UNIVERSITY OF CAPE COAST

TESTING THE WEAK FORM MARKET EFFICIENCY OF SELECTED AFRICAN STOCK MARKETS

BY

ISAAC ADOBAW

Thesis submitted to the Department of Economics of the Faculty of Social Sciences, University of Cape Coast in partial fulfilment of the requirements for the award of Master of Philosophy degree in Economics

NOVEMBER, 2014

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Name: Isaac Adobaw

Signature:………………………. Date:…………….………………

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Name: Dr. James Atta Peprah

Signature:……………………………… Date……………………………..

Co-Supervisor's Name: Dr. Isaac Bentum-Ennin

Signature:……………………………….. Date…………..…………………

ABSTRACT

The ability of African stock markets to operate effectively depends on their level of informational efficiency. This study tests the weak form efficiency of six African stock markets which comprised three smaller and three larger stock markets.

Using monthly and weekly stock market returns series from 1995 to 2013, the study tested the degree of weak form market efficiency by employing unit root tests, run test and the more robust Wright's variance ratio test. By employing a general autoregressive conditional heteroscedasticity (GARCH) approach with time varying parameters on the monthly stock market returns series, a test of evolving efficiency which captures gradual changes in efficiency was carried out.

The results shows that the three larger markets used in the study, Egypt, South Africa and Zimbabwe, were found to be weak form efficient. Among the smaller markets used in this study, Mauritius was found to be weak form efficient while Ghana and Nigeria were not weak form efficient. In order to improve efficiency of African stock markets, securities and exchange commissions of stock markets in Africa are encouraged to set up information dissemination institutions to enhance the dissemination of information relating to stock market.

ACKNOWLEDGEMENTS

It is a great honour for me to work on this topic and I feel glad having accomplished this task. Along with my sincerity and interest, there are people, who really helped me to make this work a success. First, I would like to pass my appreciation and gratitude to my honourable supervisor and co supervisor Dr James Atta Peprah and Dr Isaac Bentum-Ennin respectively. Their suggestions and ideas in every step of my work helped me a lot to write this thesis. Professor Paul Alagidede, I cannot hide my appreciation for your invaluable contribution to the success of this work. Your beautiful desire to see young African minds grow saw you go to the ends of the world to get all that I asked for, most especially, the data for the study. I am very grateful for your service.

I ask the blessings of God on my beloved siblings, Joseph Adobaw and Abraham Adobaw, whose selfless attitude opened financial doors to support this study. You guys are special. To my sweet mum, Mama Deborah, I say God bless you so much for your constant prayers and support. Janet Hayford, you will always remain a darling. Your emotional and psychological support is irreplaceable. I pray my God to give you every desire of your heart. Finally I say a big thank you to all and sundry who contributed one way or the other for the success of this study. God bless you all.

DEDICATION

To my big brothers, Joseph and Abraham

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AMH	Adaptive Market Hypothesis
ARIMA	Autoregressive Integrated Moving Average
ASEA	African Securities Exchanges Association
ATS	Automated Trading System
BDS	Brock, Dechert and Scheinkman
BSE-SENSEX	Bombay Stock Exchange Sensitive Index
BVMAC	Bourse Regionale des Valeurs Mobilieres d'Afrique Centrale
BVRM	Bourse Regionales des Valeurs Mobilieres
CAPM	Capital Asset Pricing Model
CDS	Central Depository System
CMA	Capital Markets Authority
CSCS	Central Securities Clearing System
CSE	Casablanca Stock Exchange
CSE-MPI	Colombo Stock Exchange Milanka Price Index
DEM	Development and Enterprise Market
DJIA	Dow Jones Industrial Average
DSI	Databank Stock Index
EGX	Egyptian Stock Exchange
EMH	Efficient Market Hypothesis
ETF	Exchange-Traded Fund

FTSE	Financial Times Stock Exchange
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GBP	British Pound
GCB	Ghana Commercial Bank
GDP	Gross Domestic Product
GMM	Generalized Methods of Moments
GNP	Gross National Product
GSE	Ghana Stock Exchange
GSE-CI	Ghana Stock Exchange Composite Index
GSE-FSI	Ghana Stock Exchange Financial Stock Index
IFC	International Finance Corporation
IID	Independently and Identically Distributed
INID	Independently but not Identically Distributed
IPO	Initial Public Offering
JET	Johannesburg Stock Exchange Equities Trading
JSE	Johannesburg Stock Exchange
KSE	Karachi Stock Exchange
DSE-GEN	Dhaka Stock Exchange General Indices
LSE	London Stock Exchange
MENA	Middle East and North Africa
MSCI	Morgan Stanley Capital International
MUR	Mauritian Rupee
MVR	Multiple Variance Ratio
NIID	Not Independently and not Identically Distributed

NSE	Nigeria Stock Exchange
OLS	Ordinary Least Squares
OTC	Over-the-counter
PP	Philips-Perron
RW	Random Walk
S&P	Standards and Poors
SAFEX	South African Futures Exchange
SEM	Stock Exchange of Mauritius
SEMATS	Stock Exchange of Mauritius' Automated Trading System
SETS	Stock Exchange Trading Systems
STRATE	Share Transactions Totally Electronic
SMM	Standardized Maximum Modulus
USc	United States cents
USD	United States Dollar
VR	Variance Ratio
WFE	World Federation of Exchanges
ZAR	South Africa Rand
ZSE	Zimbabwe Stock Exchange

CHAPTER ONE

INTRODUCTION

Background to the study

Stock markets are a vital component for economic development as they provide listed companies with a platform to raise long-term capital and also provide investors with an avenue for investing their surplus funds. Stock markets therefore encourage investors with surplus funds to invest them in additional financial instruments that better match their liquidity preferences and risk appetite. Better savings mobilization may increase the savings rate, and in turn spur investments and earn investment income to the owners of those funds.

The number of African stock markets has been growing steadily over the last three decades rising from eight before 1989 to twenty-nine as at 2013 and plans are on the drawing board to open new stock markets in Congo D.R., Equatorial Guinea, Ethiopia, the Gambia, Lesotho, Madagascar, Mauritania and Sierra Leone (Ntim, Opong, Danbolt, & Dewotor, 2011). Kenny and Moss (1998) suggests that this dramatic growth in the number of stock markets in Africa can be attributed to the financial sector reforms which took place during the era of economic reforms in Africa. Most of these markets were formed at the instigation of government to act as vehicles to privatize state-owned enterprises (Mlambo & Biekpe, 2007; Moss, 2003).

The growth in stock markets in the African economies has reflected the increased demand for such transactions and the lower costs of investing in international markets. According to 1999 International Finance Corporation

(IFC) statistics, from 1989-1998 the number of developing countries with actively trading stock markets increased from 31 to 78 and the number of domestic companies listed on emerging market stock indices rose over 300 percent from 8,709 to 26,354, and market capitalisation in the emerging markets increased by 256 percent to US$1.91 trillion (Magnusson & Wydick, 2002).

Dailami and Atkin (1990) describe the provision of liquid capital to finance domestic capital formation as a major factor for long-term economic growth in developing countries. The authors observe that the reality of low levels and reducing supply of foreign funds relative to demand from traditional sources, such as commercial banks, gives maximum room for governments in many developing countries to pay increased attention to capital market development as a way of improving domestic resource mobilization, enhancing the supply of long-term capital and encouraging the efficient use of existing capital assets.

As economies grow and develop, more funds are needed to meet the rapid pace of growth and development and the stock markets serve as a veritable tool in the mobilization and allocation of savings among competing uses which are critical to the growth and efficiency of the economy. Stock market liquidity again helps to reduce the downside risk and cost of investing in projects that do not pay-off for a long time. With a liquid market, the initial investors are not denied access to their savings for the duration of their investment project because they can quickly and easily sell their stake in a company as noted by (Bencivenga & Smith, 1991).

Stock markets provide a vehicle for mobilizing foreign savings and/or international investment for developmental purpose. Again, stock markets provide investors the necessary opportunities to diversify their portfolios across a variety of assets (Simons & Laryea, 2006). In 2012 the South African bond market recorded a huge foreign portfolio investment, with such inflows accounting for the bulk of the financing of the current account deficit. There were also sizable inflows into bond markets in several frontier economies, including Ghana and Nigeria (International Monetary Fund, 2013a). The development and efficiency of the African stock markets is more likely to boost economic growth and provide a good future for African economies.

In spite of the rapid growth in the number of stock markets in Africa, stock markets in Africa (with the exception of South Africa) remain rather underdeveloped compared to their counterparts in developed and other emerging markets (WFE, 2008). Crucially, they remain extremely thinly traded and illiquid with very comparatively low market capitalizations (Mlambo & Biekpe, 2007).

The ability of African stock markets to operate effectively depends on their level of informational efficiency (Smith, Jefferies & Ryoo, 2002). This raises a crucial policy question as to whether African stock markets can improve their informational efficiency by integrating their operations.

However most African stock markets are not weak form efficient, that is, the stock prices do not follow a random walk process and therefore it is possible to study patterns in past prices to enjoy capital gains from purchase and sale of stocks. A market following a random walk is consistent with equity being appropriately priced at an equilibrium level, whereas the absence of a random walk infers distortions in the pricing of capital and risk (Worthington and Higgs, 2004). Studies by Appiah-Kusi and Menyah (2003) reveal that the Batswana, Ghanaian and the Ivorian stock markets are not weak form efficient while Olowe (1999) and Smith and Jefferies (2005) concluded from their study that the Nigerian Stock market and Johannesburg Stock Exchange of South African are weak form efficient respectively.

According to Simons and Laryea (2006), inefficiencies within the African stock market can be attributed to thin trading as stocks trading these markets are non-synchronous causing trading volume to be low. Again thin trading provides room for manipulation by insiders at the expense of other investors. Other reasons could be market imperfections (information asymmetry), lax disclosure requirements and high real cost of capital. It is important, therefore, that stock markets in developing countries are able to pass as least the lowest hurdles of speculative efficiency.

In spite of the macroeconomic challenges facing the continent, the performance of the African stock markets has been impressive in recent times. The Ghana stock exchange (GSE), with a U.S. dollar return of 144 percent, outperformed 61 markets around the world surveyed by Databank Financial Services Limited to be adjudged the world's best performing stock market in 2004. In that same year, Uganda, Kenya, Egypt, Mauritius and Nigeria were among the best performers (Yartey & Adjasi, 2007).

Statement of the problem

An efficient stock market has little or no friction in its trading process. The smooth level of transaction given an efficient market provides a vehicle for mobilizing savings and investment resources for development (Simons & Laryea, 2006). Since the establishment of efficient market hypothesis (EMH) by Fama (1970), a number of empirical studies have been undertaken to determine the degree of efficiency mainly in developed economies (Beechey, Gruen, & Vickery, 2000; Dockery & Vergari, 1997; Fama, 1970).

However, few studies have been conducted on developing economies like those of Africa on the subject of capital market efficiency partly due to paucity of data (Simons and Laryea 2006). Among the few exceptions are (Simons & Laryea (2006); Mlambo and Biekpe (2007), Olowe (1999) and Osei (2002). To achieve a higher level efficiency, passing the previous level of efficiency becomes a prerequisite. That is, in order to perform a semi-strong form test of market efficiency, the market understudy should first pass the weak form market efficiency. Semi-strong form market efficiency test is a prerequisite for strong from market efficiency test. African markets are known not to be weak form efficient. Therefore this study among other studies tests the weak form market efficiency of some African stock market.

The prior studies on the efficiency of African stock markets offer contradictory results (Dickinson & Muragu, 1994; Ntim et al, 2008; Parkinson, 1984). A plausible explanation is that most of the extant African studies use conventional techniques such as autocorrelation tests and unit root tests, whose robustness have been questioned elsewhere (Hsieh, 1991; Ntim et al 2008; Savit, 1988).

With the increasing importance of emerging African markets, both in terms of size and number, the need for reliable evidence on their informational efficiencies is particularly important. First, unlike their developed counterparts, African countries have fledgling economies in which market efficiency still has significant developmental implications. Second, African stock markets, with the exception of South Africa, have low correlations with global stock markets (Moin, 2007). This offers portfolio diversification opportunities for international investors (Ntim et al, 2008).

Again, all previous studies employed tests which lead to the inference that a stock market either is or is not weak form efficient. Gradual changes in stock market efficiency over time are not captured. It seems implausible that a relatively new emerging stock market is equally efficient over the whole of its history. When a market first starts trading, it takes time for the price discovery process to become known. As markets operate and market microstructures develop, emerging stock markets are likely to become more efficient (Cornelius, 1993).

Smith and Jefferies (2005) and Hall, Urga and Zalewska-Mitura (1998) employed a general autoregressive conditional heteroscedasticity (GARCH) approach with time varying parameters, a test of evolving efficiency and found out that stock markets which were at one time inefficient in the weak sense tended to move towards efficiency in the course of time while others diverged further from efficiency. Given that stock markets undergo transition from weak form inefficiency to weak form efficiency in the course of time or diverge further away from efficiency, especially for developing ones, the degree of efficiency may not be constant but dynamic.

Furthermore, several institutional reforms to make stock market more effective have been carried out over the past decade in a many African stock markets. Most African stock markets have employed more efficient trading, clearing and settlement systems between 2001 and 2013. Again several stock markets in Africa now publish more than a single index compared to the period before the 2000's. However, no studies have been conducted in Africa to illustrate evolving efficiency of African stock markets since the study by Smith and Jefferis (2005) who performed a test of evolving efficiency for seven African stock markets using data from 1990 to 2001.

This study implements this test of evolving efficiency over time for six African stock markets namely the Egyptian Stock Exchange (EGX), Ghana Stock Exchange (GSE), Stock Exchange of Mauritius (SEM), Nigeria Stock Exchange (NSE), Johannesburg Stock Exchange Ltd (JSE) and the Zimbabwe Stock Exchange (ZSE) using data between 1995 and 2013.

Objectives of the study

The general objective is to test the weak form market efficiency for six African stock markets.

The specific objectives of the study are to:

- Examine the time series properties of stock returns.
- Test the weak form market efficiency for each of the six stock markets
- Illustrate gradual changes towards weak form market efficiency in each of the African stock markets.

Research hypotheses

Given the objectives of the study the following research hypotheses will be tested.

1. H_0: Returns on African stock markets follow a normal distribution and are less volatile.

   H_A: Returns on African stock markets do not follow a normal distribution and are more volatile.

2. H_0: African stock markets are individually efficient in the weak form.

   H_A: African stock markets are individually not efficient in the weak form.

3. H_0: African stock markets individually experience changes in their efficiency through time.

   H_A: African stock markets individually do not experience gradual changes in their efficiency through time.

Significance of the study

The study is expected to be of immense benefit to researchers (both in academia and practitioners), investors (institutional and individual), potential investors, policy makers, experts, professionals and students, in understanding the degree of weak form market efficiency among the selected African capital market. Students will be afforded the privilege to broaden their scope of knowledge about African stock markets and the efficient market hypothesis. Potential investors will gather enough from this study to assist them in choosing which African stock market to invest in as this study throws light on returns and market efficiency of African stock markets. Policy makers will benefit from policy recommendations in this study even as it reveals potent measures in improving stock market efficiency. Again the study will add to the stock of knowledge on the tendency of African stock markets to experience gradual changes toward weak form market efficiency through time.

Scope of the study

This study tests the weak form market efficiency of six stock markets in Africa. The study illustrates the evolution of market efficiency through time. The research is restricted to nation-wide stock indices from which stock market returns are calculated. The analysis of this study is done using weekly and monthly stock price returns. The study covers the period from 1995 to 2013.

Organization of the study

The research work is organized into six chapters. Chapter one presents the introductory background to the research topic. It presents the statement of the problem, objectives of the study, hypotheses to be tested, significance of the study, as well as scope of the study. Chapter two provides a background on stock markets in Africa in terms of their history, progress over time, impact and current trends while chapter three reviews some theoretical and empirical literature on market efficiency (especially weak form market efficiency); a critique of the various literature as well as presents a summary of the major findings of the literature review. The methodology of the study is presented in chapter four. It covers the research design, model specification, estimation technique, estimation problems, evaluation methods, choice and measurement of the relevant variables, database of the study, sample size and procedure and data analysis.

Chapter five looks at the empirical analysis of the results and discussion of the study. This is followed by a test of the stated hypotheses at a significant level. The discussion includes interpretations of the findings in relation to previous findings from literature. Finally, chapter six presents a summary, conclusion and recommendations of the study based on the results and findings as well as directions for future research and limitations of the study.

CHAPTER TWO

THE AFRICAN STOCK MARKETS

Introduction

This chapter presents the state and nature of stock markets in Africa in terms of their history, progress over time, impact and current trends. Also, this chapter takes a look at the Ghanaian, Nigerian, Zimbabwean, Egyptian, Mauritian and South African Stock Markets. The chapter further sets the tone for empirical literature on African stock markets presented in chapter three.

General characteristics of African stock markets

African Economies have growth prospects and perceptions of Africa among investors are becoming more distinctly positive over the long-term horizon with capital investments there set to reach $150billion by 2015. (Capital Markets Authority, 2010). There has been a considerable development in the African capital markets since the early 1990s. Prior to 1989, there were just five stock markets in sub-Saharan Africa and three in North Africa. There are twenty-nine stock exchanges in Africa today, up from eighteen a decade ago representing 38 nations' capital markets ranging from starts ups like Somalia and Sudan stock exchanges to the Nigeria and Johannesburg stock exchanges. The Egyptian Exchange is the oldest established in 1883 and the youngest being Somalia established in 2012 (Egyptian Exchange, 2013; Ntim et al., 2008).

There are two regional block exchanges in Africa: the Bourse Regionales des Valeurs Mobilieres (BRVM), located in Abidjan, Cote d'Ivoire; and the Bourse Regionale des valeurs Mobilieres d'Afrique Centrale (BVMAC), located in Libreville, Gabon. The BRVM serves the countries of Benin, Burkina Faso, Guinea Bissau, Cote d'Ivoire, Mali, Niger, Senegal and Togo; the BVMAC serves Central African Republic, Chad, Congo, Equatorial Guinea and Gabon. Twenty-four out of the twenty-nine stock exchanges in Africa are members of the African Securities Exchanges Association (ASEA).

On the global front, African stock markets accounted for approximately 3 percent of listed companies as at end of 2009. In 2010, the net effect of new listings and de-listings was 76 companies. The number of firms listed has declined over 2006-2009 (growth rate of -4%) with the well established markets of South Africa and Egypt recording significant drops in the number of firms listed. The JSE has the highest number of listings on the continent numbering 410 as at 2013 and accounting for approximately 28% of the total number of listings in African stock exchanges. The Nigeria Exchange follows with 223 listings (15%) and Egyptian with 212 listings (14.5%). Tunisia ranks 7th in this indicator of stock market size behind South Africa, Nigeria, Egypt, Mauritius, Morocco and Zimbabwe. Consequently, the top six stock exchanges in the continent with regards to number of listings account for 75 percent of the total listings on African stock exchanges while the top three exchanges account for 58 percent of total listings (Capital Markets Aurthority, (2010).

As at December 2009, the WFE total market capitalization was US$46.5 trillion. African stock market capitalization accounted for a meagre 2 percent. With the exception of South Africa, most African stock markets doubled their market capitalization between 1992 and 2002. Total market capitalization for African markets increased from US$113,423 million to US$ 244,672 million between 1992 and 2002 (Yartey & Adjasi, 2007). However in 2008, only Ghana, Malawi, Tanzania and Tunisia registered an increase in market capitalization. However, market performance improved in 2009 with a majority of stock markets posting a positive capital appreciation with the exception of a few including Kenya, Nigeria and Ghana. Market concentration of the 5 largest exchanges in Africa is 95 percent.

The largest African stock market in terms of market capitalization is the JSE. By calculation, the market capitalization of the JSE is almost ten times (9.5 times as at 2010) the combined capitalization of the rest of Sub-Saharan Africa's stock markets and over 100 times their average (World Bank, 2011). Most African stock markets are also small relative to their economies, with the market capitalization of Namibia only representing 9.67 percent of gross national product (GNP) as at 2010, while in the case of Tanzania, Uganda and Ghana, the market capitalizations in 2010 were 5.52 percent, 10.51 percent and 10.93 percent of GNP respectively which are far meagre compared to market capitalization GNP ratio in advanced countries like United Kingdom (137.37% of GNP) and United States of America (117.5% of GNP). Excluding South Africa the average market capitalization is about 27 percent of gross domestic product (GDP). This is in contrast with other emerging markets like Malaysia with a capitalization of about 173 percent in 2010 (World Bank, 2011)

Except for Johannesburg Stock Exchange, African stock markets are still small and often dominated by a few large corporations. For example on the Ghana Stock exchange in June 2011, five out of the total of thirty five stocks accounted for almost 50 percent of number of transactions with only Ghana Commercial Bank (GCB) contributing 17.15 percent. On the Nigerian Stock Exchange, Dangote Group makes up 30 percent of the market.

Table 1: List of some African Stock Exchanges and Some Market Statistics

Economy	Number of Listed Domestic companies	Market Capitalization (% of GDP)	Value Traded (% of GDP)	Turnover (%)
Botswana	21	27.43	0.94	3.35
Egypt	213	37.69	16.95	43.04
Ivory Coast (BRVM)	38	31.16	0.58	1.99
Ghana	35	10.93	0.32	3.37
Kenya	55	44.91	3.37	8.6
Malawi	14	26.97	0.4	1.46
Mauritius	86	66.9	3.68	6.36
Namibia	7	9.67	0.15	1.82
Nigeria	215	25.12	2.61	12.54
South Africa	360	278.24	93.47	39.6
Tanzania	11	5.52	0.11	N/A
Uganda	8	10.51	0.06	0.36
Zambia	19	17.39	1.59	9.16
Zimbabwe	76	153.11	15.31	14.95

Source: World Bank, 2011.

