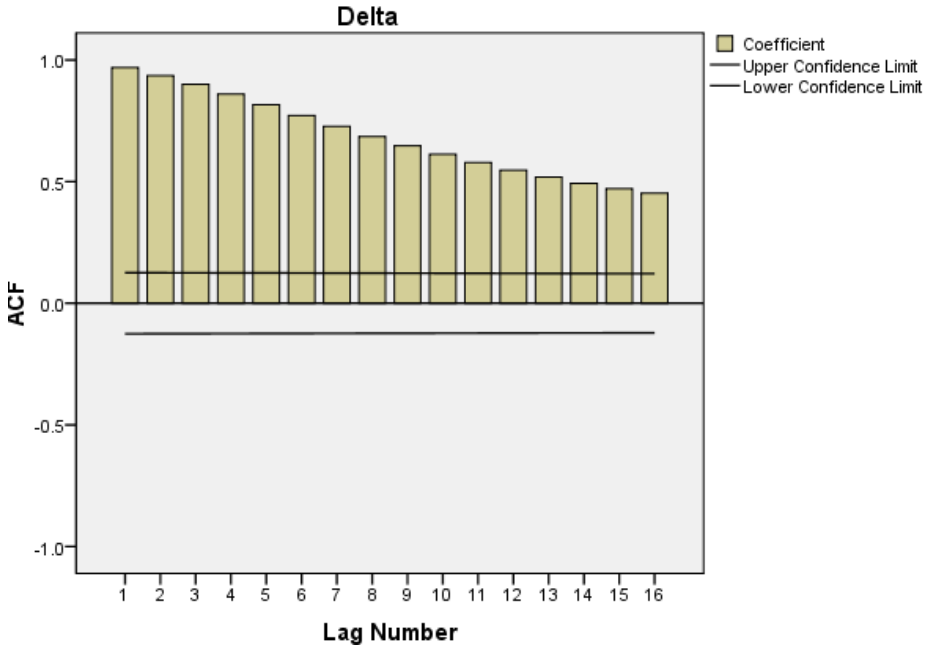


**Figure 4.6:** Auto-correlation Plot for Delta

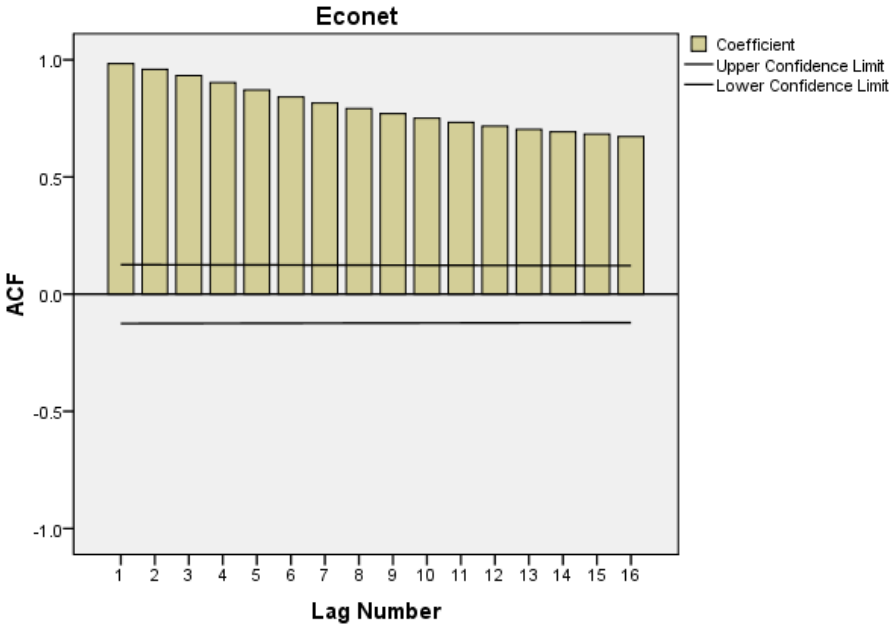


**Figure 4.7:** Auto-correlation Plot for Econet

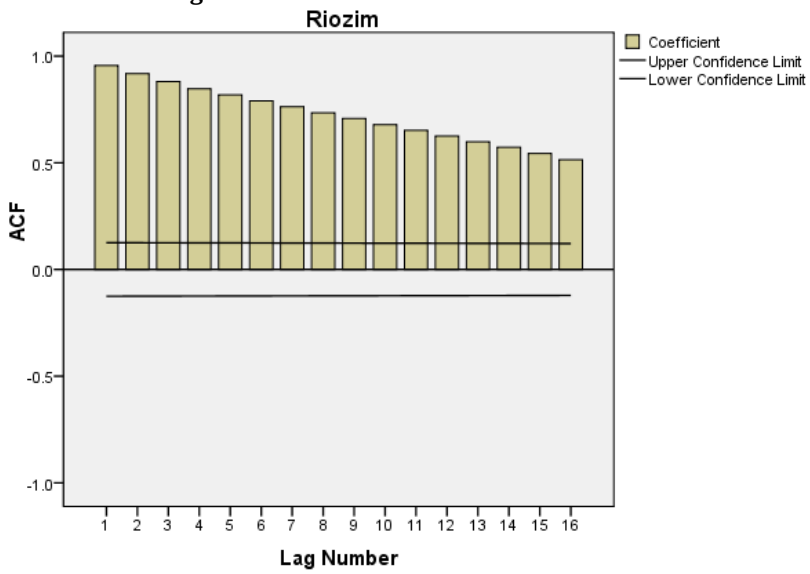


**Figure 4.8:** Auto-correlation Plot for Riozim

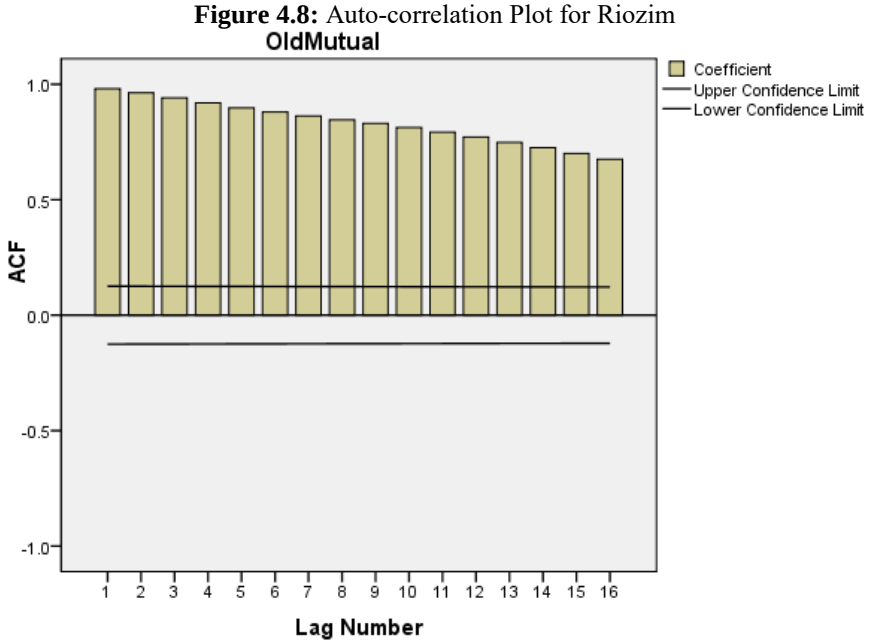


**Figure 4.9:** Auto-correlation Plot for Old Mutual

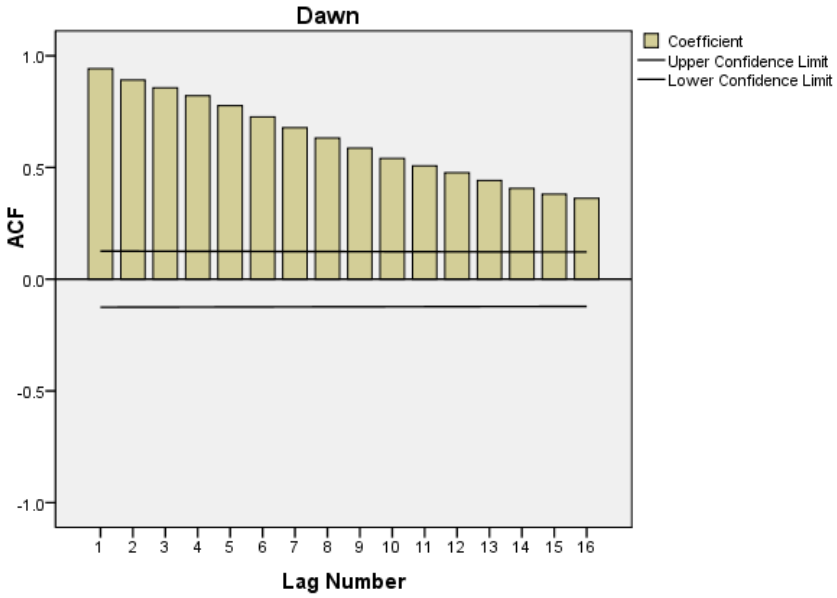


**Figure 4.10:** Auto-correlation Plot for Dawn

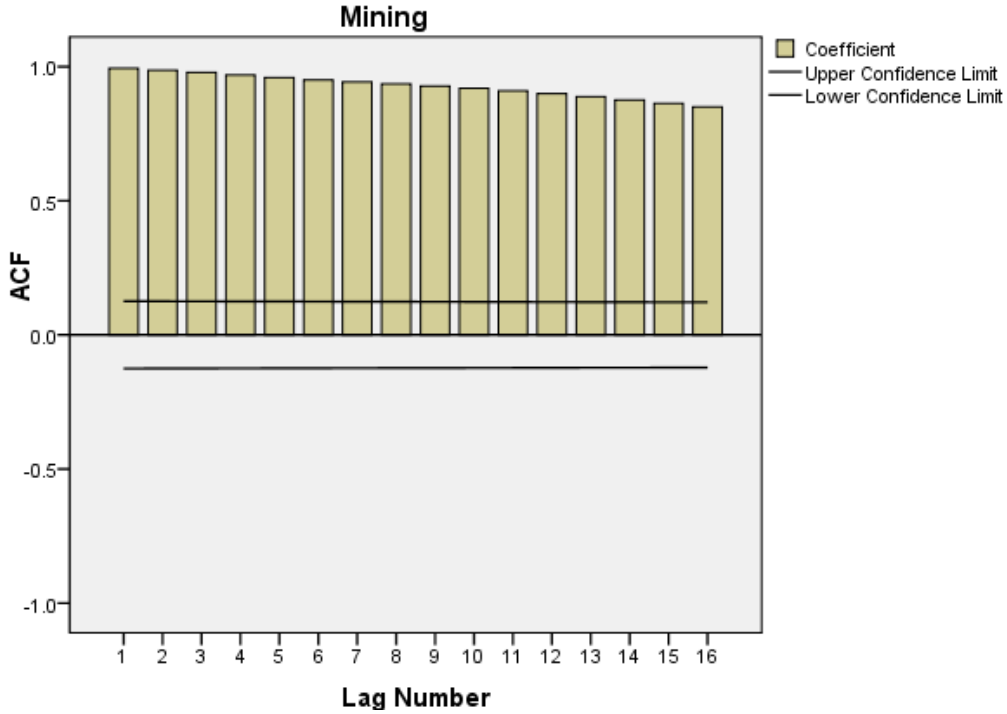


**Figure 4.11:** Auto-correlation Plot for the Mining Index

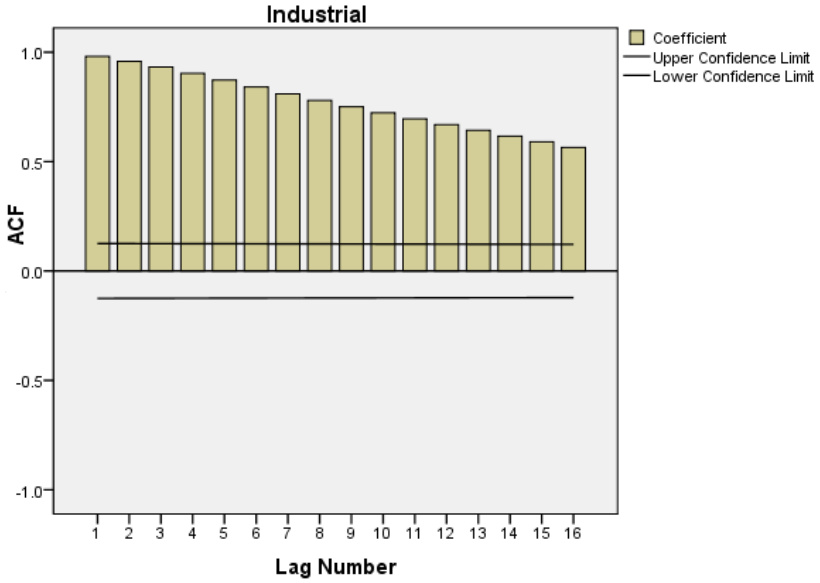


**Figure 4.12:** Auto-correlation Plot for the Inustrial Index

Source: SPSS

All firms, the industrial index and the mining have significant correlation coefficients, so the correlograms of all the firms and the indices confirm that ZSE share prices are not independent. This shows that they do not follow the RWH hence the stock market is weak form inefficient. This means that technical analysis can be used by investors to earn above average returns. This conclusion reaffirms the empirical findings of past researchers on the ZSE, (Chikoko and Muparuri, 2013; Nyangara and Mazviona, 2012; Sunde and Zivanamoyo, 2008; Smith, 2008; Jefferis and Smith, 2005; Appiah-Kusi and Menyah, 2003; Magnusson and Wydick, 2002; Smith, Jefferis and Ryoo, 2002; Zivanomoyo, 2011). However, there seems to be some evidence of