In spite of the above, it is worthy to note that Zimbabwe, South Africa and Mauritius individually have market capitalization GDP ratio greater than several advanced countries including the United Kingdom and the United States (World Bank, 2011).

Trading in shares is less frequent, and when it happens, it is usually limited to a few firms. Of 213 companies listed on the EGX, the ten most active stocks represented 62.23 percent of the total value and 77.52 percent of the total volume of shares traded. Many companies listed do not have access to reliable and up to date information technology; in some, trading is done manually as in Malawi. The small size of African stock markets and lack of liquidity is a major weakness and in many cases the general public does not have confidence in the integrity of stock exchanges.

The majority of stock markets in Africa trade daily from Monday to Friday (Sunday to Thursday in Egypt). Trading times also vary, ranging from one hour per trading day in Tanzania to the whole business day from 08h00 to 16h30 in Zimbabwe. Trading methods on African stock exchanges vary from open-outcry to call-over to electronic trading systems. The Nigerian stock market has replaced the call-over trading system with the automated trading system (ATS). Clearing, settlement and delivery of transactions on the exchange are now done electronically by the Central Securities Clearing System (CSCS) in Nigeria.

Following the closure of the open outcry trading floor in June 1996, the JSE introduced an order driven, centralized, automated trading system known as the JSE Equities Trading (JET) system. In May 2002 the JET system was converted to the Stock Exchange Trading Systems (SETS) used on the

London Stock Exchange (LSE). SETS is a world-class, flexible and robust trading platform that promise improved liquidity and ensure more efficient functionality. SETS also allows South African based companies access to offshore privileges without having to move offshore.

Table 2: Infrastructural and Institutional Development Indicators

Country	MR	C&S	SC	FP	TS	TD
Algeria	Yes	Electronic	4	Yes	Electronic	1
Botswana	Yes	Manual	5	Yes	Manual	5
BRVM	Yes	Manual	4	Yes	Electronic	3
Egypt	Yes	Electronic	4	Yes	Electronic	5
Ghana	Yes	Electronic	5	Yes	Electronic	5
Kenya	Yes	Electronic	5	Yes	Electronic	5
Malawi	Yes	Manual	7	Yes	Manual	5
Mauritius	Yes	Electronic	3	Yes	Electronic	5
Morocco	Yes	Electronic	3	Yes	Electronic	5
Namibia	Yes	Electronic	3	Yes	Electronic	5
Nigeria	Yes	Electronic	3	Yes	Electronic	5
South Africa	Yes	Electronic	3	Yes	Electronic	5
Swaziland	Yes	Manual	5	Yes	Manual	5
Tanzania	Yes	Electronic	5	Yes	Electronic	N/A
Tunisia	Yes	Electronic	5	N/A	N/A	N/A
Zimbabwe	Yes	Manual	7	Yes	Manual	5

Source: Yartey & Adjasi (2007) and Websites of stock Exchanges

Key to Table 2: MR-market regulator; C&S-clearing and settlement; SC-settlement cycle; FP-foreign participation; TS-trading system; TD-trading days; N/A-Not available

Other markets that adopted the JSE's trading system include Ghana and the Namibia Stock Exchanges. Migration from an open outcry to an electronic trading system on the Casablanca Stock Exchange (CSE) took place between 4 March 1997 and 15 June 1998. All securities quoted on the CSE are now traded on the electronic trading system. Orders entered by dealers are automatically sorted by price limit and in chronological order, in the "market order book". On the central market, the less liquid securities are quoted on a call auction or fixing basis (once per session). The more liquid securities are quoted on a continuous basis. The electronic trading system automatically downloads to a market information system. This means that data providers can receive real-time market data (time, price, number of shares traded, etc), just as it appears on the dealers' screens (Mlambo and Biekpe, 2001)

Despite the problems of small size and low liquidity, African stock markets continue to perform remarkably well in terms of return on investment. The Ghana Stock Exchange was adjudged as the world's best-performing market at end of 2004 with a year return of 144 percent in US dollar terms compared with 30 percent return by Morgan Stanley Capital International Global Index (Databank Group, 2004). Within the continent itself five other bourses—Uganda, Kenya, Egypt, Mauritius and Nigeria apart from Ghana—were amongst the best performers in the year.

For the period 2007-2009, annualized dollar index returns in African capital markets have been greatly affected with only Ghana, Tanzania, Tunisia and Zambia registering positive returns for the 3 year period. In 2008, Ghana stock exchange registered the highest dollar index return in Africa registering an increase of 58 percent. Other markets that registered positive growth in

Africa during this period were Malawi (26%), Tanzania (21%), Tunisia (11%) and Zambia (18%) (Capital Market Authority, 2010).

The Egyptian and Nigerian Stock Exchanges were the worst performing markets during the period under review registering decreases of 56 percent and 46 percent respectively. Kenya was the 5th worst performing market during the review period registering an index decrease of 35 percent. However, in 2009, market performance registered significant improvement with most markets registering positive returns. Tunisia was the best performing market in Africa registering an index increase of 48 percent. Other significant increases were observed in South Africa, Mauritius, Namibia, Zambia, and Egypt stock exchanges. Kenya continued to register negative growth as the index declined by 8 percent during the period (Capital Markets Authority, 2010).

A number of factors have contributed to the expansion and growth of African stock markets. Many countries have been undergoing economic reform programmes that have involved a reduction in the role of the state in the economy and a strengthening of the role of the private sector. This has been accompanied by a greater role for market forces in price determination and the allocation of both real and financial resources. Financial sector reforms have often included the establishment of new stock markets, or improving the environment in which existing stock markets operate. Furthermore, privatization programmes in several countries have involved the listing of shares in formerly nationalized firms, which are often very large in relation to the size of national economies, thus providing a supply of new shares and a further boost to stock market development (Yartey, 2008).

This process has been accompanied by increased attention from international investors. Their interest reflects the growing size of African markets, along with the potential for high returns accompanied by the diversification benefits resulting from low correlations with other markets. At the same time many of the barriers to entry that have previously restricted the participation of foreign investors in many African markets are being progressively eased. Many countries have liberalized exchange controls on both current and capital account, making entry and exit easier, and direct restrictions on foreign ownership of shares have also been relaxed, although some controls do remain. Standards of market governance have improved, with several countries introducing new or revised legislation and governance structures. (Smith and Jefferis, 2005)

Though returns in the major African stock markets are high, they are very volatile. The IFC Nigerian stock market index, for example, showed an average gain of 26.4 percent through the ten years prior to 1999. For Zimbabwe, the average yearly return was 16.8 percent during this period, while the more mature South African stock market yielded a more modest return of 12.3 percent (IFC, 1999). The long-term high yields in markets such as Nigeria and Zimbabwe, however, come at the expense of nearly heart-stopping volatility: While the Zimbabwe index rose 143.8 percent during one year (in 1993), it plummeted by 59.8 percent during the previous year, 1992 and by 53.3 percent in 1997; while the yield on the Nigerian index was 190.9 percent in 1994 and 63.0 percent in 1996, the index registered declines of 34.9, 20.9, and 25.1 percent in 1992, 1995, and 1998 respectively. Yet the high returns over the long horizon have not remained unnoticed: At least twelve financial institutions had by 1996 created “Africa funds”, with capitalisation of about $US 1 billion, which solely target African markets (Magnusson & Wydick, 2002).

Review of Stock Markets on Country Bases

Egyptian Stock Exchange

The Egyptian stock exchange (EGX) is one of the oldest in the world and comprises two exchanges, the Alexandria Stock Exchange officially established in 1888, and Cairo, established in 1903 respectively. The EGX was the fifth most active stock exchange worldwide prior to the nationalization of industry and the adoption of central planning policies in the early 1950’s. These policies led to a considerable reduction in stock exchange activity and the market remained largely dormant throughout the 1980’s. The EGX began operating again as a market for capital only in the 1990’s, when market-oriented reforms brought financial institutions, operations and policies closer to internationally accepted principles and practices. These reforms increasingly recognized the development of equity markets and the financing of capital formation as key factors bearing upon the prospects for long-term growth (Egyptian Exchange, 2013)

The revitalization of the Egyptian stock market in the 1990’s took place within a process of deregulation and privatization of the economy, which played an important role in developing the stock exchange as a channel for divesting state-owned enterprises through public stock offerings, and as a venue enabling the private sector to raise capital. A new capital market law was key to this process, as it defined the regulatory framework for financial intermediaries, established and the Capital Market Authority (CMA) as an independent regulatory agency for the securities industry, and strengthened investor rights and financial disclosure requirements ("Egyptian Exchange", 2013).

These reforms set the stage for a significant market expansion, with a trend development in size and liquidity. New equity issues, volume and value of trading, and the number of traded companies all recorded significant progress. As a result, market capitalization increased from 8.2 percent to 25.3 percent of GDP during 1992-97, and the turnover ratio from 5.5 percent to 34.2 percent. By the end of November 1998, there were 833 listed companies on the Egyptian Stock Exchange with a market capitalisation of approximately 71.3 billion Egyptian pounds (up from 627 companies listed in 1991 with a market capitalisation of 8.8 billion Egyptian Pounds) (Egyptian Exchange, 2013).

The trading system at EGX has perceived gradual development from an outcry system (prior to 1992) to an automated order-driven system. In May 1998, EGX contracted with "EFA", a Canadian software company, to provide a new trading, clearing and settlement system. The trading component of this system started operations in May 2001, after applying a locally developed automated trading system for almost 9 years. The EGX in 2000 established "settlement guarantee fund" with a size of 30 million Egyptian pounds to clear unsettled transactions and to enhance timely settlement of transactions, (Egyptian Exchange, 2013).

EGX endorses informational efficiency and therefore established the Egypt Information Dissemination Company in 2001 to transmit EGX trading data as well as information about listed companies locally and internationally. In its endeavour to keep abreast with the latest technological advancements, based on its vision to become the financial hub and investment gateway in the Middle East and North African (MENA) Region that best serves its stakeholders, EGX has upgraded its trading platform to “OMX” high performance "X-Stream" solution, and launched it on 27 November 2008, replacing the old trading system "EFA Horizon".

X-stream is designed to support the increasing volume of trading on EGX as well as the simultaneous trading multiple product classes including equities, debt, commodities, exchange traded funds (ETFs), futures and options in both an exchange traded and cash or over-the-counter (OTC) or derivatives environment. X-stream has the capacity to meet the future needs of EGX.

In other to track the performance of different indices in different sectors, the EGX from 2007 publishes 12 sector indices. The EGX also publishes CASE 30 price index, EGX 100 price index, EGX 70 price index, S&P/EGX price index and EGX 20 price and index. The exchange has normal trading sessions from 10.30am to 2.30pm, local time, on all weekdays, except Fridays, Saturdays and holidays declared by the exchange in advance (Egyptian Exchange, 2013).

Ghana Stock Exchange

The Ghana Stock Exchange (GSE) was established in July 1989 as a private company limited by guarantee under the Companies Code of 1963. It was given recognition as an authorized Stock Exchange under the Stock

Exchange Act of 1971 (Act 384) in October 1990. Trading commenced on its floor on November 12, 1990. The exchange changed its status to a public company limited by guarantee in April 1994. It currently lists 37 equities (from 35 companies) and 2 corporate bonds. The manufacturing and brewing sectors currently dominate the exchange. A distant third is the banking sector while other listed companies fall into the insurance, mining and petroleum sectors (Ghana Stock Exchange, 2013).

Most of the listed companies on the GSE are Ghanaian but there are some transnational companies such as Golden Star Resources and Tullow Plc. The GSE has achieved remarkable success both on the continent and in the world at large. In 1993, the GSE was the sixth best index performing emerging stock market, with a capital appreciation of 116 percent. In 1994 it was the best index performing stock market among all emerging markets, gaining 124.3 percent in its index level (Ghana Stock Exchange, 2013).

The Ghana Stock Exchange was adjudged as the world's best-performing market at end of 2004 with a year return of 144 percent in US dollar terms compared with 30 percent return by Morgan Stanley Capital International Global Index (Databank Group, 2004). As at November 2013, Ghana stock exchange had a market capitalization of about US$31.5 billion. Starting from January 2011, the GSE publishes two indices, namely the GSE Composite Index (GSE-CI) and the GSE Financial Stocks Index (GSE-FSI). The calculation of the GSE Composite Index (GSE-CI) is based on the volume weighted average closing price of all listed stocks. The GSE-FSI index has its constituents as listed stocks from the financial sector including banking and insurance sector stocks ("Ghana Stock Exchange", 2013).

Trading on the GSE takes place every working day lasting 5 hours. Since March 2009, settlement of trades is done electronically using a web based application. Settlement occurs three business days (T+3) after the trade date. The System allows for mutual settlement of trade on T+0 or T+1 basis. The GSE uses an electronic trading platform known as the GSE Automated Trading System (GATS) (Ghana Stock Exchange, 2013).

Stock Exchange of Mauritius

The Stock Exchange of Mauritius Ltd (SEM) was incorporated in Mauritius on March 30, 1989 under the Stock Exchange Act 1988, as a private limited company responsible for the operation and promotion of an efficient and regulated securities market in Mauritius. Since October 6th, 2008, SEM became a public company. SEM in fact started its operations as a small pre-emerging exchange with a manual trading platform, but has during the last two decades witnessed a significant overhaul of its operational, technological and regulatory frameworks which has placed it among the leading exchanges in Africa in terms of operational excellence. SEM is today a full-fledged member of the World Federation of Exchanges (WFE) (Stock Exchange of Mauritius, 2014).

SEM operates two markets: the official market, which started operation in 1989, and the Development and Enterprise Market (DEM), which started operation in 2006. DEM is a market designed for Small and Medium-sized Enterprises (SME's) and newly set-up companies which possess a sound business plan and demonstrate a good growth potential. SEM can list, trade and settle equity and debt products in USD, Euro, GBP, ZAR and MUR. Local investors account for about 60 percent of the daily trading activities, and foreign investors account for the 40 percent remaining. Seventy-five percent of that local volume is generated by institutions like mutual funds, pension funds and insurance companies (Stock Exchange of Mauritius, 2014).

SEM started its operations with the Official Market in 1989 with five listed companies and a market capitalisation of nearly USD 92 million. The size of the market has grown from a market capitalisation to GDP ratio of less than 4 percent in 1989 to a current market capitalization/GDP ratio exceeding 80 percent (the highest in Sub Saharan Africa excluding South Africa), in an economy that has witnessed a 5 percent average growth rate during the last 25 years. Currently, there are 42 companies listed on the Official Market representing a market capitalisation of nearly US$ 7 billion as at 31 December 2013. The DEM was launched on 4 August 2006 and there are presently 47 companies listed on this market with a market capitalisation of nearly US$ 1.8 billion as at 31 December 2013 (Stock Exchange of Mauritius, 2014).

The successful implementation of the Central Depository System (CDS) in January 1997 has brought about prompt, efficient clearing and settlement of trades and at the same time reduced some of the inherent risks in the process on the Stock Exchange of Mauritius. SEM's Automated Trading System (SEMATS) was launched on 29th June 2001. It constitutes a state-of-the-art electronic trading system built on third generation technology. The stock exchange market in Mauritius is one of the most open markets in Africa, and readily welcomes investors from different regions (“Stock Exchange of Mauritius”, 2014).

In 2010, SEM brought major changes to its Listing Rules to align them with the Collective Investment Schemes Regulations 2008 with aim to position the SEM as an attractive platform for the Listing of Global and Specialised Funds. In April 2012, SEM introduced listing rules for Depositary Receipts and Mineral Companies on the Official Market of the SEM as well as requirements for the listing of junior Mineral Companies and Exploration Companies on the Development and Enterprise Market (DEM).

In terms of performance, the SEM has been remarkable in recent years. In September 2012, SEM was awarded for the second consecutive year the "Most Innovative African Stock Exchange of the Year Award" at the Africa investor prestigious annual Index Series Awards held at the New York Stock Exchange (NYSE).

Zimbabwe Stock Exchange

The first stock exchange in Zimbabwe opened in Bulawayo in 1896. It was however only operative for about six (6) years. Other stock exchanges were also established in Gweru and Mutare. The latter, also founded in 1896, thrived on the success of local mining industry, but with the realization that deposits in the area were not extensive, activity declined and closed in 1924. After World War II a new exchange was founded in Bulawayo and dealing started in 1946 (Zimbabwe Stock Exchange, 2013).

A second floor was opened in Salisbury (Harare) in December 1951 and trading between the two (2) centres was by telephone. They continued operating until it was decided that legislation should be enacted to govern the rights and obligations of both members of the Exchange and the general investing public. Only stockbrokers and authorized dealers are allowed to transact in shares on behalf of the public (“Zimbabwe Stock Exchange”, 2013).

The ZSE uses a call over system on the floors of the exchange. The ZSE conducts one callover session on a daily working day and trading records are published and circulated to different stakeholders including the investing public, Information vendors and media. Share prices are quoted in United States cents (USc) and trading time: 10:00 hours to 11:30 hours (Zimbabwe Stock Exchange, 2013).

The ZSE has two broad categories for indices namely the Industrial Index and the Mining Index. Both have Base Value of 100 = February 2009. OTC trading is not allowed in the market. Short selling is permitted if notification and prior approval is sought from the Zimbabwe Stock Exchange (Zimbabwe Stock Exchange, 2013).

Nigerian Stock Exchange

The Nigerian stock exchange (NSE) was established in 1960 as the Lagos Stock Exchange. As at December 2013, it had about 258 listed companies with a total market capitalization of about $80.8billion. It started operations in Lagos in 1961 with 19 securities listed for trading. In December 1977 it became known as The Nigerian Stock Exchange, with branches established in some of the major commercial cities of the country ("Nigeria Stock Exchange", 2013).

The NSE is regulated by the Securities and Exchange Commission which has the mandate of surveillance over the exchange to forestall breaches of market rules and to deter and detect unfair manipulations and trading practices. The exchange has an Automated trading System since 1999 thus facilitating online trading on the exchange. Trading on the exchange lasts 5hours each business day ("Nigeria Stock Exchange", 2013).

The Exchange maintains an All-Share Index formulated in January 1984 (January 3, 1984 = 100). Only common stocks (ordinary shares) are included in the computation of the index. The index is value-weighted and is computed daily. The highest value of 66,371.20 was recorded on March 3, 2008.

Also, the Exchange has introduced the NSE-30 Index, which is a sample-based capitalization-weighted index plus four sectorial indices. Similarly, five sectorial indices have been introduced to complement existing indices. These are NSE-Food/Beverages Index, (Later renamed NSE – Consumer Goods Index) NSE Banking Index, NSE Insurance Index, NSE Industrial Index and NSE Oil/Gas Index ("Nigeria Stock Exchange", 2013).

Johannesburg Stock Exchange

JSE Limited (previously the JSE Securities Exchange and the Johannesburg Stock Exchange) is the largest stock exchange in Africa. It is situated at the corner of Maude Street and Gwen Lane in Sandton, Johannesburg, South Africa. In 2003 the JSE had an estimated 472 listed companies and a market capitalisation of US$182.6 billion (€158 billion), as well as an average monthly traded value of US$6.399 billion (€5.5 billion). As of 31 December 2012, the market capitalisation of the JSE was at US$903 billion ("Johannesburg Stock Exchange Limited ", 2013).

The Johannesburg Stock Exchange (JSE) was founded in 1887 to enable the new mines and their financiers to raise funds for the development of the fledgling mining industry. However, the majority of the companies listed today are non-mining organizations. JSE Limited is by far the largest exchange in Africa and the 17th largest in the world in terms of market capitalization (JSE Limited, 2014).

A number of initiatives were introduced in the late 1990s to improve the efficient functioning of the exchange. The first major change occurred in November 1995, when the Stock Exchanges Control Act changed the way in which stocks were traded in South Africa, opening the door to non-South Africans, and allowing brokers to buy and sell stock for their own account. The trading system is now automated through an electronic clearing and settlement system, STRATE (Share Transactions Totally Electronic) (Yartey, 2008).

The bond market has been separated from the JSE to the Bond Exchange of South Africa and is licensed as a financial market in terms of the Financial Markets Control Act. A real-time stock exchange news service was launched in 1997 in an attempt to enhance market transparency and investor confidence. JSE listing requirements require listed companies to disseminate any corporate news or price sensitive information on the service prior to using any other media or outlet.

In 2001, the JSE merged with the South African Futures Exchange (SAFEX) and thereby become the leader in both equities and futures and options trading in South Africa. New capital adequacy requirements, which have major financial implications for broking firms has also been developed.

These are based on European Union requirements and involve the separation of clients' funds from those of brokers.

. The JSE's trading and information systems were replaced with that of the London Stock Exchange. The trading engine and information dissemination feed-handler is hosted in London and connected remotely to the JSE. More than 1,500 traders and information users access the system via a sophisticated Application Service Provider with sub-second response time. The JSE also aligned their equities trading model with that of Europe, and reclassified their instruments in line with the Financial times stock exchange (FTSE) Global Classification system. This has led to the introduction of the FTSE/JSE Africa Index Series that makes the South African Indices comparable to similar indices worldwide. Trade information of instruments listed on the JSE can now be disseminated by the LSE to more than 104,000 trading terminals around the world, raising the profile of the JSE among the international investor community (Yartey, 2008).

The JSE is licensed as a stock exchange (for equities) and as a financial market (for financial and agricultural derivatives) in terms of these Acts, but, in common with international practice, a philosophy of self-regulation by the markets is practiced and applies to the JSE. The JSE members and their clients (investors) must comply with trading and other rules set by the JSE from time to time. The JSE acts as regulator of its members and ensures that markets operate in a transparent and fair manner ensuring investor protection. Similarly, issuers of securities must comply with the JSE Listings Requirements which are aimed at ensuring sufficient disclosure in the public interest of all information relevant to investors.

The JSE performs the role of regulating applications for listing, the continuing obligations of listed companies and the interpretation of JSE listings requirements. In addition, the JSE regulates applications for the alteration of an existing listing and any corporate actions arising from this and scrutinizing company documentation with a view of disclosure to the public. The exchange was demutualized in July 2005 after 118 years of existence as a mutual entity. (Yartey, 2008).

Conclusion

This chapter reviewed the African stock markets with emphasis on the six stock markets used in this study. The chapter revealed that African economies have growth prospects given recent developments even though most of them are yet to compete on the international stage. African stock markets are dominated by the Johannesburg Stock Exchange (JSE). Most African stock markets are migrating from open outcry to electronic trading systems so that securities are traded electronically. Again African stock markets are small in size and have low liquidity. In spite of the above, African markets have performed remarkably well in terms of return on investment. The expansion and growth of African stock markets can be attributed to economic reforms that have made the private sector the engine of growth in most African economies.

CHAPTER THREE

REVIEW OF RELATED LITERATURE

Introduction

The main aim of this chapter is to present the review of related literature on the research topic. Under this, the discussion initially focuses on the theoretical underpinnings and later looks at the empirical studies that have been conducted by different researchers and/or institutions and the findings of such researches. The chapter further gives a summary whether these findings support or contradict what the theory establishes about market efficiency.

Theoretical Literature

Economic origins of market efficiency

The intellectual debate on the efficiency of financial and economic markets can be traced back to the father of modern economics, Adam Smith. In his book entitled, "the wealth of nations" in 1766, he explained the theory of the invisible hand which efficiently allocates factors of production and argued for the self-restoring or stabilizing nature of economic markets. Consequently, many researchers argue that Smith believed economic and financial markets to be efficient and any form of market intervention to be obsolete.

However, what these researchers fail to recognize is that Adam Smith wrote more than just his book on the wealth of nations. In fact, seven years earlier, he wrote a book on the theory of moral sentiments in which he pointed to apparent behavioural biases in the human decision making process (Smith, 1759). Clearly, these observations are in contrast with the argument that he believed economic markets to be perfectly efficient. In order to prevent further intellectual abuse of Adam Smith's work, Vernon Smith (1998) wrote a paper on the apparent contradictions between both works, concluding that the beliefs held by Adam Smith were far more nuanced than one would believe when only reading The Wealth of Nations. In conclusion, it would be intellectually unfair to contend that even Adam Smith believed that economic and financial markets were efficient.

Statistical foundations of market efficiency

The theory of probability provided the important building blocks for the later development of a theory on the efficiency of financial markets, which has its origins in the world of gambling. The first mathematical work on probability theory dates back to 1564 and was also a guide to gambling: Liber de Ludo Aleae (The Book of Games of Chance), by the Italian mathematician Girolamo Cardano.

According to Hald (1990), Cardano considered different dice and card games, giving readers advice on how to gamble. Other than just a guide for gamblers, the work of Cardano is also of scientific relevance, given his theoretical digressions on the possible outcomes of games of chance. In fact, Cardano defined the terms probability and odds for the first time and even presented what he believed to be the fundamental principle of gambling: equal conditions.

Next to the work of Cardano, most early research that was essential in the later development of a theory on efficient markets was conducted in the 19th century. For example, Brown (1828) observed what we now call a Brownian motion for the first time, when he was looking through the microscope and noticed the apparent random movement of particles suspended in water.

In later years, Regnault (1863) proposed a theory on stock prices when he found that the deviation of the price of a stock is directly proportional with the square root of time, a relation that is still valid in the world of finance today. The first statement about the efficiency of financial markets came from Granger and Andersen (1978). Gibson (1889) in his book about the stock markets of London, Paris and New York wrote: "When shares become publicly known in an open market, the value which they acquire there may be regarded as the judgment of the best intelligence concerning them." Alfred Marshall during the 19th century transformed economics into a more exact science, drawing from the fields of mathematics, statistics and physics. He popularized the usage of demand and supply curves and marginal utility, and brought together different elements from welfare economics into a broader context. The influence of Marshall on the field of economics was significant, in particular because his book on the principles of economics became a seminal work in the field.

The concept of market efficiency had been anticipated at the beginning of the 20th century in the dissertation submitted by Bachelier to the Sorbonne for his PhD in mathematics in which he was first to present a mathematical model for the motion that Brown (1828) had observed.

Bachelier (1990) recognised that "past, present and even discounted future events are reflected in market price, but often show no apparent relation to price changes". This recognition of the informational efficiency of the market leads Bachelier to say in his work that "if the market, in effect, does not predict its fluctuations, it does assess them as being more or less likely, and this likelihood can be evaluated mathematically". This gives rise to a brilliant analysis that anticipates not only Albert Einstein's subsequent derivation of the Einstein-Wiener process of Brownian motion, but also many of the analytical results that were rediscovered by finance academics in the second half of the century. Sadly, Bachelier's contribution was overlooked until it was circulated to economists by Paul Samuelson in the late 1950s subsequently published in English by Cootner (1964).

Although there could have been an emerging theory of speculative markets during the first half of the twentieth century, this was not to be. Instead, the early literature followed the path of accumulating a variety of empirical observations that did not sit easily alongside the paradigms of economics or the beliefs of practitioners.

Bachelier had concluded that commodity prices fluctuate randomly, and later studies by Working (1934) and Cowles and Jones (1937) were to show that US stock prices and other economic series also share these characteristics. The stochastic process developed by Bachelier became one of the centerpieces of finance, as Samuelson (1965) based his explanation of a random walk, which was introduced by Pearson (1905), on Bachelier's early research. There was, in addition, disturbing evidence about the difficulty of beating the equity market.

Alfred Cowles III, founder of the Cowles Commission and benefactor of the Econometric Society, published in the launch issue of Econometrica a painstaking analysis of many thousands of stock selections made by investment professionals. Cowles (1933) found that there was no discernable evidence of any ability to outguess the market. Subsequently, Cowles (1944) provided corroborative results for a large number of forecasts over a much longer sample period. By the 1940s, there was therefore scattered evidence in favour of the weak and strong form efficiency of the market, though these terms were not yet in use.

Economic foundations of market efficiency

After the elaboration on some of the statistical origins of market efficiency, the study has looked at the work of some notable economists, before and after the Great Depression of 1929. A very prominent researcher at that time was Fisher, who made multiple contributions to the field of finance (Fox, 2009). He made great progress on the search for a general equilibrium theory and provided important insights for utility theory, which later proved useful for von Neumann and Morgenstern in their definitive book on general utility theory in 1944.

Despite some of his brilliant contributions, Fisher became even more famous because of his public statements prior to the Great Depression that started in 1929 (Fox, 2009). Fisher was advocating the collection of data to approach the financial market in a much more scientific way than before. Through his revolutionary statistical analysis of stock market prices, he was able to make predictions about future price levels, which led him to publicly announce that the boom in stock prices prior to the 1929 crash was the prelude of a "permanently high plateau". When only a few days later stock prices plunged like never before, Fisher was publicly humiliated. Subsequent work of Fisher was received with great suspicion, even though it later appeared to be as brilliant as most of his pre-1929 work.

Very much like Marshall and Fisher, Cowles (1933, 1944) tried to turn economics into a more exact science and found that investors are unable to beat the market by means of price forecasting. Working (1934) came up with similar conclusions stating that stock returns exhibit behaviour similar to lottery numbers. Together, the work of Cowles and Working point towards what was later called an informationally efficient stock market. In 1936, Keynes published his seminal book General Theory of Employment, Interest, and Money. In his work, which mostly impacted and shaped the field of macroeconomics, Keynes introduced the concept of animal spirits. According to him, investors base their decisions on a "spontaneous urge to action, rather than inaction, and not on the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities".

One year later, Cowles and Jones (1937) published a paper that provided early proof of serial correlation in time series of stock prices. Together with the more theoretical work of Keynes, this empirical evidence formed an early challenge to the existence of efficient markets. Nevertheless, a real discussion on the efficiency of financial markets only emerged after the establishment of the efficient market hypothesis (EMH) by Fama in 1970. As a result of their collaboration during the war, von Neumann and Morgenstern (1944) published their book on the theory of games and economic behaviour.

Not only was the book the starting point of game theory, it also proved to be essential in the development of a theory on efficient markets. The most important piece of theory in their book was about the maximization of what was called expected utility: a new concept for dealing with uncertainty by multiplying probabilities with utilities of potential outcomes.

After the Second World War, Markowitz (1952) published his paper on portfolio selection. Operating within the mean-variance framework, he presented a model in which it was possible to determine the optimal portfolio of securities, providing a maximum level of return given a certain level of risk. Central to his theory was the idea of diversification as a way of getting rid of all systematic or correlated risk, leaving only the so-called idiosyncratic risk of individual securities. The approach of Markowitz in trading off risk and return was very similar to what other economists had been occupied with during the war: considering the trade-off between power and precision of bombs (Fox, 2009).

Asset pricing revolution

Sharpe (1964) revolutionized the world of finance by presenting the capital asset pricing model (CAPM). Building on the earlier work of Markowitz (1952), the CAPM allows for the calculation of a theoretical rate of return on an asset, given the amount of non-diversifiable risk the asset entails. The reason only non-diversifiable risk is taken into account is the assumption that the asset is added to a well-diversified portfolio that neutralizes idiosyncratic risk to all extent.

Asset pricing models, like the one presented by Sharpe, were very important in the debate on efficient markets that emerged in later years, as it provided researchers with the opportunity to theoretically derive the price and return of financial assets. That way, it was possible to examine whether the actual return on an asset was in line with the theoretical rate of return derived from the underlying asset pricing model. In later years, scholars came across some interesting asset pricing anomalies and argued that the CAPM was too limited by only accounting for one factor of risk.

Ross (1976) came up with an alternative: arbitrage pricing theory, which is far more flexible than the model of Sharpe, and states that the expected return on an asset is a linear function of different factors of risk, each with their respective factor sensitivity. Whenever the actual return on the asset deviates from the one derived from the theoretical model, the force of arbitrage brings the actual rate of return back in line with the theoretical one. By discounting for several sources of risk instead of just non-diversifiable risk, the model addresses the major flaw of the CAPM.

However, the model of Ross is very general and does not give any guidelines as to what specific factors of risk to account for. Fama and French (1993) further improved asset pricing theory by presenting their three factor model. Starting from their observation of pricing anomalies with respect to market capitalization and growth versus value strategies, they found the expected rate of return to depend on the exposure of the asset to each of three factors: market risk premium (non-diversifiable risk), market capitalization and the book-to-market ratio. With their model, they not only addressed the biggest flaw of the CAPM (only one risk factor), but also were specific in formulating their factors of risk, unlike Ross. Following the momentum puzzle pointed out by Jegadeesh and Titman (1993), Carhart (1997) extended Fama and French's model to a four-factor model, taking into account a momentum risk factor.

The random walk theory

The random walk theory asserts that the price of a stock is equal to its price today plus a purely random shock (or error term) thus making forecasting asset prices futile. The theory posits that security prices seemed to follow a random walk which means security prices change randomly, with no predictable trends or patterns and that the movement of stock prices from day to day do not reflect any pattern (Dimson & Mussavian, 2000).

In the early 1950s researchers were, for the first time, able to use electronic computers to study and ascertain the behaviour of lengthy price series. The assumption of economists at the time was that one could "analyse an economic time series by extracting from it a long-term movement, or trend, for separate study and then scrutinising the residual portion for short-term oscillatory movements and random fluctuations" (Kendall, 1953).

When Kendall examined twenty-two UK stock and commodity price series, however, the results surprised him. He concluded that "in series of prices which are observed at fairly close intervals the random changes from one term to the next are so large as to swamp any systematic effect which may be present. The data behave almost like wandering series." The near-zero serial correlation of price changes was an observation that appeared to contradict the views of economists. Subsequently, these empirical observations came to be labelled the "random walk model" or even the "random walk theory" (Dimson & Mussavian, 2000).

If prices wander randomly, then this poses a major challenge to market analysts who try to predict the future path of security prices since there is no scope for profitable speculation in the stock market. Drawing on Kendall's work and earlier research by Working (1934), Roberts (1959) showed that a time series generated from a sequence of random numbers was indistinguishable from a record of US stock prices – the main tool used by technical analysts to predict future price levels. "Indeed," he wrote, "the main reason for this paper is to call to the attention of financial analyst's empirical results that seem to have been ignored in the past, for whatever reason, and to point out some methodological implications of these results for the study of securities."

Just at the same time, Osborne (1959) analysed US stock price data out of pure academic interest, presenting his results to other physicists and academicians at the US Naval Research Laboratory. Osborne (1959) shows that common stock prices have properties analogous to the movement of molecules. He applies the methods of statistical mechanics to the stock market, with a detailed analysis of stock price fluctuations from the point of view of a physicist.

In spite of the emerging evidence on the randomness of stock price changes, there were some instances of anomalous price behaviour, where certain series appeared to follow predictable paths. This includes a subset of the stock and commodity price series examined by Working (1934), Cowles and Jones (1937) and Kendall (1953) (Dimson & Mussavian, 2000).

In 1960, however, there was a realisation that autocorrelation could be induced into returns series as a result of using time-averaged security prices. Working (1960) and Alexander (1961) independently discovered this. Once returns series are based on end-of period prices, returns appear to fluctuate randomly.

The mid-1960s was a turning point in research on the random character of stock prices. In 1964, Cootner published his collection of papers on that topic, while Fama's (1965) doctoral dissertation was reproduced, in its entirety, in the Journal of Business. Fama reviews the existing literature on stock price behaviour, examines the distribution and serial dependence of stock market returns, and concludes that "it seems safe to say that this paper has presented strong and voluminous evidence in favour of the random walk hypothesis" (Dimson & Mussavian, 2000).

The Beginning of Efficient Market Theory

With a better view or understanding of price formation in competitive markets, the random walk model came to be seen as a set of observations that can be consistent with the efficient markets hypothesis. The switch of emphasis began with observations such as that of Samuelson (1965), whose paper entitled "Proof That Properly Anticipated Prices Fluctuate Randomly" began with the observation that "in competitive markets there is a buyer for every seller. If one could be sure that a price would rise, it would have already risen." Samuelson asserted that "arguments like this are used to deduce that competitive prices must display price changes...that perform a random walk with no predictable bias."

Samuelson explains that "we would expect people in the market place, in pursuit of avid and intelligent self-interest, to take account of those elements of future events that in a probability sense may be discerned to be casting their shadows before them." By presenting his proof in a general form, Samuelson added rigour to the notion of a well-functioning market. It is not clear whether these results ought to be seen as obvious or surprising, nor was it clear to Samuelson who wrote that "the theorem is so general that I must confess to having oscillated over the years in my own mind between regarding it as trivially obvious (and almost trivially vacuous) and regarding it as remarkably sweeping. Such perhaps is characteristic of basic results" (Dimson & Mussavian, 2000).

In the same year Samuelson described the idea of efficient markets, Fama (1965a) also defined an efficient market for the first time and assembled a comprehensive review of the theory and evidence of market efficiency later in 1970. Based on the empirical investigation of stock market prices, he observed that financial markets follow a random walk. Though his paper proceeds from theory to empirical work, he notes that most of the empirical work preceded development of the theory.

Another paper by Fama (1965b) elaborated on the random walk pattern in stock market prices to show that technical and fundamental analysis could not possibly yield risk-adjusted excess returns. Fama and Blume (1966) considered the profitability of technical trading rules like the popular filter rule that was described by Alexander (1961). They concluded that no economic profits could be made using these filter rules since trading costs would be too high even when adopting the most profitable very small-width filters. This also confirmed their beliefs of financial markets being informationally efficient. Roberts (1967) was the first one to coin the term efficient market hypothesis (EMH) and suggested a distinction between several types of efficiency.

The definitive paper on the EMH was published by Fama (1970) in the form of his first of three reviews of the theoretical and empirical work on efficient markets. He defined an efficient market to be a market that fully reflects all available information and introduced three different types of informational efficiency. Summarizing results from weak form, semi-strong form and strong form efficiency tests, Fama concluded that almost all of the early evidence pointed towards a financial market that was efficient in at least the weak sense. Although he found some price dependencies, they never sufficed to be used in profitable trading mechanisms, making markets weak form efficient.

Fama also considered the joint-hypothesis problem. Essentially, he argued that it would be impossible to ever correctly test the EMH, because no academic consensus was found on the true underlying asset-pricing model. Whenever a test of market efficiency would reject the efficiency hypothesis, there was always the possibility that it was simply due to the underlying asset pricing The only conclusion that could be made from efficiency tests is that a market is efficient or not with respect to a certain underlying asset pricing model. The same conclusion could never be made independently from the underlying model.

Besides Fama (1970), other researchers have attempted to formulate a clear definition of what is meant by an efficient market. Jensen (1978) wrote "a market is efficient with respect to information set θt if it is impossible to make economic profits by trading on the basis of information set θt." Malkiel (1992) stated that a stock market is efficient whenever the prices of stocks remain unchanged, despite information being revealed to each and every market participant. Even though there is a lot of academic merit to the definitions of Jensen and Malkiel, the definition of Fama is adopted. More particularly, this thesis focuses on weak form market efficiency, i.e. the set of available information we consider consists only of historical price information (Fama, 1970).

Forms of market efficiency

Economists often define three levels of market efficiency, which are distinguished by the degree of information reflected in security prices. The levels of market efficiency are weak form, semi-strong form and strong form market efficiency.

In the first level, that is, weak form market efficiency, prices reflect the information contained in the record of past prices. If stock prices follow a random walk, it is not possible to make superior profits just by studying past prices. This is called the weak form of efficiency. In the 'weak form efficiency' form, market prices rapidly reflect all information contained in the history of past prices. Mathematically, weak form efficiency is:

$$P_1 = P_{t-1} + \text{Expected return} + \text{Random error}_t \qquad (1)$$

Where:

P_1 is the price today

P_{t-1} is the last observed price

Expected return is the expected return on the stock (in monetary terms)

Random $error_t$ is a random component occurring over the interval (due to new information about the stock)

In this form of efficiency, technical analysts, analysts or investors who attempt to identify over- or undervalued stocks by searching for patterns in past prices, make no superior gains. They help to make price changes random because competition in technical research ensures that current prices reflect all information in the past sequence of prices and that future price changes cannot be predicted from past prices. Some technical analysts are very successful. However, this success is more due to luck and good judgment rather than to technical trading rules because technical rules are useless when stock prices follow a random walk.

The second level of efficiency requires that prices reflect not just past prices but all other published information, such as one might get from reading the financial press. This is known as the semi strong form of market efficiency. If markets are efficient in this sense, then prices will adjust immediately to public information such as the announcement of the last quarter's earnings, a new issue of stock, a proposal to merge two companies, and so on. Investors are not able to earn superior returns by buying or selling after the announcement. In the 'Semi-strong form efficiency' form market prices reflect all publicly available information (Brealey, Meyers & Allen, 2010). In this form of efficiency, fundamental analysts, analysts who attempt to find under- or overvalued securities by analyzing fundamental information, such as earnings, asset values, and business prospects, are not able to earn superior returns.

Investors study the company's business and try to uncover information about its profitability that will shed new light on the value of the stock. They help to make price changes random because competition in fundamental research will tend to ensure that prices reflect all relevant information and that price changes are unpredictable.

Finally, there is the strong form of efficiency, in which prices reflect all the information that can be acquired by painstaking analysis of the company and the economy. In such a market one would observe lucky and unlucky investors, but one cannot find any superior investment managers who can consistently beat the market. In the 'Strong-form efficiency' form market prices rapidly reflect all information that is potentially available to determine the true value. In such a market, prices would always be fair and no investor would be able to make consistently superior forecasts of stock prices. As an insider, you cannot hide information on gold (Brealey et al., 2010).

Implications of the efficient market hypothesis are that asset prices move almost randomly over time and securities will be fairly priced, based on their future cash flows, given all information that is available to investors. Because information is reflected in prices immediately, investors should only expect to obtain a normal rate of return. Awareness of information when it is released does an investor no good because the price adjusts before the investor has time to trade on it.

Early aftermath of the efficient market hypothesis

In the early aftermath of Fama's work (1965a, 1965b), a lot of research was undertaken in order to test or prove the validity of the EMH. Like Fama (1970) concluded in his first review paper, a lot of the empirical evidence was pointing towards a weak form efficient stock market. However, different scholars and researchers found contradicting evidence against the EMH. Kemp & Reid (1971) pointed out that a lot of the earlier research to into consideration only U.S. stock market data. Using British data, they pointed out stock price movements to deviate from what is expected under the random walk hypothesis, which contradicts with what was argued by Fama. Grossman (1976) found the first evidence of an important paradox: "informationally efficient price systems aggregate diverse information perfectly, but in doing this the price system eliminates the private incentive for collecting the information". In his literature survey, Ball (1978) found consistent excess returns after the public announcement of firms' earnings, which is a clear violation of the theory on semi-strong form efficient markets, as no excess returns should be possible when trading on public information. When looking at long-term interest rates, Shiller (1979) found that the observed volatility is in excess of that predicted by expectations models. This observation implies some extent of forecastability of long-term interest rates, which contradicts the EMH.