cyclicality behaviour with the ZSE alternating from inefficiency to efficiency since some researchers concluded that the ZSE is weak form efficient, (Jecheche 2012; Mlambo and Biekpe, 2007). Assuming all the conclusions are right, the ZSE is an inefficient market most of the time and it is rarely weak-form efficient.

## 5. Conclusions and Recommendations

Researcher drew conclusions and made recommendations based on the analysis and interpretations made to the data above.

### 5.1 Conclusions

The study sought to enlighten investors and shareholders if stock prices on the ZSE follow the Random Walk Hypothesis model. This was necessitated by the claim that markets alternate between efficiency and inefficiency in response to environmental conditions, nature and number of active participants in the market (the Adaptive Markets Hypothesis), (Lo, 2005). The study covered a one year period from January 2014 to December 2014. The study sample consisted of ten firms and two indices from ten sectors on the ZSE. The main objective of the study were to test the validity of the RWH of share prices of firms on the ZSE using the following hypotheses:

$H_0$: The share prices on the ZSE follow the Random Walk Hypothesis**.**
$H_1$: The share prices on the ZSE do not follow the Random Walk Hypothesis.

This study employed two statistical techniques, one parametric and one nonparametric, to test the null hypothesis and determine the extent to which findings from each test are comparable. The data was analysed using the Chi-square Test to determine the normality of the data. The results showed that for the 10 firms and the Industrial Index under study, the data was not normally distributed yet it was for the mining index. The non-parametric Runs Test was used to test for randomness. The results in the Runs Test showed that all the Z-values for the 10 firms, the Mining and Industrial Indices are greater than the critical value of 1.96, meaning the data does not follow the Random Walk Hypothesis. The data for all firms was also tested for independence using the Auto- correlation test. The parametric Autocorrelation test also showed that the share prices are not independent. Both methods confirmed that share prices on ZSE do not follow the Random Walk Hypothesis model. The researchers concluded that the alternative hypothesis is true and rejected the null hypothesis.

Theory asserts that if the RWH is valid, then successive price changes will follow no particular trend or pattern. This implies that historic prices have no potential to predict future prices. The Random Walk Hypothesis is also known as the Efficient Market Hypothesis. The weak form of the EMH postulates that stock prices instantaneously adjust to incorporate all information contained in past share prices. Believing this, all securities are correctly priced always. Hence buy orders executed on the assumption that shares are undervalued and sell orders executed on the assumption that share prices are overvalued will not earn investors above normal returns. This means that technical analysis will be of no use.

However, as stated above, the ZSE is weak form inefficient as results from Runs tests indicate non-randomness and those from Autocorrelation tests show dependence between sequential share prices. It is therefore concluded that from January 2014 to December 2014, market prices of shares rarely coincided with their fundamental values. This means that they were sometimes overvalued or undervalued. Hence historic share prices on the ZSE were proven to have a propensity to predict future share prices. Researchers used that basis to argue that the ZSE does not follow the RWH and rejected the null hypothesis. The implication is that investors can use technical analysis skills to earn above normal returns on the bourse.

The above conclusion together with past conclusions on the form of market efficiency of the ZSE brings the Adaptive Markets Hypothesis under scrutiny.

### 5.3 Recommendations

The researchers therefore recommend that another research be carried out on the ZSE to formulate models to forecast shares prices so that investors can take advantage of the weak form inefficiency to create wealth.

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