The most convincing piece of contradicting evidence came from the paradox that was presented by Grossman and Stiglitz (1980), following the earlier work of Grossman (1976). In order for investors to be motivated to spend resources for collecting and analyzing information to trade on, they must have some form of incentive (Grossman & Stiglitz, 1980). If a stock market would prove to be perfectly efficient, however, there would be no reward for collecting information, since that information would already be reflected in the current stock price. This simple paradox shows that financial markets can never become entirely efficient, as no investor would be motivated to collect information in the first place. Consequently, no one would trade on new information and it would become impossible for stock market prices to reflect all available information.

In addition, firms should expect to receive fair value for the securities they sell. This means that the price they receive from issuing securities is equal to its present value. Thus, valuable financing opportunities that arise from fooling investors are unavailable in efficient capital markets.

Limitations of the efficient market hypothesis (EMH)

At a theoretical level, the EMH has many obvious limitations. The most important of these limitations stems from the fact that EMH is a "pure exchange" model of information in markets. What this means is that the theory makes no statements whatsoever about the "supply side" of the information market that is about how much information is available, whether it comes from accounting reports or statements by managers or government statistical releases, what its reliability is, how continuous it is, the frequency of extreme events, and so forth. The theory addresses only the demand side of the market. The EMH says that, given the supply of information, investors will trade on it until in equilibrium there are no further gains from trading. Consequently, the EMH is silent about the shapes of return distributions and how they evolve over time (Brealey et al., 2010).

Information is modelled in the EMH as an objective commodity that has the same meaning for all investors. In reality, investors have different information and beliefs. The actions of individual investors are based not only on their own beliefs, but beliefs about the beliefs of others—that is, their necessarily incomplete beliefs about others' motives for trading. This likely becomes most important during periods of rapid price changes.

In addition, information processing is assumed in the EMH to be costless, and hence information is incorporated into prices immediately and exactly. While it seems reasonable to assume that the cost to investors of acquiring public information is negligible, information processing (or interpretation) costs are an entirely different matter. They have received little attention. However, seasoned investors (such as Warren Buffet) have access to better information and subsequently may have lower required returns.

The EMH also is silent on the issue of investor taxes. In reality, many investors pay taxes on dividends and capital gains, with some offsets for capital losses. The effects of investor taxation on security prices and expected returns are potentially large, but not well understood.

From the above, it should be apparent that the EMH adopts a simplified view of markets. To those who take theories literally—not as useful abstractions—the combined effect of these simplifications as well lead the question whether behavioural finance is the answer. Where does behavioural research come into this picture? Hence the emergence of behavioural finances theory.

Behavioural finance theory

This started when the early financial economists observed and reported anomalies within the capital market. The first discussion of an anomaly in the market reaction to public information was Philip Brown's study of the market reaction to earnings announcements in 1968. It was observed that the market response to the announcements persisted for several months, a phenomenon that later became known as "post earnings announcement drift" or "earnings momentum". By the mid-1970s this pattern had been observed in several studies, including Basu (1977) whose findings challenge the EMH and it was the first to test the notion that value-related variables might explain violations of the Capital Asset Pricing Model (CAPM) (Beechey, Gruen & Vickery 2000; Keim, 2006). But the genesis of the behavioural finance literature is generally identified as the publication of two famous papers by De Bondt and Thaler (1985, 1987). Since then, behavioural theory has succeeded in poking many more holes in the theory of efficient markets.

Many researchers have given several definitions to behavioural finance however it can be said to be the integration of economic and finance with psychology and the decision making sciences. Behavioural finance is an attempt to explain what causes some of the anomalies that have been observed and reported in the finance literature Fuller (1998). Also, behavioural finance relates how stock prices are affected by investors' behaviours (Barak & Demireli, 2006). All these definitions explain behavioural finance one way or the other. As noted by Olsen (1998), advocates of behavioural finance recognize that the standard finance model of rational behaviour as noted above under the EMH can only be true within a specific boundary however; they assert that it is an incomplete model since it does not consider individual behaviour.

The behavioural finance theory further argued that some financial phenomenon can be well explained using models such as that of the behavioural finance which recognizes that some investors are not fully rational and that it is not feasible for arbitrageurs to offset all instances of mispricing (Barberis & Thaler, 2003). Behavioural finance attempts to explain investor biases based on psychological characteristics such as belief perseverance and anchoring (Scott, Stumpp, & Xu, 1999).

In addition, investors may also suffer representativeness bias which causes them to believe that stocks of growth companies will be good stocks. Other biases include self-attribution bias where investors have the tendency to attribute any success to their own talent while blaming any failure on bad luck. Beside this, other market developments such the existence of noise traders could lead to either over or under reaction on the market making it quite volatile (Brown, 1999). All the above biases suffered by investors emanate purely from investor psychology (behaviour) which cannot be explained by the traditional standard finance theory.

Due to the above, Lee (2003) came up with fusion investing model which is the integration of the two elements of investment value – fundamental value and investor sentiments. Similarly, Shiller (1984), using the dividend discount model, showed that the market price of securities is the expected dividend discounted to infinity (its fundamental value) plus a term that represents the noise.

Development of tests for weak form market efficiency

October 19th, 1987 remains an unforgettable day in the history of capital markets: Black Monday. This day became infamous because of the crashing of stock markets around the world. Starting in Hong Kong, the crash spread to Europe and eventually the United States later the same day. The Dow Jones Industrial Average (DJIA) dropped by 508 points or 22.61 percent, which to this day is the largest percentage drop ever in its value. Different phenomena came together to cause this dramatic event. Among them include program trading, market psychology, overvaluation and eventually illiquidity (Shiller, 1989). Despite its negative impact on investors and the global economy, this unique event also provided researchers with valuable new data for scientific analysis.

Advocates of behavioural finance also pointed towards Black Monday to further illustrate that investors are not fully rational and overreact to information in times of market mania. Together with the valuable data from the Black Monday crash, the evolution of computing power allowed researchers to come up with new and more advanced empirical tests of market efficiency (Bodie, Kane, & Marcus, 2010).

Past studies have focused on three particular types of statistical tests of the weak form of the EMH. A first group of weak form market efficiency tests looks at return autocorrelations. The general philosophy behind these tests is that if significant autocorrelation is found among the returns on a stock, there is some extent of predictability, which is in contradiction with the EMH (Lim & Brooks, 2011). The empirical work testing return autocorrelations can be split based on the horizon of returns. Autocorrelations in the short run (day, week, month) tend to be positive for returns on portfolios (e.g. Conrad & Kaul, 1993; Lo & MacKinlay, 1990) and negative for returns on individual stocks (e.g. Lehmann, 1990; Jegadeesh, 1990). Autocorrelations in medium horizon returns (1-12 months) tend to be positive for the long horizon (1-5 years) return autocorrelations tend to be negative (Bodie et al., 2010). For short horizon returns, Lo and MacKinlay (1990, 1997) find significant autocorrelation among returns on S&P-500 stocks.

However, the pattern of autocorrelation is weaker for weekly and monthly returns, and for larger rather than small stocks. Jegadeesh and Titman (1993, 2001) considered stock returns in the medium horizon and found significant evidence of momentum profits, which gave rise to an important puzzle in asset pricing theory. Proponents of behavioural finance used this finding of momentum profits to argue that a gradual adjustment of prices causes the predictable drifts or autocorrelation in returns, which implies that financial markets do not promptly incorporate news in past prices, and hence are not weak form efficient (Bodie et al., 2010).

For evidence of return autocorrelation on the longer horizon we can refer back to De Bondt & Thaler (1985), who showed that investors tend to overreact to dramatic and unexpected news events. Some of the (momentum) puzzles found when analyzing return autocorrelations were further investigated by researchers on the behavioural finance side of the debate. Using behavioural theories of under- and overreaction to information, some researchers were able to explain the observed puzzles. De Barak and Demireli (2006) showed that the long horizon negative autocorrelation in returns (reversal) can be explained by a stylized model with two types of agents: fundamentalists, who get signals about intrinsic values, and chartists, who learn indirectly about intrinsic values by looking at prices. Whenever a good signal is received by fundamentalists, prices increase. Chartists will observe this rise in prices, causing some chartists to buy, which in turn further increases prices and causes more chartists to buy.

Eventually, share prices are so far beyond intrinsic values that fundamentalists start selling again. Another explanation was provided by Barberis, Shleifer, and Vishny (1998). They explained underreaction to information using conservatism, that is, investors erroneously believe that the earnings process underlying stock prices is mean-reverting and so they underreact to news. To explain overreaction, they refer to the representativeness heuristic: investors overextrapolate from a sequence of growing earnings, overreacting to a long trend. Daniel, Hirshleifer, and Subrahmanyam (1998) related overreaction to overconfidence, as traders tend to overestimate the precision of their private signals, leading to prices being pushed above the fundamental level in the case of good news.

Some researchers also developed specific linear serial correlation tests to analyze the weak form of the EMH (Lim & Brooks, 2011). These tests simply examine the third version of the random walk hypothesis and have been adopted right from the start of the debate (e.g. Granger & Morgenstern, 1963; Fama, 1965a). However, the most popular linear serial correlation test was developed several decades after the start of the debate by Lo and MacKinlay (1988), when they presented their variance ratio (VR) test. The VR test can be used to check the null hypothesis of serially uncorrelated returns, which points towards informational efficiency of stock prices, and is expressed as the ratio of the k-period return variance over k times the variance of the one-period return. According to the random walk hypothesis, stock prices are following a random walk when the variance of the k-period return is the same as k times the variance of the one-period return. So in order to test whether returns are serially uncorrelated, it suffices to test whether the variance ratio is significantly different from one. Applying their own VR test, Lo and MacKinlay found that the random walk hypothesis does not hold for weekly stock market returns.

Unit root tests, which can examine the stationarity of stock returns, form a second class of weak form market efficiency tests. The basic idea is that stock returns that contain a unit root, and are hence non-stationary, are following a random walk (Lim & Brooks, 2011). The most popular approach to examine stationarity has proven to be the Augmented Dickey-Fuller (ADF) test, which is also examined for robustness in the next section. Current research has led to the development of more sophisticated tests of stationarity as well. However, it was shown that the existence of a unit root in stock returns is not a sufficient pre-requisite for the random walk hypothesis to hold (Rahman & Saadi, 2008). In addition to stationarity, returns need to be serially uncorrelated in order for those returns to be following a random walk.

The final class of weak form market efficiency tests considers non-linear serial dependence. Since linear autocorrelation tests only account for linear effects, some researchers pointed out that stock markets could exhibit inefficient behavior, even when linear autocorrelation tests point towards informational efficiency in the weak sense (Granger & Andersen, 1978). Among popular tests of non-linear serial dependence are the Hinich bicorrelation test (Hinich, 1996), the Engle Lagrange multiplier test (Engle, 1982) and the Brock-Dechert-Scheinkman test (Broock, Scheinkman, Dechert, & LeBaron, 1996). Almost every empirical paper employing one or more of these tests reports significant nonlinear serial dependence across worldwide stock markets (Lim & Brooks, 2011).

Despite the emergence of these different tests, a consensus on the validity of the EMH remained to be found. By the beginning of the 1990s, the debate had split researchers into two camps, believers of the EMH on the one hand, and proponents of behavioural finance on the other. As a reaction to the emergent body of anomalous evidence and the rise of behavioural finance, Fama (1991) wrote a second review covering tests of the different forms of the EMH. He concluded that the idea of efficient markets still remained valid because the observed anomalies tended to disappear over time and because anomalous traders seemed to cancel each other out.

Alternative approach to weak form market efficiency testing

Looking for a way to settle the debate and taking into account the paradox pointed out by Grossman and Stiglitz (1980), Campbell, Lo, MacKinlay, and Whitelaw (1998), suggested a new approach in testing for market efficiency. Instead of using all-or-nothing tests that did not lead to a definitive answer, they suggested an approach in which the degree of market efficiency was tested over time. This approach would enable researchers to draw more nuanced conclusions, which could eventually help move the debate along. Other than introducing this idea, Campbell et al. did not present a concrete approach. However, they inspired other researchers to come up with several alternative tests of market efficiency.

A first alternative approach is the non-overlapping sub-period analysis, which looks at different separated time windows and the evolution of efficiency between those windows (Lim & Brooks, 2011). This approach is only useful when examining the impact of a specific policy from one time window to another. For example, one could investigate the effects of a short sell prohibition on market efficiency. The first sub-period would then consist of all the historical data up until the last day before the prohibition took effect, and the second sub-period would start at the moment the prohibition was adopted until today.

Another possible alternative is the use of rolling estimation windows. The idea behind this alternative is to transform a data sample of n observations into n-l+1 windows, with l being the length of the window (Lim & Brooks, 2011). Here, the different time windows overlap, as they are pushed forward until the final observation is included in the last time window. This rolling approach allows researchers to look at underlying changes in efficiency on a shorter time scale than is the case with the non-overlapping sub-period analysis. Furthermore, rolling estimation windows accommodate a comparison of stock market efficiency through time, since a varying degree of efficiency is measured, rather than a static binary condition of efficiency.

Time-varying parameter models constitute a final alternative approach to market efficiency testing. This approach draws from state space models to allow standard regression parameters to change over time (Lim & Brooks, 2011). The greatest advantage is that this allows regression methods to be applied to more dynamic concepts like time-varying efficiency. Primarily, these models have been applied to developing stock markets, as these could not have been efficient from inception. The time-varying parameter model allows for an evolution of those markets towards efficiency, by letting regression parameters evolve through time. A static approach like one of the classic tests would not allow for this underlying shift in parameters and would thus be biased. Recently, however, different time-varying parameter models have also been applied to developed financial markets.

Despite the potential of these emerging methodological approaches, the debate remains unsettled. To further address the critiques uttered against the EMH, Fama (1998) wrote a third and final review on the empirical work testing market efficiency, and concluded that there is a lack of valid evidence to disprove his theory. In subsequent years, it seemed as if the discussion would never be settled and that it would slowly fade away to the history books. Nevertheless, advocates of behavioural finance did not rest their case and put in a lot of effort to make behavioural finance more known to a broader audience.

Current state of the debate

Today, there is still no definitive view on the efficiency of financial markets, even though proponents of both the EMH and behavioural finance have conducted further research. Shiller (2003) claims that theories of efficient markets should remain as a characterization of an ideal world, but not as an accurate description of global financial markets. Literally preceding the article of Shiller in the same journal, Malkiel (2003) argues that "if any $100 bills are lying around the stock exchanges of the world, they will not be there for long". His statement became a classical economics joke to explain that efficiency anomalies would not persist because someone would benefit from the opportunity immediately, through the price arbitrage mechanism.

Currently, there are two important reasons why the debate on efficient markets is still not settled. The first one relates to an alternative theoretical framework. Being critical of an existing theoretical framework is somewhat straightforward. Indeed, a theory is supposed to be imperfect as it is only a framework to describe reality. However, coming up with a new and improved theory is far less evident. Thus far, advocates of behavioural finance have failed in coming up with such a new theory that could replace the EMH. While several behavioural biases have been documented in the academic literature, there is still a lack of an overarching framework that could describe the efficiency of financial markets in a behavioural way.

Well aware of this problem, Lo (2004, 2005) looked at evolutionary biology to reconcile opinions from both ends of the efficiency spectrum when he formulated the adaptive markets hypothesis (AMH). In his theory, he also incorporates the concept of a varying degree of efficiency following Campbell et al. (1997). Despite its potential, the AMH has not yet replaced the EMH as the definitive theory on the efficiency of financial markets.

Empirical Studies

Mlambo and Biekpe (2001) investigated the weak-form efficiency of ten African stock markets namely Botswana, Bourse Regionales des Valeurs Mobilieres (BVRM), Egypt, Ghana, Kenya, Mauritius, Morocco, Zambia, Tunisia and Zimbabwe using the runs test methodology for serial dependency. Returns were calculated on a trade-to-trade basis and weighted by the number of days between trades. They found that serious thin-trading was observed on all markets, and more so for Namibia and Botswana, the two markets with significant dual-listed stocks on the JSE. In all the markets that they studied (except Namibia), a significant number of stocks rejected the random walk. Their study revealed that the Kenyan and Zimbabwean stock markets were also concluded as generally weak form efficient, since a significant number of stocks conformed to the random walk.

Simons and Laryea (2006) examined the efficiency of selected African stock markets namely South Africa, Egypt, Mauritius and Ghana using weekly and monthly data series from 1990 to 2003. They employed both nonparametric and parametric tests to ascertain weak form efficiency of these markets. Their results indicated that with the exception of South Africa, the stock markets in their sample were weak form inefficient. They also used Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) models to forecast future returns in the Ghanaian, Mauritian and Egyptian markets to exploit their inefficiency. In these markets, the models generated forecasts that outperformed the naïve model, confirming our earlier results.

Frimpong and Oteng-Abayie (2007) found out that the Ghana Stock Exchange is weak form inefficient. Their results from the random walk (RW) and GARCH models unanimously rejected the presence of random walks in the Databank Stock Index (DSI) daily market returns. Furthermore, they tested for nonlinearity which proved the strength of the McLeod-Li and Brock, Dechert and Scheinkman (BDS) test that the residuals of the market returns do not follow a random walk generating process. Their findings in this study indicate that the Ghana Stock Exchange is weakly inefficient. Their results from the RW and GARCH models unanimously reject the presence of random walks in the DSI daily market returns. Furthermore, the tests for nonlinearity proved on the strength of the McLeod-Li and BDS test that the residuals of the market returns do not follow a random walk generating process. The absence of random walks infers distortions in asset pricing and risk, a mark of market inefficiency

Ntim et al. (2008) had the objective to empirically ascertain whether the distributional properties of African continent-wide stock price indices differ from their national counterparts. Their study revealed that, irrespective of the diagnostic used, the 24 African continent-wide stock price indices returns are less non-normally distributed than any of the eight individual national stock price indices in their study. They recorded the evidence of statistically significant improvements in the informational efficiency of the African continent-wide stock price indices over the individual national stock price indices. The majority of the African continent-wide stock price indices returns are weak-form efficient against the robust Wright's (2000) ranks and signs tests. By contrast, none of the individual national indices are efficient against the ranks and signs tests.

Mecagni and Sourial (1999) empirically investigated the behaviour of Egyptian stock market returns, the informational efficiency of the market, and the relationship between volatility and returns in light of the key role that a well-functioning stock market may play to promote higher rates of savings, investment and economic growth. The study found that irrespective of the index examined, ESE stock returns are characterized by a distribution departing from a normal one, and by volatility that tends to change over time and to be serially correlated. For all indices the ESE stock returns also display significant serial correlation, in turn implying the existence of deviations from market efficiency in the pricing of equities.

Omay and Karadagli (2010) in their paper tested whether the Bulgarian, Greek, Hungarian, Polish, Romanian, Russian, Slovenian and Turkish stock price series contain unit root, consistent with weak form efficiency. Using nonlinear unit root test due to Kapetanios, Shin, and Snell (2003), they rejected the null hypothesis of unit root for Russian, Romanian and Polish stock price series. Conducting a linear panel unit root test, they found that this group of countries' stock markets are all efficient whereas a nonlinear panel unit root test revealed that as a group they are inefficient in the weak form sense.

Jefferis and Smith (2005) classified formal African stock markets into four categories: South Africa, medium-sized markets, small new markets which have experienced rapid growth, and small new markets which have yet to take off. Using a GARCH approach with time varying parameters, a test of evolving efficiency were implemented for the seven markets covered in their study: South Africa, Egypt, Morocco, Nigeria, Zimbabwe, Mauritius and Kenya, for periods starting in the early 1990s and ending in June 2001. Their study found that the Johannesburg stock market is weak form efficient throughout the period, and three stock markets became weak form efficient towards the end of the period: Egypt and Morocco from 1999 and Nigeria from early 2001.

These contrast with the results for the Kenya and Zimbabwe stock markets which showed no tendency towards weak form efficiency, and the Mauritius market which displayed a very slow tendency to eliminate inefficiency. They concluded that differences in stock market efficiency can be related to turnover, capitalization and the institutional characteristics of markets

Hall, Urga, and Zalewska-Mitura (1998), in their paper, proposed a test of changing market efficiency based on a time varying parameter model with GARCH in mean effects. They demonstrated the effectiveness of their model via a Monte Carlo study, which showed that their approach was quite effective at capturing both the level and the speed of change of time varying correlation structure in a series of returns.

By applying this procedure to the returns from two indices of the Russian stock market, they demonstrated that the market was initially inefficient and that it took something of the order of two and a half years to become efficient. They then applied the technique to a range of individual shares on the market and found the result that some of them seemed to be efficient while others were not. Further amongst the inefficient shares there seemed to be no tendency towards becoming efficient.

Worthington and Higgs (2004) studied the weak-form market efficiency in European emerging and developed stock markets by employing tests of serial correlation (parametric and non-parametric), unit root tests and multiple variance test statistics. The results for the tests of serial correlation in their study conclusively rejected the presence of random walks in daily returns for all markets save Germany, Ireland, the Netherlands, Portugal and the United Kingdom. Similarly, they found that the unit root tests concluded that unit roots, as necessary conditions for a random walk, were absent from all or nearly all of the return series. Finally, the multiple variance ratio procedure conclusively rejects the presence of random walks in most European markets. In their study, among the developed markets, only Germany, Ireland, Portugal, Sweden and the United Kingdom satisfy the most stringent random walk criteria with France, Finland, the Netherlands, Norway and Spain meeting at least some of the requirements of a strict random walk. Among the emerging markets, only Hungary satisfied the strictest requirements for a random walk in daily stock returns.

By examining the weak form of efficiency on the four major stock exchanges of South Asia including Karachi stock index 100 (KSE-100), Bombay stock exchange sensitive index (BSE-SENSEX), Colombo stock exchange Milanka price index (CSE-MPI) and Dhaka stock exchange general index (DSE-GEN), Nisar and Hanif (2012) employed four different statistical tests including runs test, serial correlation, unit root and variance ratio tests. They found that in case of KSE monthly, BSE weekly and monthly, and DSE weekly and monthly, results support market efficiency while in daily return case none of the market is efficient. The Durbin Watson test suggests that in all the four major stock markets there is a correlation among the past successive returns. By applying the ADF test to test the unit root on the four major stock exchanges of South Asia, they found that all the stock exchange returns do not contain unit root and thus there is predictability in calculating the future returns of all the four major stock exchanges of South Asia and these are not weak form of efficient markets. The variance ratio test revealed that the stock market returns do not follow a random walk and hence it is evidence of market inefficiency. Their results were consistent with each other except run test providing evidence against market efficiency.

Islam, Watanapalachaikul and Clark (2007) employed runs test and autocorrelation function test the degree of efficiency of the Thai stock market. Their results show that that there is an autocorrelation on Thai stock market returns indicating weak form market inefficiency. The runs test confirmed that the Thai stock market is inefficient in the weak sense.

Conclusion

This chapter reviewed the economic origins of market efficiency, statistical foundations of market efficiency, economic foundations of market efficiency, asset pricing revolution, the random walk theory, forms of market efficiency, behavioural finance theory and the limitations of the efficient market hypothesis as well as empirical studies on efficient market hypothesis on several stock markets around the world. The chapter revealed that efficiency of financial and economic markets can be traced back to Adam Smith while the concept of market efficiency had been anticipated at the beginning of the 20th century. The review of random walk hypothesis in the context of market efficiency revealed that the price of a stock is equal to its price today plus a purely random shock thus making forecasting asset prices futile.

CHAPTER FOUR

METHODOLOGY

Introduction

The aim of this chapter is to capture the research design, develop and specify empirical models for the various tests of weak form market efficiency as well as test for evolving efficiency through time.

Study design

The research employs quantitative in the data analysis. The philosophy behind the choice of this type of research design is guided by: Dow Theory, Elliot Wave Theory and the Fundamentalist theory. The Dow Theory is a method of evaluating future security prices and market directions based on statistical analysis of variables such as trading volume, price changes with the aim to identifying any discernible patterns. The Elliot Wave Theory states that security prices are governed by cycles founded upon the Fibonacci series (trend line theory) (1-2-3-5-8-13-21......) and the fundamental theory studies the cause of market movement, supply - demand factors, as well as government interventions.

Theoretical Model of Efficient Market Hypothesis

Before the efficiency issues of African stock markets are examined, there is the need to revisit the definition of EMH. The EMH is a statement about

1. the theory that stock prices reflect the true value of stocks;

2. the absence of arbitrage opportunities in an economy populated by rational, profit-maximizing agents; and
3. the hypothesis that market prices always fully reflect available information (Fama 1970; Islam et al 2007).

In Jensen (1978), an efficient market is defined with respect to an information set Φ_t if it is impossible to earn economic profits by trading on the basis of Φ_t. Fama (1970) presented a general notation describing how investors generate price expectations for stocks. This could be explained as (Cuthbertson, 1996):

$$E(p_{j,t+1} \mid \Phi_t) = [1 + E(r_{j,t+1} \mid \Phi_t)]p_{jt} \quad (2)$$

where E is the expected value operator, $p_{j,t+1}$ is the price of security j at time t+1, $r_{j,t+1}$ is the return on security j during period t+1, and Φ_t is the set of information available to investors at time t. The left-hand side of the formula $E(p_{j,t+1} \mid \Phi_t)$ denotes the expected end-of-period price on stock j, given the information available at the beginning of the period Φ_t. On the right-hand side, $1 + E(r_{j,t+1} \mid \Phi_t)$ denotes the expected return over the forthcoming time period of stocks having the same amount of risk as stock j.

Under the efficient market hypothesis (EMH), investors cannot earn abnormal profits on the available information set Φ_t other than by chance. The level of over value or under value of a particular stock is defined as:

$$x_{j,t+1} = p_{j,t+1} - E(p_{j,t+1} \mid \Phi_t) \quad (3)$$

where $x_{j,t+1}$ indicates the extent to which the actual price for security j at the end of the period differs from the price expected by investors based on the information available Φ_t. As a result, in an efficient market it must be true that:

$$E(x_{j,t+1} \mid \Phi_t) = 0 \quad (4)$$

This implies that the information is always impounded in stock prices. Therefore the rational expectations of the returns for a particular stock according to the EMH may be represented as:

$$P_{t+1} = E_t P_{t+1} + \varepsilon_{t+1} \quad (5)$$

where P_t is the stock price; and ε_{t+1} is the forecast error. $P_{t+1} - E_t P_{t+1}$ should therefore be zero on average and should be uncorrelated with any information Φ_t. Also $E(x_{j,t+1} \mid \Phi_t) = 0$, the expected value of the forecast error, is zero:

$$E_t \varepsilon_{t+1} = E_t (P_{t+1} - E_t P_{t+1}) = E_t P_{t+1} - E_t P_{t+1} = 0. \quad (6)$$

Underlying the efficiency market hypothesis, it is opportune to mention that expected stock returns are entirely consistent with randomness in security returns. This position is supported by the law of iterated expectations (Campbell et al. 1997; Samuelson 1965). The expectational difference equation can be solved forward by repeatedly substituting out future prices and using the law of iterated expectations:

$$E_t [E_t + I_t (X)] = E_t(X). \quad (7)$$

Data Description and Source

The countries considered in this study are South Africa, Egypt, Zimbabwe, Nigeria, Ghana and Mauritius. The choice of countries is motivated by the availability and the periodicity in the data series and also to ascertain if efficiency is related to the size and depth of the market, in terms of market capitalization and the volume of trading (Simons & Laryea 2006). Thus South Africa, Egypt and Zimbabwe are examples of bigger and established markets, whereas Nigeria, Ghana and Mauritius represent smaller and relatively newer markets.

To ensure a representation of all stock markets in Africa, the stock markets of these countries were purposively chosen. Ghana and Nigeria stock markets represent Western block of Africa, Egypt Northern block, Mauritius Eastern block and South Africa and Zimbabwe southern block.

The data employed in the study is composed of weekly and monthly market value-weighted equity indices for six African equity markets – Ghana, Nigeria, Egypt , Mauritius, Zimbabwe and South Africa. All data used in this study were obtained from Datastream. Data for South Africa, Egypt and Zimbabwe were organized by Morgan Stanley Capital International (MSCI) and specified in domestic currency while data for Ghana, Nigeria and Mauritius were organized by Standards and Poors (S&P). A composite index is not produced for the Zimbabwe Stock Exchange – only separate indices for the industrial and mining sectors. Since the stock market is dominated by the industrial sector, this index is used.

The series encompass dissimilar sampling periods given the varying availability of each index with Zimbabwe starting on 19th February 2009, South Africa on 1st June 1995, Ghana and Mauritius on 29th December 1995, Nigeria on 30th June 1995, and Egypt on 30th December 1994. The end date for Egypt and Ghana is 15th November 2013 while the end date for Nigeria, Zimbabwe, South Africa and Mauritius are 31st October 2013, 19th November 2013, 21st November 2013, and 29th October 2013 respectively.

Weekly and monthly data are specified. The natural log of the relative price is computed for the weekly intervals to produce a time series of continuously compounded returns, such that:

$$R_t = \ln P_t - \ln P_{t-1} \tag{8}$$

Where

R_t = market return for period t

P_t = market index for period t

P_{t-1} = market index for period t-1

ln = natural logarithm

to test the hypothesis that the stock market of the economies of interest is weak-form efficient.

Tests for Market Efficiency

Random Walk Hypothesis

There are three possible forms of the random walk according to Campbell et al. (1997). The simplest, but strongest form of the random walk (RW1) is the one with independently and identically distributed (IID) increments with zero mean and constant variance, denoted by $u_t \sim IID(0,\sigma^2)$: For example, assume the time-series at hand is the return on a certain stock. The equation of the first version of the random walk then tells us that the return of today is equal to the return of yesterday plus an expected return change or drift and a certain IID random error term (Smith & Jefferies, 2005). The expected price of today will thus be equal to the price of yesterday plus a certain drift. The second version of the random walk (RW2) is a generalization of the first one, as the increments are only assumed to be independently but not identically distributed (INID), which allows for unconditional heteroskedasticity in the $\{u_t\}$. The reason for this generalization is purely empirical, as stock returns have proven to be distributed in a non-identical way through time. This ought to be no surprise since a lot has changed throughout the years. Stock markets have evolved in terms of economic, technological, social, institutional and regulatory aspects.

As a consequence, stock prices and stock returns are not identically distributed through time and a less constrained model that accounts for this statistical property is needed. The third and final version of the random walk is a further generalization of the independent increment model (RW2). It is now assumed that the increments are uncorrelated but not independently and not identically distributed (NIID). The reason for this further relaxation of assumptions is again empirical. Especially for stock prices, researchers have found it implausible for today's stock return to be completely independent from yesterday's return. The uncorrelated increment model (RW3), because of its more realistic assumptions, has proven to be the most popular to test for random walks in stock return time-series (Smith & Jefferis, 2005).

The analysis starts from this third version of the random walk as well. There is also the need to point out the link between random walks and weak form efficient markets. As we saw before, a weak form efficient financial market is a market in which all past price information is fully reflected in stock prices. Therefore, it is impossible to predict future prices based on past price information. The random walk model says precisely the same as this weak form efficient market condition. The stock price of tomorrow is unpredictable, as there is no way of predicting the arbitrary drift term.

This parallel between the weak form market efficient condition and the random walk made it interesting for researchers to test weak form market efficiency indirectly, by testing if stock returns are following a random walk (RW3). This is also the exact principle that is used in the various market efficiency test like the Variance Ratio test. This paper focuses on RW3, with volatilities changing over time.

Unit root tests

Two different unit root tests are used to test the null hypothesis of a unit root in this study: namely, the Augmented Dickey-Fuller (ADF) test, the Phillips-Peron (PP) test. To start with, the well-known ADF unit root test of the null hypothesis of non-stationarity is conducted in the form of the following regression equation:

$$R_{it} = \alpha_0 + \alpha_1 t + \rho_0 R_{it-1} + \sum_{i=1}^{q} \rho_i R_{it-i} + \varepsilon_{it} \quad (9)$$

where R_{it} denotes the price for the i-the market at time t, ρ are coefficients to be estimated, q is the number of lagged terms, t is the trend term, α_1 is the estimated coefficient for the trend, α_0 is the constant, and ε is white noise.

Thus, the ADF, and the PP test the null hypothesis that a series contains unit root (non-stationary) against the alternative hypothesis of no unit root (stationary).

That is:

H_0: $\rho = 0$

H_0: $\rho \neq 0$

MacKinnon's critical values are used in order to determine the significance of the test statistic associated with ρ_0. The PP incorporates an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root by estimating the non-augmented Dickey-Fuller test equation and modifying the test statistic so that its asymptotic distribution is unaffected by serial correlation. The chosen alpha level for this study is 5 percent. Therefore if the t-statistic is less than -2.86 (critical value at 5%), the null hypothesis is rejected and conclude that the series is stationary. On the other hand, if the t-statistic is greater than -2.86, the null hypothesis will not be rejected and the conclusion will be that the series is non-stationary and thus stock series follow a random walk.

It should be noted that one of the main weaknesses of ADF is that in the presence of a structural break, the standard ADF tests are biased towards the non-rejection of the null hypothesis. Perron argues that most series (macroeconomic and stock) are not characterized by a unit root but rather that persistence arises only from large and infrequent shocks, and that the economy or market returns to deterministic trend after small and frequent shocks. Most macroeconomic and stock market time series are not characterized by the presence of a unit root. Fluctuations are indeed stationary around a deterministic trend function.

Due to this, the PP test deals with potential serial correlation in the errors by employing a correction factor that estimates the long–run variance of the error process with a variant of the Newey–West (1994) formula. In principle, the PP tests should be more powerful than the ADF alternative though both use same critical values for their tests.

One advantage of the PP tests over the ADF tests is that the PP tests are robust to general forms of heteroskedasticity in the error term U_t. However, the issue has been raised by some authors in relation to the trade-off between the power of the test and the amount of information incorporated with respect to the choice of break point. Again, these tests only capture the single most significant break in each variable, raising questions about the presence of multiple breaks in each individual variable. Though, the PP has been shown to exhibit serious size distortions in the presence of negative autocorrelations, the PP test complements the ADF for unit root and that is why this study uses the ADF and PP test to verify whether or not the stock market series follow a random walk.

Run Test

The run test, also called Geary test, is a non-parametric test whereby the number of sequences of consecutive positive and negative returns is tabulated and compared against its sampling distribution under the random walk hypothesis (Campbell et al. 1997; Gujarati, 2003). A run is defined as the repeated occurrence of the same value or category of a variable. It is indexed by two parameters, which are the type of the run and the length. Stock price runs can be positive, negative, or have no change. The length is how often a run type occurs in succession (Gujarati, 2008). Under the null hypothesis that successive outcomes are independent, the total expected number of runs is distributed as normal with the following mean:

$$\mu = \frac{N(N+1) - \sum_{i=1}^{3} n_i^2}{N} \tag{10}$$

and the following standard deviation:

$$\sigma_\mu = \left[\frac{\sum_{i=1}^{3}[\sum_{i=1}^{3} n_i^2 + N(N+1)] - 2N(\sum_{i=1}^{3} n_i^3 - N^3)}{N^2(N-1)}\right]^{\frac{1}{2}} \tag{11}$$

where n_i is the number of runs of type I and N is the number of observations. The test for serial dependence is carried out by comparing the actual number of runs, a_r in the price series, to the expected number μ. The null proposition is:

H_0 : E(runs) = μ

H_1: E(runs) ≠ μ

Calculated Z-statistics for the run test are reported in the results chapter. If Z-statistic is between -1.96 and +1.96, the null hypothesis is not rejected which means that prices of the stock appears in random fashion, that is, the stock market is weak form efficient. And if Z-statistic is less than -1.96 and greater than +1.96, the null hypothesis is rejected which means that stock prices appear in random fashion.

Multiple variance ratio tests

Variance ratio (VR) test initially proposed by Lo and MacKinlay is used to detect autocorrelation and heteroskedasticity in the returns. Based on Lo and MacKinlay's (1988) earlier single variance ratio (VR) test, Chow and Denning (1993) adjust the focus of the tests from the individual variance ratio for a specific interval to one more consistent with the random walk hypothesis by covering all possible intervals. As shown by Lo and MacKinlay (1988), the variance ratio statistic is derived from the assumption of linear relations in observation interval regarding the variance of increments. If a return series follows a random walk process, the variance of a qth-differenced variable is q times as large as the first-differenced variable. For a series partitioned into equally spaced intervals and characterised by random walks, one qth of the variance of ($R_t - R_{t-q}$) is expected to be the same as the variance of ($R_t - R_{t-1}$):

$$Var(R_t - R_{t-q}) = qVar(R_t - R_{t-1}) \tag{12}$$

Where q is any positive integer. The variance ratio is then denoted by:

$$VR(q) = \frac{\frac{1}{q}Var(R_t - R_{t-q})}{Var(R_t - R_{t-1})} = \frac{\sigma^2(q)}{\sigma^2(1)} \tag{13}$$

such that under the null hypothesis VR(q) = 1. For a sample size of nq + 1 observations ($R_0, R_1, \ldots, R_{nq}$), Lo and Mackinlay's (1988) unbiased estimates of $\sigma^2(1)$ and $\sigma^2(q)$ are computationally denoted by:

$$\hat{\sigma}^2(1) = \frac{\sum_{k=1}^{nq}(R_k - R_{k-1} - \hat{\mu})^2}{(nq-1)} \tag{14}$$

And

$$\hat{\sigma}^2(q) = \frac{\sum_{k=q}^{nq} (R_k - R_{k-q} - q\hat{u})^2}{h} \qquad (15)$$

where $\hat{\mu}$ sample mean of ($R_t - R_{t-1}$): and:

$$h \equiv q(nq+1-q)(1-\frac{q}{nq}) \qquad (16)$$

Lo and Mackinlay (1988) produce two test statistics, Z(q) and Z*(q), under the null hypothesis of homoskedastic increments random walk and heteroskedastic increments random walk respectively. If the null hypothesis is true, the associated test statistic has an asymptotic standard normal distribution. With a sample size of nq + 1 observation (R_0, R_1,…, R_{nq}) and under the null hypothesis of homoskedastic increments random walk, the standard normal test statistic Z(q) is:

$$z(q) = \frac{\hat{VR}(q) - 1}{\hat{\sigma}_0(q)} \qquad (17)$$

Where

$$\hat{\sigma}_0(q) = \left[\frac{2(2q-1)(q-1)}{3q(nq)}\right]^{\frac{1}{2}} \qquad (18)$$

The test statistic for a heteroskedastic increments random walk, Z*(q) is:

$$Z^*(q) = \frac{\hat{VR}(q) - 1}{\hat{\sigma}_e(q)} \qquad (19)$$

Where

$$\hat{\sigma}_e(q) = \left[4\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2 \hat{\delta}_k\right]^{\frac{1}{2}} \qquad (20)$$

And

$$\frac{\sum_{j=(k+1)}^{nq} (R_j - R_{j-1} - \hat{\mu})^2 (R_{j-k} - R_{j-k-1} - \hat{\mu})^2}{\left[\sum_{j=1}^{nq} (R_k - R_{k-q} - q\hat{u})\right]^2} \qquad (21)$$

Lo and MacKinlay's (1988) procedure is devised to test individual variance ratios for a specific aggregation interval, q, but the random walk hypothesis requires that VR(q) = 1 for all q. Chow and Denning's (1993) multiple variance ratio (MVR) test generates a procedure for the multiple comparison of the set of variance ratio estimates with unity. For a single variance ratio test, under the null hypothesis, VR(q) = 1, hence Mr(q) = VR(q) – 1 = 0. Consider a set of m variance ratio tests {Mr(qi)i = 1,2,…,m}. Under the random walk null hypothesis, there are multiple sub-hypotheses:

H_{0i}: $M_r(q_i) = 0$ for i = 1,2,…,m

H_{1i}: $M_r(q_i) \neq 0$ for any i = 1,2,…,m

The rejection of any one or more H_{0i} rejects the random walk null hypothesis. For a set of test statistics, say Z(q), {Z(q_i)|i = 1,2,…,m}, the random walk null hypothesis is rejected if any one of the estimated variance ratio is significantly different from one. Hence only the maximum absolute value in the set of test statistics is considered. The core of the Chow and Denning's (1993) MVR test is based on the result:

$$PR\{\max(Z(q_1)|,...,|Z(q_m|) \leq SMM(\alpha;m;T) \qquad (22)$$

Where $SMM(\alpha;m;T)$ is the upper α point of the Standardized Maximum Modulus (SMM) distribution with parameters m (number of variance ratios) and T (sample size) degrees of freedom. Asymptotically when T approaches infinity:

$$\lim_{T \to \infty} SMM(\alpha; m; \infty) = Z_{\alpha^*/2} \tag{23}$$

Where $Z_{\alpha^*/2}$ = standard normal distribution and $\alpha^* = 1-(1-\alpha)^{1/m}$. Chow and Denning (1993) control the size of the MVR test by comparing the calculated values of the standardized test statistics, either Z(q) or Z*(q) with the SMM critical values. If the maximum absolute value of, say Z(q) is greater than the SMM critical value then the random walk hypothesis is rejected. Importantly, the rejection of the random walk under homoskedasticity could result from either heteroskedasticity and/or autocorrelation in the equity price series. If the heteroskedastic random walk is rejected then there is evidence of autocorrelation in the equity series. With the presence of autocorrelation in the price series, the first order autocorrelation coefficient can be estimated using the result that $\hat{M}_r(q)$ is asymptotically equal to a weighted sum of autocorrelation coefficient estimates with weights declining arithmetically:

$$\hat{M}_r(q) = 2\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)\hat{\rho}(k) \tag{24}$$

Where q=2:

$$\hat{M}_r(2) \equiv \hat{VR}(2) - 1 = \hat{\rho}(1) \tag{25}$$

Conventional variance-ratio (VR) tests developed by Lo and MacKinlay (1988) have been widely used to test the random walk hypotheses of the weak-form market efficiency (Ayadi & Pyun, 1994; Urrutia, 1995; Simons & Laryea, 2006). However, Wright (2000), demonstrates that Lo and MacKinlay’s (1988) parametric variance-ratio tests lack power when returns of financial assets are non-normal (Appiah-Kusi & Menyah, 2003; Jefferis & Smith, 2005). Therefore, with evidence of non-normality in African stock returns increasing, the study adopts non-parametric variance-ratio tests developed by Wright (2000) to test the random walk hypotheses. In statistics, non-parametric tests are generally known to be more powerful in the presence of non-normality (Luger, 2003; Ntim et al).

As already noted, the Lo–MacKinlay tests, which are asymptotic tests whose sampling distribution is approximated based on its limiting distribution, are biased and right-skewed in finite samples. In this respect, Wright (2000) proposed a non-parametric alternative to conventional asymptotic VR tests using signs and ranks. Wright's (2000) tests have two advantages over the Lo–MacKinlay test when sample size is relatively small: (1) as the rank (R_1 and R_2) and sign (S_1 and S_2) tests have an exact sampling distribution, there is no need to resort to asymptotic distribution approximation, and (2) the tests may be more powerful than the conventional VR tests against a wide range of models displaying serial correlation, including fractionally integrated alternatives. The tests based on ranks are exact under the NIID assumption, whereas the tests based on signs are exact even under conditional heteroskedasticity. Moreover, Wright (2000) showed that ranks-based tests display low-size distortions, under conditional heteroskedasticity.

Given a variable in first differences $\{x_t\}_{t=1}^{T}$, let r(x) be the rank of x_t among

(x_t, . . . , x_t). Under the null hypothesis that x_t is generated from an NIID sequence, r(x) is a random permutation of the numbers of 1, . . . , T with equal probability. Wright (2000) suggested the R_1 and R_2 statistics, defined as

$$R_1(k) = \left(\frac{(Tk)^{-1} \sum_{t=k}^{T} (r_{1,t} + \ldots + r_{1,t-k+1})^2}{T^{-1} \sum_{t=k}^{T} r_{1,t}^2} - 1 \right) \times \phi(k)^{-1/2} \tag{26}$$

$$R_2(k) = \left(\frac{(Tk)^{-1} \sum_{t=k}^{T} (r_{2,t} + \ldots + r_{2,t-k+1})^2}{T^{-1} \sum_{t=k}^{T} r_{2,t}^2} - 1 \right) \times \phi(k)^{-1/2} \tag{27}$$

Where the standardized ranks $r_{1,t}$ and $r_{2,t}$ are given by

$$r_{1,t} = \frac{r(x_t) - (T+1)/2}{\sqrt{((T-1)(T+1)/12)}} \tag{28}$$

$$r_{2,t} = \Phi^{-1} \frac{r(x)}{T+1} \tag{29}$$

where φ(k) is defined as

$$\phi(k) = \frac{2(2k-1)(k-1)}{3kT} \tag{30}$$

and ϕ^{-1} is the inverse of the standard normal cumulative distribution function. The R_1 and R_2 statistics follow the same exact sampling distribution. The critical values of these tests can be obtained by simulating their exact distributions.

The tests based on the signs of first differences are given by

$$S_1(k) = \left(\frac{(Tk)^{-1} \sum_{t=k}^{T} (s_t + \ldots + s_{t-k+1})^2}{T^{-1} \sum_{t=k}^{T} s_t^2} - 1 \right) \times \phi(k)^{-1/2} \quad 31$$

$$S_2(k) = \left(\frac{(Tk)^{-1} \sum_{t=k}^{T} (s_t(\bar{\mu}) + \ldots + s_{t-k+1})^2}{T^{-1} \sum_{t=k}^{T} s_t^2} - 1 \right) \times \phi(k)^{-1/2} \quad 32$$

where φ(k) is defined in (30), $s_t = 2u(x_t, 0)$, $s_t(\bar{\mu}) = 2u(x_t, \mu)$ and

$$u(x_t, q) = \begin{cases} 0.5 & if \quad x_t > q \\ -0.5 & otherwise \end{cases} \tag{33}$$

In a Monte-Carlo experiment and empirical testing, Wright (2000) demonstrates that the ranks (R_1 and R_2) are robust under the assumption of homoskedasticity (random walk hypothesis), while the signs (S_1 and S_2) are powerful under heteroskedastic (random walk hypothesis) conditions (Ntim et al, 2008).

In this study, the Z-statistic for R_1, R_2 and S_1 are reported in the results section for variance ratio test. The test probabilities are computed using permutation bootstrap with 1000 replications. Given that the chosen alpha for this study is 5 percent, if the calculated p-value is 0.05 and greater, the null hypothesis is not rejected which means that prices of the stock appears in random fashion, that is, the stock market is weak form efficient. And if the calculated p-value is less than 0.05, the null hypothesis is rejected which means that stock prices appear in random fashion.

Modelling Evolving Market Efficiency through time

The weak form efficiency hypothesis requires that there should be no profit opportunities which are based on the past movement in asset prices. This means that an efficient market should be an unpredictable one. This has often been tested by carrying out simple regressions of the form:

$$R_t = \beta_0 + \beta_i R_{t-1} + u_t \tag{34}$$

where $R_t = P_t - P_{t-1}$ is the natural logarithm of rate of return on an asset and weak form efficiency implies that $B_i = 0, i > 0$, and so $P_t = B_0 + P_{t-1} + U_t$

Equation 34 above is often tested by estimating such equations, either using ordinary least squares (OLS) or generalized method of moments (GMM) and simply testing this hypothesis. In the case of the African Stock markets this is not however, a very sensible approach as it would effectively be testing efficiency over the whole period of their existence and it is hardly credible that they came into being as fully efficient markets. The early inefficiency would therefore bias the results of the estimation and test and one may conclude that there are profit opportunities simply because of past inefficiencies (Laurence, 1986).

There is the need to find some way of allowing the estimation procedure to model this changing structure so as to achieve two aims. First there should be a measure or test of current market efficiency so that the possibility of present profit opportunities can be accessed.

Second there must be a measure of the timing of the move (if it has occurred) towards full efficiency, so that we will be able to say something about how quickly markets learn to become efficient and to exploit the former profit opportunities. This can be achieved only by developing a version equation 34 which explicitly allows for the changing parameters which may be present. This can be done initially be reformulating equation 34 as

$$R_t = \beta_{0t} + \beta_{it} R_{t-1} + u_t \qquad (35)$$

so that the parameters now have time subscripts and can vary over time (Hall et al, 1998)

A second important element of conventional financial models is that the error process will often not prove to have a full set of NIID properties. If in particular the variance of the error process is changing over time in a systematic way this will cause problems for the testing procedure and it may also affect the required rate of return. If this changing variance structure is omitted and also has a serial correlation property then again one may find spurious correlation's and incorrectly reject market efficiency. This can be dealt with by combining the time varying parameter model with a standard GARCH-M model in the following way (see Jefferis & Smith, 2005):

$$R_t = \beta_{0t} + \beta_{1t} R_{t-1} + \delta h_t + u_t \qquad (36)$$

$$u_t \mid \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = a_0 + a_1 u_{t-1}^2 + \gamma h_{t-1} \qquad (37)$$

$$\beta_{it} = \beta_{it-1} + v_{it} \qquad (38)$$

$$i = 0,1 \qquad v_{it} \sim N(0, \sigma_i^2)$$

Where h_t is the conditional variance of the error term and Φ is the information set available at time t. This set of equations (36, 37 and 38) is then a standard state space model which is estimated by using the Kalman Filter. The Kalman filter sequentially updates coefficient estimates and generates the set of $\hat{\beta}_{it}$ s, i=0,1 and t=1…T and their standard errors.

From equation 36, a market is efficient when $\hat{\beta}_{1t}$ =0. However $\hat{\beta}_{1t}$ is variable so its value is different for every observation. This implies that there will be N-1 values of $\hat{\beta}_{1t}$ where N is the number of observations. Therefore a market will tend towards weak form efficiency as the values of $\hat{\beta}_{1t}$ consistently approach zero (0). Graphs of $\hat{\beta}_{1t}$ will therefore illustrate the evolution of weak form efficiency through time. According to Hall et al. (2005) and Smith and Jefferies (2005), if the values of $\hat{\beta}_{1t}$ lie within the range ±0.1, then the market is weak form efficient. If the values of $\hat{\beta}_{1t}$ lie without that range, then the market is not weak form efficiency.

Apriori Expectations

Given the results of previous studies, it is expected that the stock return series of Johannesburg Stock Exchange will follow a random walk while all the remaining five stock markets in this study are less likely to follow a random walk.

Conclusion

In this chapter, the analytical framework for the various tests for weak form market efficiency and the test for evolving efficiency has been discussed. Wright's non-parametric variance ratio test was identified to be more robust than all tests used in this study. Lastly the expected results for each stock market studied in this model were discussed. Having set out the analytical framework, the next chapter moves on to test the weak form market efficiency of the countries of interest in this study.

CHAPTER FIVE

RESULTS AND DISCUSSION

Introduction

This chapter presents and analyses the results of the tests for weak form market efficiency outlined in chapter four. The main objective of this study is to test the weak form market efficiency of the Egypt, Ghana and Mauritius, Nigeria, South Africa and Zimbabwe stock markets. The chapter is divided into three main sections. The time series properties of the stock market returns series are presented in the first section. The second section presents results of battery of tests of weak form market efficiency for all stock exchanges in this study. Among the battery of tests, the unit root test for stationarity in the stock market series is conducted first, then the run test and finally the variance ratio test. Test for evolving efficiency is presented in the final section. These results are discussed in relation to the hypotheses of the study.

Time series properties of stock returns

In this section, an analysis of the descriptive statistics is carried out and presented. These statistics mean, median, standard deviation, skewness, kurtosis, Jarque-Bera and p-values are reported. Table 3 shows a summary of the descriptive statistics of the variables at levels. P-values are in parentheses.

The lowest mean weekly and monthly stock returns are in Mauritius followed by South Africa and the highest are in Zimbabwe followed by

Nigeria. The mean monthly returns for Zimbabwe are 1.65 times that of Mauritius.

Table 2: Descriptive Statistics of Returns for the African Stock Markets used in the Study

Descriptive Statistics	Mean	Std Dev	Skewness	Kurtosis	Jarque-Bera
Weekly Egypt	.002571	.039965	-.410658 (0.0000)	6.69128 (0.0000)	586.901 (0.0000)
Monthly Egypt	.011104	.0922428	-.087323 (0.5813)	4.18016 (0.0062)	13.4026 (0.0000)
Weekly Ghana	.002573	.02286	1.25728 (0.0000)	20.5348 (0.0000)	12198.72 (0.0000)
Monthly Ghana	.011196	. 056638	.632024 (0.0003)	6.11786 (0.0000)	100.9271 (0.0000)
Weekly Mauritius	.001901	.023822	-.062761 (0.4307)	21.7322 (0.0000)	13641.61 (0.0000)
Monthly Mauritius	.008261	.053608	-1.00280 (0.0000)	8.9744 (0.0000)	354.1403 (0.0000)
Weekly Nigeria	.002923	.032180	-.172202 (0.0294)	6.49056 (0.0000)	491.595 (0.0000)
Monthly Nigeria	.012710	.080577	-.266010 (0.1017)	9.0142 (0.0000)	334.1678 (0.0000)
Weekly South Africa	.002316	.02824	-.434846 (0.0000)	7.8810 (0.0000)	982.2103 (0.0000)
Monthly South Africa	.010200	.058659	-1.00265 (0.0000)	8.65600 (0.0000)	330.1049 (0.0000)
Weekly Zimbabwe	.003133	.047225	-.929233 (0.0000)	19.8890 (0.0000)	2983.146 (0.0000)
Monthly Zimbabwe	.013614	.140612	-.424308 (0.1612)	11.91757 (0.0000)	190.5774 (0.0000)

Note: P-values in Parenthesis

Source: Computed from stock price indices of Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe stock markets in Datastream

The standard deviations of monthly stock returns vary from 0.053608 (Mauritius) to 0.140612 (Zimbabwe) while that of weekly stock returns vary from 0.02286 (Ghana) to 0.047225 (Zimbabwe). Given the standard deviation values, variability is quite similar for Mauritius, Ghana and South Africa while returns for Zimbabwe are considerably more volatile (2.62 times that of Mauritius). According to Sourial and Mecagni (1999) a highly volatile stock returns is an indication of infrequent trading. From the statistics, trading is more frequent in Ghana, Mauritius and South Africa than in Nigeria, Egypt and Zimbabwe.

The stock returns series display negative skewness for all stock exchanges but Ghana. Negative skewness implies that mean the mass of the distribution of stock returns is concentrated on the right of the distribution of stock returns. The implication here is that there is the greater likelihood of large increase in returns than falls for all stock markets but Ghana. The kurtosis or degree of excess for both weekly and monthly stock returns in all markets is also large, varying from 6.49056 (Nigeria) to 21.7322 (Mauritius) and 4.18016 (Egypt) to 11.91757 (Mauritius) respectively thereby indicating leptokurtic distributions, that is, their distributions have thicker (fatter) tails than a normal distribution.

Finally, the calculated Jarque-Bera statistics and corresponding p-values in Table 3 are used to test the null hypotheses that the weekly and monthly distributions of African stock market returns are normally distributed. All p-values are smaller than the .01 level of significance suggesting the null hypothesis of normal distribution can be rejected, confirming the results based either on skewness or on kurtosis. None of these returns is then well approximated by the normal distribution. The evidence of non-normal returns behaviour in this series is consistent with results of previous studies (Jefferis & Smith, 2005; Ntim et al, 2008; Nisar & Hanif, 2012; Simons & Laryea, 2006)

Tests for weak form market efficiency

Unit root test

In this study, the augmented dickey-fuller (ADF) test and Philips-Perron (PP) test were selected to test for unit root. Unit root test was conducted on weekly and monthly stock return series for Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe stock markets and are presented in Table 4. The results rejected the null hypothesis of unit root at 5% level of significance in weekly and monthly stock returns for all stock exchanges.

For weekly stock return series, from Table 4, the ADF t-statistics are -28.899, -27.005, -29.346, -28.264, -32.261, -14.975 for Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe respectively which are less than the MacKinnon tabulated value -2.860. Again the P-value is also smaller than alpha at 5%. So we can conclude that the weekly stock return series does not contain unit root and the data is stationary. This is evidence against weak form market efficiency.

For monthly stock return series, the ADF test statistic is -12.195, -10.568, -11.805, -13.071, -14.975 and 9.494 for Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe respectively which are much less than the MacKinnon tabulated value -2.860 as shown in Table 4. Again the P-value is also too smaller than alpha at 5%. So we can conclude that the monthly stock return series does not contain unit root and the data is stationary. This is evidence against weak form market efficiency

The PP test statistic for all stock exchanges whether weekly or monthly does not tell a different story from the ADF test statistic. In fact there are only marginal differences in the results. For weekly stock return series, the PP test statistic is -29.198, -27.843, -29.591, -28.830, -32.234, -13.446, for Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe respectively which are less than the MacKinnon tabulated value -2.860. Again the P-value is also smaller than alpha at 5%. So we can conclude that the weekly stock return series does not contain unit root and the data is stationary. This is evidence against weak form market efficiency.

For monthly stock return series, the PP test statistic are -12.373, -10.940, -12.018, -13.181, -14.975, and -9.037 for Egypt, Ghana, Mauritius, Nigeria, South Africa And Zimbabwe respectively which are less than the MacKinnon tabulated value -2.860. Again the P-value is also too smaller than alpha at 5%. So we can conclude that the monthly stock return series does not contain unit root and the data is stationary. This is evidence against weak form efficiency.

Table 3: Results for Unit Root Tests

Stock Index	ADF t-statistic	PP t-statistic
Weekly Egypt	-28.899 (0.0000)	-29.198 (0.0000)
Monthly Egypt	-12.195 (0.0000)	-12.373 (0.0000)
Weekly Ghana	-27.005 (0.0000)	-27.843 (0.0000)
Monthly Ghana	-10.568 (0.0000)	-10.940 (0.0000)
Weekly Mauritius	-29.346 (0.0000)	-29.591 (0.0000)
Monthly Mauritius	-11.805 (0.0000)	-12.018 (0.0000)
Weekly Nigeria	-28.264 (0.0000)	-28.830 (0.0000)
Monthly Nigeria	-13.071 (0.0000)	-13.181 (0.0000)
Weekly South Africa	-32.261 (0.0000)	-32.234 (0.0000)
Monthly South Africa	-14.975 (0.0000)	-14.975 (0.0000)
Weekly Zimbabwe	-13.448 (0.0000)	-13.446 (0.0000)
Monthly Zimbabwe	-9.494 (0.0000)	-9.037 (0.0000)

Note: P-values in parenthesis

Source: Computed from stock price indices of Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe stock markets in Datastream.

Based on the results of the unit root test, stock market returns series for all stock exchanges do not follow a random walk and that the stock markets under study are weak form inefficient. However, studies have shown that the existence of unit root is not sufficient pre-requisite for the random walk hypothesis to hold (Verheyden, 2013.). Again, according to Smith and Jefferis (2005), the unit root test of market efficiency is not robust or a powerful one and subsequent analysis using different tests provided contrasting results. Therefore the study went on to look at non-parametric tests of market efficiency given non-normality of stock returns.

Run Test

The Table 5 presents the results of run test. Results for Egypt stock returns using the run test for daily and weekly returns are not consistent with each other. For weekly returns, P-value is 0.000 which signifies a strong rejection of null hypothesis of random walk. However, the P-value of 0.05 for the Egypt monthly stock return series using the run test leads us to fail to reject the null hypothesis at 5% level of significance. Hence on the basis of monthly stock return series for Egypt, we can conclude that the returns are randomly generated, an evidence for weak form market efficiency.

In case of Ghana, results for daily and monthly returns lead us to reject the null hypothesis of random walk since the P-value is 0.000 which is clearly smaller than alpha of 5%. Hence we conclude that based on the run test results for weekly and monthly returns, Ghana returns are not randomly generated, evidence against weak form market efficiency.

The results for weekly and monthly stock returns for Mauritius are not consistent. The P-value 0.01 obtained for weekly returns lead us to reject the null hypothesis of random walk at 5% level of significance implying that the weekly returns are not randomly generated and that an investor can predict today's stock price from past prices in Mauritius. On the contrary, monthly returns P-value for Mauritius is 0.25, hence we fail to reject the null hypothesis of random walk at 5% level of significance. Thus on the basis of monthly returns, the run test results indicate that no investor can make capital gains from the purchase and sale of stock consistently over time since all information regarding past prices is fully incorporated in stock price of today. Any gain on the Mauritian stock market on this basis is by luck or chance.

The run test results for Nigeria is similar to that of Ghana as the null hypothesis of random walk is rejected at 5% level of significance for both weekly and monthly stock returns series whose P-values are both 0.000. These results imply that one can predict future stock prices from past prices. Technical analysts are of relevance in this market. The activities of technical analysts with the view to making capital gains from the purchase and sale of stock in this market over time may cause this market to be efficient in the weak sense.

The results for weekly and monthly stock returns are consistent for South Africa, both failing to reject the null hypothesis of random walk at 5% level of significance. The results for the monthly stock returns series strongly fails to reject the null hypothesis at 5% level of significance. This implies that an investor cannot consistently make profit on this stock market by merely studying past prices. On this stock market, technical analysts have little relevance. The result for South Africa is consistent with the findings of Simons and Laryea (2006) and Magnusson and Wydick (2002).

Table 4: Run Test Results

Stock Index	Number of runs	Z	P-Value
Weekly Egypt	423	-4.49	0.000
Monthly Egypt	99	-1.195	.05**
Weekly Ghana	263	-6.6	0.000
Monthly Ghana	78	-3.34	0.000
Weekly Mauritius	302	-2.49	0.01
Monthly Mauritius	98	-1.14	.25***
Weekly Nigeria	392	-5.62	0.000
Monthly Nigeria	79	-4.32	0.000
Weekly South Africa	452	-1.77	0.08**
Monthly South Africa	103	-.99	.32***
Weekly Zimbabwe	104	-2.63	.01
Monthly Zimbabwe	28	-.35	.73***
N			

Note: *, ** and *** denotes fail to reject H_0 at 1% level of significance

Source: Computed from stock price indices of Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe stock markets in Datastream.

Finally the run test results for Zimbabwe follows that of Mauritius. The results for weekly and monthly stock returns for Zimbabwe are not consistent. The P-value 0.01 obtained for weekly returns lead us to reject the null hypothesis of random walk at 5% level of significance implying that the weekly returns are not randomly generated and that an investor can predict today's stock price from past prices in Zimbabwe. On the contrary, monthly returns P-value for Zimbabwe is 0.73, hence we fail to reject the null hypothesis of random walk at 5% level of significance. Thus on the basis of monthly returns, the run test results indicate that no investor can make capital gains from the purchase and sale of stock consistently over time since all information regarding past prices is fully incorporated in stock price of today. Any gain on the Zimbabwe stock market on this basis is by luck or chance.

Variance Ratio Test

Table 6 shows the results of Wright's (2000) non-parametric variance ratio tests for the six individual African stock market return series. These include Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe respectively. As specified in column 1 of Table 6, the analysis is based on k=15, 20, 25 and 30 weeks and months where k refers to the number of interval weeks and months. Columns 2 and 3 of the same table displays the test Z-statistics for the ranks (R_1 and R_2), while column 4 contain the test Z-statistics for the sign (S) based alternative for each stock market return series examined. The ranks are robust under the assumption of homoskedasticity while the sign is powerful under heteroskedasticity conditions.

The variance ratio test results for ranks (R_1, R_2) indicate that null hypothesis of stock markets returns series for Egypt is clearly and consistently rejected at 5% level of significance at all intervals of k for both weekly and monthly stock return series since the Z-statistics do not fall between ±1.96. Similarly, the sign based alternative consistently rejects the random walk hypothesis at 5% level of significance for all intervals of k for both weekly and monthly stock returns. The Z-statistics for both weekly and monthly stock returns are without the range ±1.96. These rejections are in the upper tail (that is, they have positive signs) of the distribution, which suggests that any serial dependence is positive. The run test and variance ratio test results for weekly stock return series are consistent with each other. However at 10% level of significance, the run test and variance ratio test results for monthly stock returns series are inconsistent with each other.

The variance ratio test results for ranks (R_1 and R_2) suggest that the null hypothesis of the stock market return series for Ghana is clearly and consistently rejected at 5% level of significance at all intervals of k for both weekly and monthly stock returns series. This is because the calculated Z-statistics are without the range of ±1.96. Similarly, the sign based alternative consistently rejects the random walk hypothesis at 5% level of significance for all intervals of k for both weekly and monthly stock returns. These rejections of random walk for stock return series are in the upper tail of the distribution suggesting that any serial dependence is positive. The run test and variance ratio test results for both weekly and monthly stock return series are consistent with each other.

The variance ratio test results for ranks (R_1 and R_2) suggest that the null hypothesis of the weekly stock market return series for Mauritius is clearly and consistently rejected at 5% level of significance at all intervals of k. Similarly, the sign based alternative consistently rejects the random walk hypothesis at 5% level of significance for all intervals of k for weekly stock returns series. However, the story is different for the monthly stock return series. The variance ratio test results for R_1 for interval 15 clearly fail to reject the null hypothesis of random walk at 5% level of significance while results for intervals 20, 25 and 30 indicate that the monthly stock market return series for Mauritius are randomly generated at 10% level of significance. The R_2 and sign based alternatives consistently fail to reject the null hypothesis of random walk of stock returns at 10% level of significance. The rejection of random walk for the weekly stock returns series for Mauritius are in the upper tail of the distribution indicating that any serial dependence is positive. The results of the variance and ratio and run tests are consistent with each other confirming the effectiveness of non-parametric over parametric tests in the face of non-normal distributions.

The variance ratio test results for ranks (R_1 and R_2) suggest that the null hypothesis of the stock market return series for Nigeria is clearly and consistently rejected at 5% level of significance at all intervals of k for both weekly and monthly stock returns series. The calculated Z-statistics at all intervals do not fall within the range of ±1.96. Similarly, the sign based alternative consistently rejects the random walk hypothesis at 5% level of significance for all intervals of k for both weekly and monthly stock returns. These rejections of random walk for stock return series are in the upper tail of the distribution suggesting that any serial dependence is positive. The run test and variance ratio test results for both weekly and monthly stock return series are consistent with each other.

Among all stock exchanges discussed so far, the variance ratio test for South Africa is different as results are in favour of the stock returns series following a random walk. The results for the sign based alternative for monthly stock returns series for South Africa as well as for the ranks (R_1 and

R_2) for both weekly and monthly stock returns series strongly fail to reject the null hypothesis of random walk 5% level of significance at all intervals of k. The results for R_1 and R_2 signify that no one investor can consistently make profits by studying past prices. Any profits made on the South Africa market are by luck or chance. At 1% level of significance, for weekly stock returns for South Africa, the results of the sign based alternative lead us to fail to reject the null hypothesis of random walk at all intervals of k. At k equal to 15, we can fail to reject the null hypothesis of random walk at 5% level of significance. The significant difference between the results of the ranks and sign could more be attributed to heteroskedasticity. Given the sign based alternative's results of the variance ratio test, it is likely to detect some linear dependence in the weekly stock series. This result is consistent with that obtained from the run test on the South Africa returns series.

The results for the rank, R_2 for weekly stock returns series for Zimbabwe strongly fail to reject the null hypothesis of random walk for both weekly and monthly stock return series at 5% level of significance at all intervals of k. The results for R_1 are not consistent at all intervals of k but at 1% level of significance, we fail to reject the null hypothesis of random walk at all intervals of k. The rank, R1, based approach of Wrights variance ratio test at intervals 15 and 30 significantly fail to reject the null hypothesis of random walk at 5% while we fail to reject the null at 1% level of significance for intervals 20 and 25.

Table 5: Variance Ratio Test Results

Period (k)	R_1 (Z-statistic)	R_2 (Z-statistic)	S (Z-statistic)
Weekly Egypt			
15	5.269096	4.96265	4.954557
20	5.829262	5.510199	5.454575
25	6.20299	5.834269	5.748022
30	6.472571	6.021811	6.024031
Monthly Egypt			
15	3.824301	3.846842	3.113081
20	3.540201	3.555579	2.939203
25	3.240727	3.26074	2.573335
30	3.025284	3.079034	2.317188
Weekly Ghana			
15	12.54487	12.90086	36.82319
20	13.07579	13.49327	42.13927
25	13.2523	13.61899	46.63276
30	13.40214	13.70107	50.61251
Monthly Ghana			
15	5.923988	6.336103	2.864451
20	4.354204	4.463869	2.514322
25	3.015002	2.915023	2.144507
30	2.182579	2.008718	1.931918
Weekly Mauritius			
15	3.867415	4.514208	33.68283
20	3.70139	4.556181	38.83769
25	3.462884	4.458512	43.24479
30	3.24165	4.300895	47.09702
Monthly Mauritius			
15	1.831053**	1.586716***	0.323994***
20	1.502199***	1.273782***	0.170556***
25	1.325622***	1.121043***	0.136717***
30	0.970332***	0.783349***	0.042866***
Weekly Nigeria			
15	8.638079	7.377843	11.16153
20	8.690745	7.374433	12.1697
25	8.815275	7.424722	13.06798
30	8.981234	7.507474	13.7412
Monthly Nigeria			
15	5.046961	4.266059	6.630038
20	4.10098	3.46048	5.258041
25	3.156201	2.633794	3.698468
30	2.467126	2.062221	2.57308
Weekly South Africa			
15	0.473468***	0.136874***	1.49738**
20	0.393135***	0.160388***	1.726692*
25	0.243007***	-0.07871***	1.535378*
30	0.173117***	-0.25475***	1.621279*

Table 5 Continued

Monthly South Africa			
15	-0.39252***	-0.47612***	0.62851***
20	-0.39101***	-0.51404***	0.526347***
25	-0.45563***	-0.57879***	0.508539***
30	-0.56459***	-0.68592***	0.469423***
Weekly Zimbabwe			
15	1.671167**	1.462067***	1.42112***
20	1.504338***	1.125007***	1.497453**
25	1.516159***	1.07011***	1.491344**
30	1.704766*	1.254228***	1.574917*
Monthly Zimbabwe			
15	-0.64831***	-0.89812***	-0.32428***
20	-0.91871***	-1.04729***	-0.88481***
25	-0.89508***	-0.98143***	-1.11261***
30	-0.80326***	-0.8757***	-1.09837***

Note: *, ** and *** denotes fail to reject H_0 at 1% level of significance

Source: Computed from stock price indices of Egypt, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe stock markets in Datastream

These results indicate that no one investor can consistently make profits by studying past prices in Zimbabwe. Any profits made on the Zimbabwe are by luck or chance. At 5% level of significance, the results of the sign based alternative lead us to fail to reject the null hypothesis of random walk at all intervals of k. At intervals 15, 20 and 25 we fail to reject the null at 5%. The significant difference between the results of the ranks and sign could more be attributed to heteroskedasticity. This result is consistent with that obtained from the run test on the Zimbabwe stock returns series.

Illustration of gradual changes toward weak form efficiency

Conventional tests of the random walk hypothesis, for example the Wright (2000) non parametric variance ratio test, lead to the inference that a stock market returns series does or does not follow a random walk at a chosen significance level. Although such tests can be applied to successive time periods, they cannot readily capture gradual changes in efficiency over successive observations (Smith and Jefferies, 2005).

Figures 1 to 6 present the results of the test for evolving efficiency as they show the time-paths of the estimated $\hat{\beta}_{1t}$ coefficients together with their 95% confident intervals. If the value of estimated $\hat{\beta}_{1t}$ is between -0.1 and 0.1 we conclude that its magnitude is not significantly different from zero and that the stock market is efficient but if estimated $\hat{\beta}_{1t}$ lies without -0.1 and 0.1, the stock market is inefficient.

Let's consider Figure 1 which presents the test for evolving efficiency results for Egypt monthly returns series. The estimated $\hat{\beta}_{1t}$ has an initial value of 0.252 and it is significantly different from zero (0) in 1994. The upper and lower bounds of the 95% confidence interval are 0.55 and -0.05 respectively. Given that $\hat{\beta}_{1t}$ is significantly different from zero (0), it suggests that the Egypt was initially inefficient. The market remained inefficient and showed no tendency to move towards efficiency till 2005. After 2005, the magnitude of the estimated parameter B_{1t} gradually declines and first becomes insignificantly different from zero in 2011. Thus stock market gradually became weak form efficient from 2011 to 2013. The magnitude of $\hat{\beta}_{1t}$ for the last data point in this series is 0.07 in 2013. The upper and lower bounds of the 95% confidence interval at this point are 0.34 and -0.19 respectively.

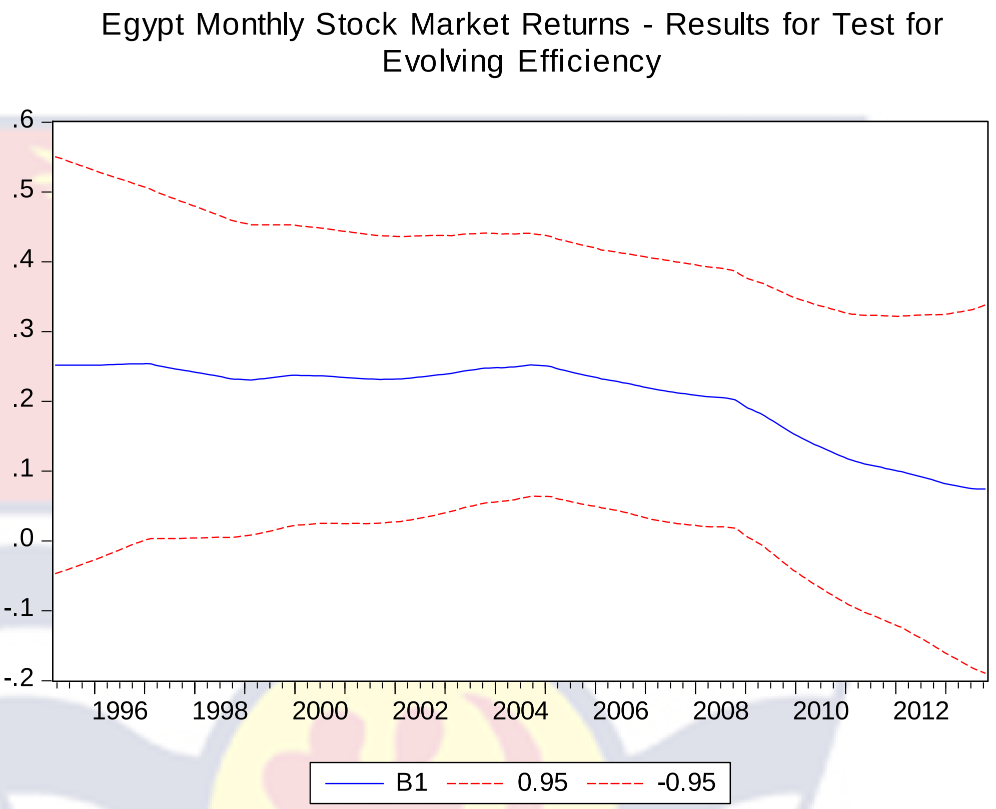


Figure1: Test for Evolving Efficiency – Egypt Stock Exchange

Source: Computed and presented from monthly Egypt price index in Datastream using E-views 7

The results for test for evolving efficiency for Ghana are reported in Figure 2. The results show that Ghana was weak form efficient given the initial B_{1t} value to be -0.09 which is insignificantly different from zero (0) with upper and lower bounds of the 95% confidence interval to be 0.21 and -0.39 respectively in 1995. The market maintained its efficiency till April 2008 when tended to move away from efficiency. The magnitude of the estimated $\hat{\beta}_{1t}$ was between -0.09 and 0.1 during this 12 year period. The market became more and more inefficient in the weak sense the period after 2008 and showed no signs of moving toward efficiency with a closing B_{1t} value of 0.26 in 2013.

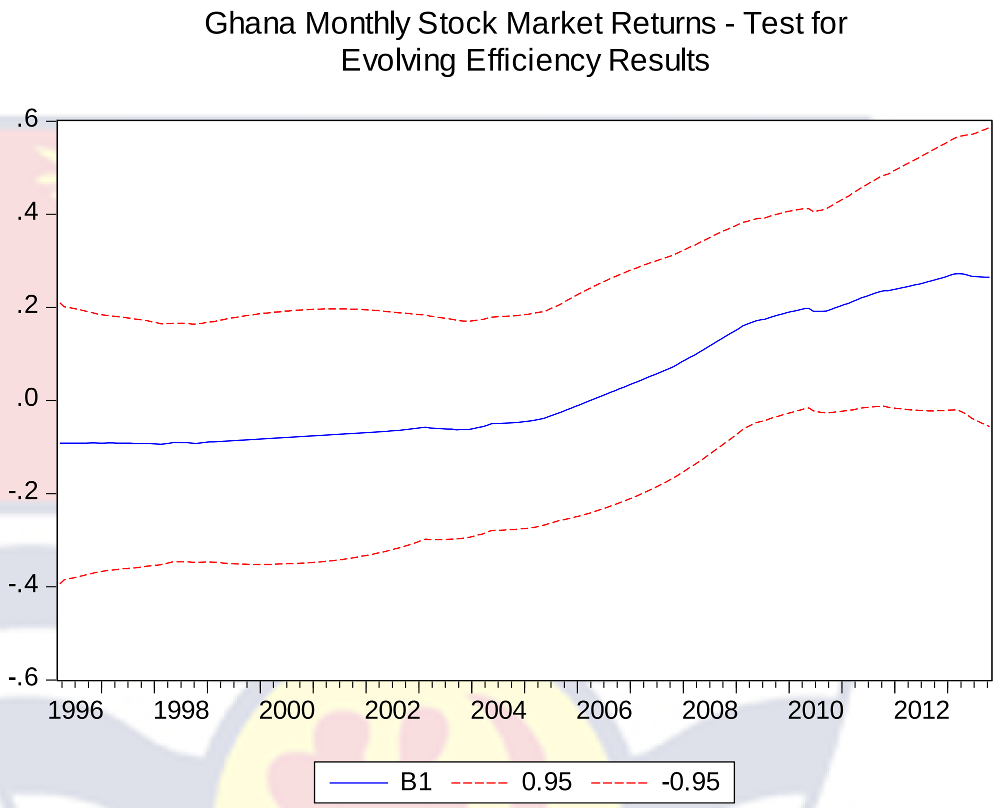


Figure 2: Test for Evolving Efficiency - Ghana Stock Exchange

Source: Calculated and Presented from Monthly Ghana price index in Datastream using E-views 7

The results for test for evolving efficiency for Mauritius are reported in figure 3. The results show that estimated B_{1t} is -0.07 and constant. The upper and lower bounds of the 95% confidence interval are 0.09 and -0.23 respectively. This market is weak from efficient and shows no tendency to change. This is a characteristic of many developed markets and similar to the results for South Africa reported in Smith and Jefferies (2005).

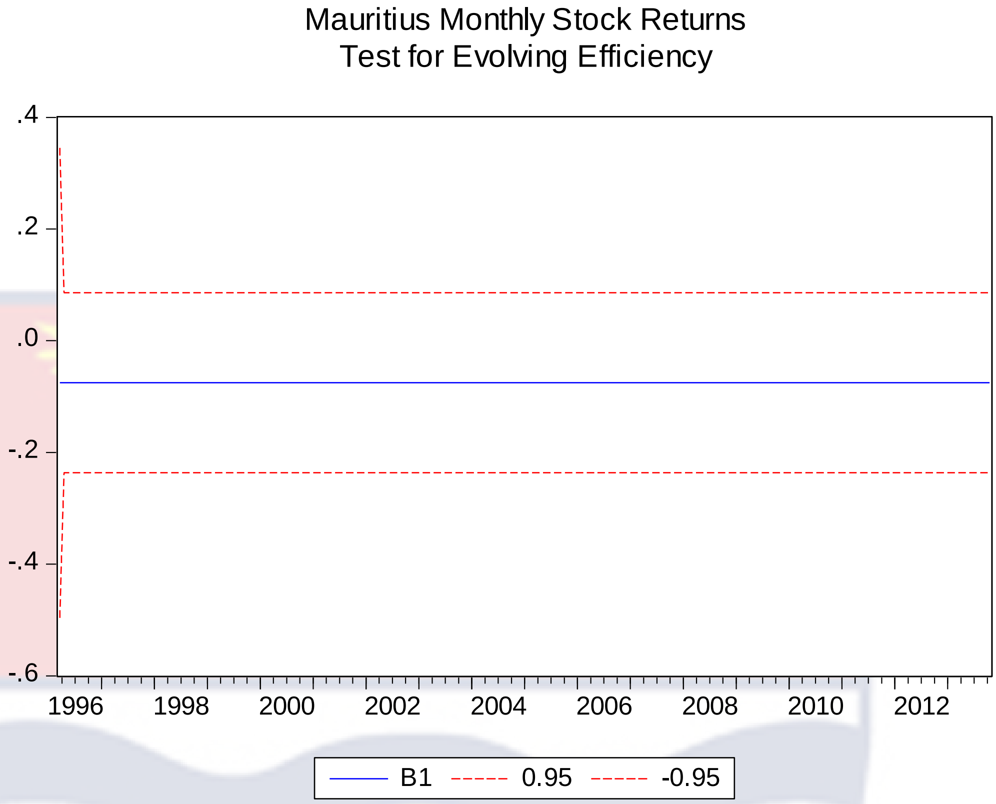


Figure 3: Test for Evolving Efficiency – Stock Exchange of Mauritius

Source: Calculated and presented from monthly Mauritius price index using E-views 7

The results for Nigeria are illustrated in figure 4 the results show that estimated $\hat{\beta}_{1t}$ is 0.13 and constant. The upper and lower bounds of the 95% confidence interval are 0.27 and 0.00 respectively. This market is weak from inefficient throughout the period and shows no tendency to change. This is a characteristic of many less developed markets and similar to the results for Lukoil daily returns on the Russian stock market in Hall et al (1998).

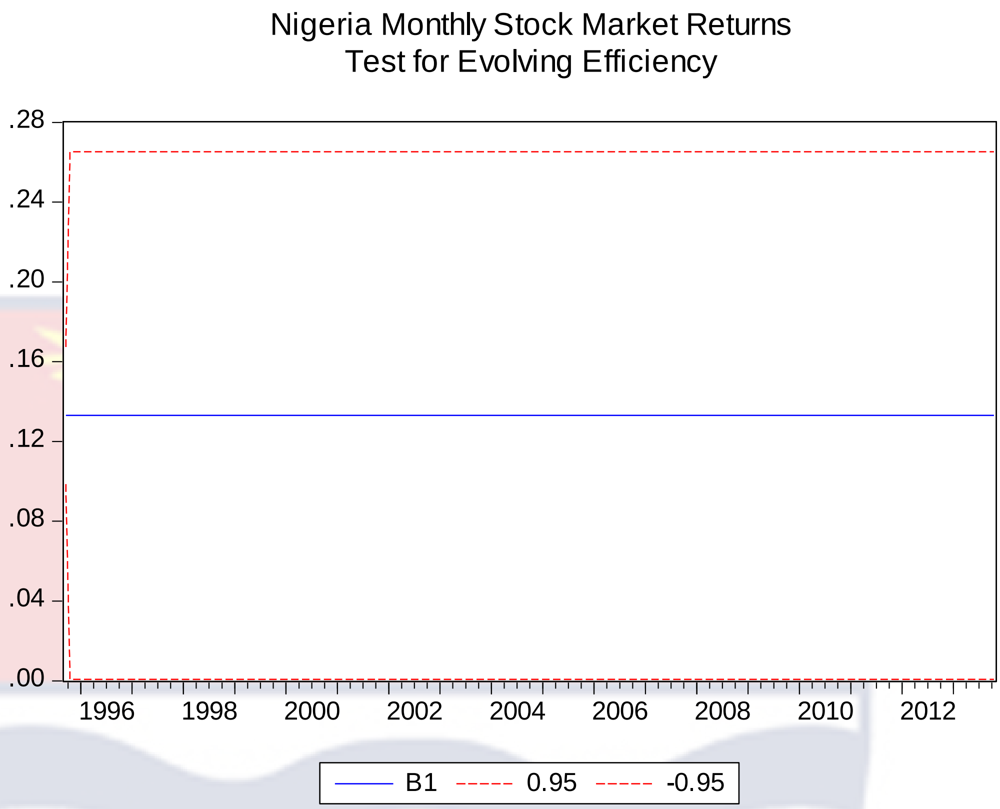


Figure 4: Test for Evolving Efficiency – Nigeria Stock Exchange

Source: Calculated and presented from monthly Nigeria Stock price index in Datastream using E-views 7

The results for test for evolving efficiency for South Africa is reported in figure 5 the results show that estimated $\hat{\beta}_{1t}$ is -0.011 and constant. The upper and lower bounds of the 95% confidence interval are 0.12 and -0.148 respectively. This market is weak from efficient and shows no tendency to change. This is a characteristic of many developed markets and similar to the results for South Africa reported in Smith and Jefferies (2005).

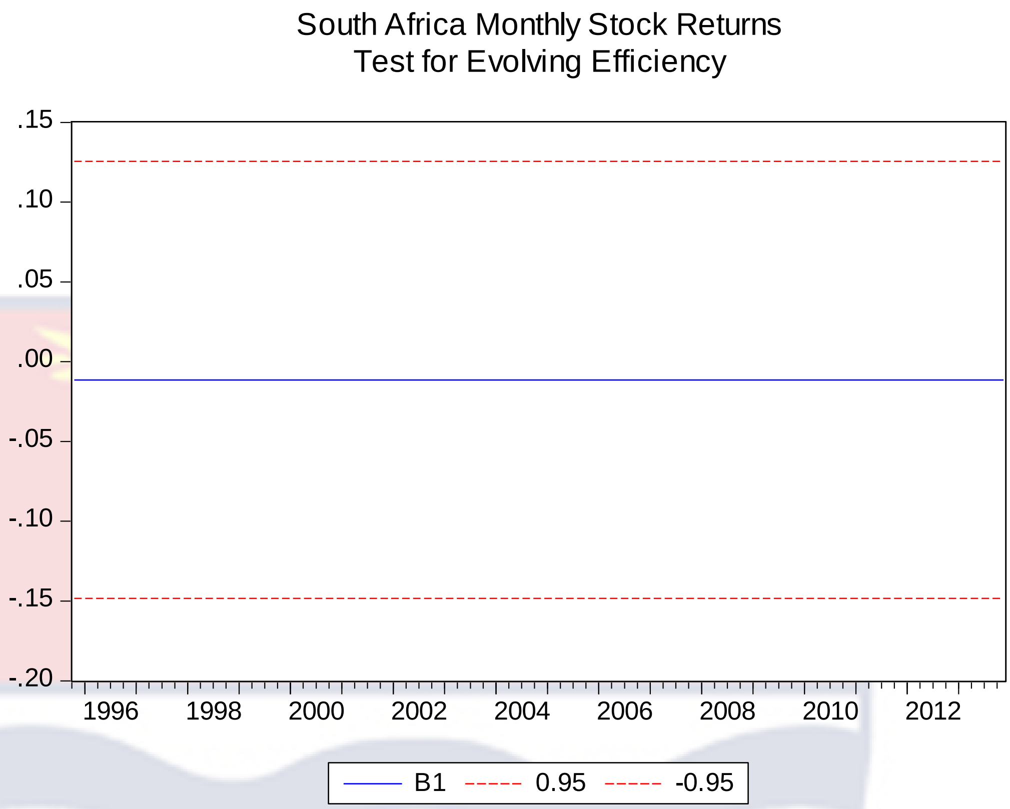


Figure 5: Test for Evolving Efficiency – Johannesburg Stock Exchange

Source: Calculated and presented from monthly JSE price index in Datastream using E-views 7

The results for test for evolving efficiency for Zimbabwe is similar to that of South Africa and is reported in figure 6. The results show that estimated $\hat{\beta}_{1t}$ is -0.003 and constant. The upper and lower bounds of the 95% confidence interval are 0.09 and -0.23 respectively. This market is weak from efficient and shows no tendency to change. This is a characteristic of many developed markets and similar to the results for South Africa reported in Smith and Jefferies (2005).

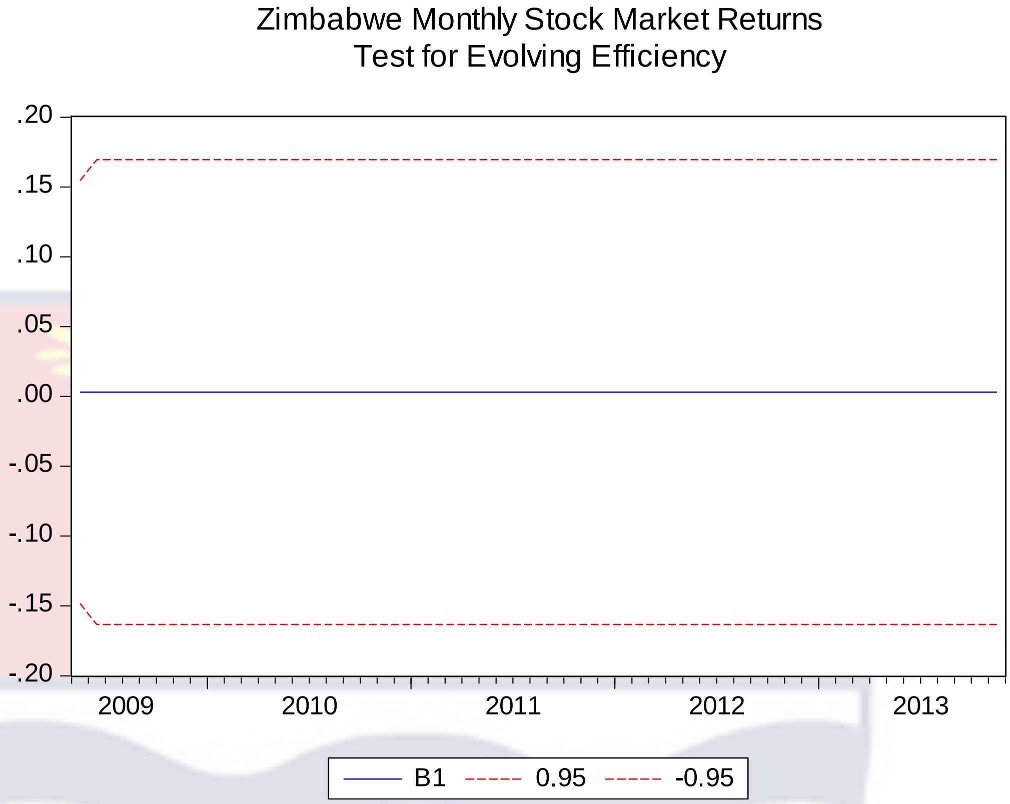


Figure 6: Test for Evolving Efficiency – Zimbabwe Stock Exchange

Source: Calculated and presented from monthly Zimbabwe Industrial price index in Datastream using E-views 7

The key results, that is, South Africa, Zimbabwe and Mauritius being weak form efficient throughout the period understudy, Egypt experiencing reduced inefficiency during the latter part of the period understudy and Ghana and Nigeria remaining weak form inefficient throughout the period understudy can be related to broader economic factors and institutional and quantitative characteristics of markets.

The larger stock markets in terms of market capitalization and turnover namely Egypt, South Africa and Zimbabwe (see Table 1) were found to be weak form efficient while the with the exception of Mauritius, smaller stock markets, Ghana and Nigeria, exhibited weak form inefficiency.

In Jefferis and Smith (2005), the Egyptian and Mauritian market were tending towards weak form market efficiency from 1997 to 2001 and 1993 to 2001 respectively. Between 2001 and 2013, the stock exchanges of Egypt and Mauritius underwent serious institutional reforms and development. Within 2001-2013, both Egypt and Mauritius stock markets established state-of-the-art electronic trading system built on third generation technology. Egypt published 12 sector indices together with EGX 100, 70 and 20 stock indices and established the Egypt information dissemination company and as well undertook promotional campaigns in London. The Mauritian stock market within the period established their second market, Development and Enterprise Market (DEM) two markets. It is within this same period that the Mauritian stock market attained weak form efficiency.

Unlike the Mauritian economy which recorded both economic and political stability between 2001 and 2013, the Egyptian economy during the period was adversely affected by the global financial crisis and political instability particularly in 2008 and early part of 2011 respectively. Though the political and economic instability slowed the movement of the Egyptian Exchange towards efficiency, it could not erode investor confidence given the strong institutional reforms and development. The Egyptian stock market rather moved towards weak form efficiency within the crisis period from 2008-2013.

Ghana and Nigeria stock exchanges between the 2001-2013 period also experienced institutional reforms and developments. They both adopted electronic trading platforms. However, the global financial crisis was harshly felt in Ghanaian and Nigerian economies. Again these two countries within the same period experienced rise in inflation, interest rates and unemployment especially from 2008 to 2013, the point where Ghana stock exchange moved further away from efficiency.

The efficient larger markets, South Africa and Zimbabwe demonstrate high levels of liquidity and turnover. In Smith and Jefferies (2005) the Zimbabwe stock exchange showed movement away from efficiency from 1999 to 2001, a time that the economy of Zimbabwe was hampered by harsh economic instability. From 2009, Zimbabwe's national economy has been recovering from a serious hyperinflation period. The introduction of the US dollar as the primary means of exchange in 2009 ensured currency stability to the economy which in turn increased investment and investor confidence. South Africa benefits from the trading of some of its shares on major international markets where they are cross-listed. It is also the only African market what approximates a developed market in size and availability of information and analysis (Smith & Jefferis, 2005).

Though this study did not provide quantitative assessment of factors causing these efficiency trends, the results provide indications of what these factors might be. Institutional reforms and development, increase in size (market capitalization and turnover ratio) and macroeconomic policies and political stability seem to be important in supporting weak form efficiency.

Conclusion

The results indicate that African stock markets with high mean returns are more likely to experience relatively less frequent trading. Stock return series for all stock markets used in this study are not normally distributed and with the exception of Ghana display negative skewness. There is therefore the greater likelihood of large increase in returns than falls in African stock markets. The results of the variance ratio and run test revealed that South Africa, Zimbabwe and Mauritius are weak form efficient, while Ghana, Nigeria and Egypt are not weak form efficient. The results of the test for evolving efficiency revealed that South Africa, Mauritius and Zimbabwe are weak form efficient throughout the time period used in this study while Nigeria remained weak form inefficient throughout the period. Egypt achieved weak form efficiency between 2011 and 2013 but Ghana moved further away from weak form efficiency. Given the results, we can conclude that the institutional characteristics of the various stock exchanges and the economies in which they operate indicate that absolute size (in terms of capitalisation and turnover) and the rate of growth of market liquidity seem to be important in supporting weak form efficiency (or movement towards it).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Introduction

The purpose of this chapter is to summarize the study and to present conclusions and recommendations derived from the analysis of the data collected. The chapter also includes suggestions for further research and limitations of the study.

Summary

Stock markets are a vital component for economic development as they provide listed companies with a platform to raise long-term capital and also provide investors with an avenue for investing their surplus funds. However stock markets in Africa remain rather underdeveloped compared to their counterparts in developed and other emerging markets though there have been considerable developments in the African capital markets since 1990's.

The study sought to test the weak form market efficiency for six African stock markets. In trying to achieve this purpose, the study employed several tests namely unit root tests, run test and variance ratio test. The unit root test tests the null hypothesis that a series contains unit root (non-stationary) against the alternative hypothesis of no unit root (stationary). The finding of unit root is an evidence for weak form market efficiency. The run test and variance ratio test are non-parametric tests and are more suited because of non-normality of the distribution of stock price return series. Again they are more robust than unit root test and other parametric tests. Given that efficiency of stock market varies over time, the study employed a GARCH approach with time varying parameters, a test of evolving efficiency, to test whether or not stock markets understudy are moving toward or further away from efficiency. The data used for the study were weekly and monthly obtained from Datastream. All the tests were conducted using E-views 7.0 software.

The run test and variance ratio test revealed that the South Africa, Mauritius and Zimbabwe stock markets are weak form efficient while the Egypt, Ghana and Nigeria stock markets are weak form inefficient. It is therefore possible for investors to study patterns and movements in past prices to predict today's price on the Egypt, Ghana and Nigeria stock markets but not on the South Africa, Mauritius and Zimbabwe stock markets. The results of the test for evolving efficiency revealed that South Africa, Mauritius and Zimbabwe stock markets remained weak form efficient throughout the period understudy while Nigeria remained weak form inefficient with no tendencies to become weak form efficient or become more weak forms inefficient. Egypt moved toward weak form efficiency while Ghana moved further away from efficiency.

Conclusions

Based on the findings of the study, a number of conclusions can be drawn. First, the distribution of stock price returns series in general do not follow a normal distribution. Stock price returns series are skewed either to the left of the distribution or to the right of the distribution.

Second, Mauritius, South Africa and Zimbabwe stock markets were weak form efficient throughout the period under study, from 1995 to 2013. Egypt stock market was not weak form efficient for most part of the period but achieved weak form efficiency between 2011 and 2013. The stock exchanges of Ghana and Nigeria were not weak form efficient throughout the period from 1995 to 2013.

The efficiency of stock markets is not static by dynamic. Stock market efficiency evolves over time. Differences in stock market efficiency can be related to institutional characteristics and development, market characteristics and political and economic stability.

Recommendations

Considering the findings, summary and conclusion of the study, the following recommendations and policies are advocated.

Stock market efficiency is achieved when information is incorporated into stock prices. Given that some markets in Africa have not passed the weak form market efficiency, information on stock markets particularly past prices must be made readily available. To ensure easy access to information, the Egyptian stock exchange has established Egypt Information Dissemination Company. Securities and exchange commissions of stock markets in African can establish similar institutions in order enhance the dissemination of information relating to stock market.

The size of the market has a bearing on efficiency of a stock market. The results suggest that policies to grow stock markets are important. For some countries, however, small size will always be a problem, bearing in mind the small size of many African economies. This suggests that regional stock markets may be a way forward, not just to benefit from economies of scale but also to improve pricing efficiency. As examples of such developments, there is already a regional stock exchange in West Africa (based in Abidjan) and there have been discussions in Southern Africa of the Johannesburg Stock Exchange acting as the hub of a regional exchange. The African Securities Exchange Association can champion the course of establishing regional blocks on the African continent.

Limitations of the Study

The main limitation of the study typical of such studies in developing countries had to do with the quality and limited availability of stock indices used in this study. In the absence of the availability of daily stock market returns series, weekly and monthly stock market series were used in this study. However, the use of weekly and/or monthly data conceals part of the information concerning stock price change. Again the absence of daily stock market returns series resulted in low frequency data. However this limitation did not pose any danger to the reliability of the results.

Suggestions for Future Research

This research considered only six out of the twenty-nine stock markets on the African continent. Further researchers could consider conducting a study on all African stock markets.

The focus of this study is on providing a quantitative assessment of degree and trends of weak-form efficiency in African stock markets. So far, very few quantitative studies if any have been conducted on causes of weak form efficiency in African stock markets. Researchers could therefore undertake a quantitative analysis of the factors causing stock market efficiency degrees and trends.

This study considers only informational efficiency. Future researcher could undertake studies on operational efficiency among African stock markets.

REFERENCES

Alexander, S. S. (1961). Price movements in speculative markets: Trends or random walks. *Industrial Management Review*, *2*, 7–26.

Appiah-Kusi, J., & Menyah, K. (2003). Return predictability in African stock markets. *Review of Financial Economics*, *12*(3), 247–270.

Ayadi, O. F., & Pyun, C. S. (1994). An application of variance ratio test to the Korean securities market. *Journal of Banking & Finance*, *18*(4), 643–658.

Bachelier, L. (1900). Theory of speculation, in Cootner (1964) *The Random Character of Stock Market Prices*, 17-78

Barak, O., & Demireli, E. (2006). *IMKB'de gözlemlenen fiyat anomalilerinin davranışsal finans modelleri kapsamında değerlendirilmesi*. Ulusal Finans Sempozyumu, 1–4.

Barberis, N., Shleifer, A., & Vishny, R. (1998). A model of investor sentiment. *Journal of Financial Economics*, *49*(3), 307–343.

Basu, S. (1977). Investment performance of common stocks in relation to their price-earnings ratios: A test of the efficient market hypothesis. *The Journal of Finance*, *32*(3), 663–682.

Beechey, M., Gruen, D. W., & Vickery, J. (2000). *The efficient market hypothesis: a survey*. Reserve Bank of Australia, Economic Research Department. Retrieved on 31st December 2013 from http://www-ho.rba.gov.au/publications/rdp/2000/pdf/rdp2000-01.pdf

Bencivenga, V. R., & Smith, B. D. (1991). Financial intermediation and endogenous growth. *The Review of Economic Studies*, *58*(2), 195–209.

Bodie, Z., Kane, A., & Marcus, A. J. (2010). *Essentials of investments*. McGraw-Hill, International edition.

Bondt, W. F., & Thaler, R. (1985). Does the stock market overreact? *The Journal of Finance*, *40*(3), 793–805.

Brealey R. A., Myers S. C and Allen F. (2010). *Principles of Corporate Finance (10th ed.)*. McGraw-Hill, New York.

Broock, W. A., Scheinkman, J. A., Dechert, W. D., & LeBaron, B. (1996). A test for independence based on the correlation dimension. *Econometric Reviews*, *15*(3), 197–235.

Brown, G. (1999). Volatility, sentiment and noise traders. *Financial analyst Journal*, *55* (2) 82-90.

Brown, R. (1828). A brief account of microscopical observations. *Edinburgh New Philosophical Journal*, *6*, 358–371.

Campbell, J. Y., Lo, A. W., MacKinlay, A. C., & Whitelaw, R. F. (1998). The econometrics of financial markets. *Macroeconomic Dynamics*, *2*(04), 559–562.

Capital Markets Authority. (2010). *A comparative analysis of the performance of African stock markets for the period 2008-2009.* Research, Policy Analysis and Planning Department, Kenya

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal of Finance*, *52*(1), 57–82.

Chow, K. V., & Denning, K. C. (1993). A simple multiple variance ratio test. *Journal of Econometrics*, *58*(3), 385–401.

Conrad, J., & Kaul, G. (1993). Long-term market overreaction or biases in computed returns? *The Journal of Finance*, *48*(1), 39–63.

Cootner, Paul (1964). *The random character of stock market prices*, MIT press.

Cornelius, P. K. (1993). A note on the informational efficiency of emerging stock markets. *Review of World Economics*, *129*(4), 820–828.

Cowles 3rd, A. (1933). Can stock market forecasters forecast? *Econometrica: Journal of the Econometric Society*, 309–324.

Cowles 3rd, A., & Jones, H. E. (1937). Some a posteriori probabilities in stock market action. *Econometrica, Journal of the Econometric Society*, 280–294.

Cowles, A. (1944). Stock market forecasting. *Econometrica, Journal of the Econometric Society*, 206–214.

Cuthbertson, K. (1996). *Quantitative Financial Economics*. John Wiley & Sons, Chichester.

Dailami, M., & Atkin, M. (1990). *Stock markets in developing countries: Key issues and a research agenda* (Vol. 515). World Bank Publications. Retrieved January 27th, 2014 from http://books.google.com/books?hl=en&lr=&id=2yPOIyrBqN8C&oi=fnd&pg=PA1&dq=Dailami+and+Atkin+(1990)&ots

Daniel, K., Hirshleifer, D., & Subrahmanyam, A. (1998). Investor psychology and security market under-and overreactions. *The Journal of Finance*, *53*(6), 1839–1885.

Databank (2004). *African stock markets consolidate gains*. Databank Research, Accra: Databank.

De Bondt, W. F., & Thaler, R. H. (1985). Does the stock market overreact? *Journal of Finance*, *40*, 793–808.

De Bondt, W. F., & Thaler, R. H. (1987). Further evidence on investor overreaction and stock market seasonality. *Journal of Finance*, 557–581.

Dickinson, J. P., & Muragu, K. (1994). Market efficiency in developing countries: a case study of the Nairobi stock exchange. *Journal of Business Finance & Accounting*, *21*(1), 133–150.

Dimson, E., & Mussavian, M. (2000). Market efficiency. *The Current State of Business Disciplines*, *4*(3), 959–970.

Dockery, E., & Vergari, F. (1997). Testing the random walk hypothesis: evidence for the Budapest stock exchange. *Applied Economics Letters*, *4*(10), 627–629.

Egyptian Exchange. (n.d.). In Wikipedia. Retrieved January 15, 2014, from http://en.wikipedia.org/w/index.php?title=Egyptian_Exchange&oldid=586157728

Egyptian Exchange. (2013). About us: Egyptian Exchange. Retrieved December 31, 2013, from Egyptian Exchange Web site: http://www.Egypt.com.eg/English/History.aspx

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*, 987–1007.

Fama, E. F. (1965a). Random walks in stock market prices. *Financial Analysts Journal*, 55–59.

Fama, E. F. (1965b). The behavior of stock-market prices. *Journal of Business*, 34–105.

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance*, *25*(I), 383–417.

Fox, J. (2009). *The myth of the rational market: A history of risk, reward, and delusion on Wall Street*. New York: Harper Business.

Frimpong, J. M., & Oteng-Abayie, E. F. (2007). Market returns and weak-form efficiency: *The case of the Ghana Stock Exchange*. Retrieved December 30th, 2013, from http://mpra.ub.uni-muenchen.de/7582/

Fuller, R. J. (1998). Behavioural finance and the sources of alpha. *Journal of Pension Plan Investing*, *2*(3), 291–293.

Ghana Stock Exchange. (n.d.). *In Wikipedia*. Retrieved January 15, 2014, from http://en.wikipedia.org/w/index.php?title=Ghana_Stock_Exchange&oldid=582848331

Ghana Stock Exchange. (2013). *About us: Ghana stock exchange*. Retrieved January 15, 2014, from Ghana Stock Exchange Website: http://www.Ghana.com.gh/index1.php?linkid=4

Gibson, G. (1889). *The stock markets of London, Paris and New York*. New York: G.P. Putnam's Sons.

Granger, C. W. J., & Andersen, A. P. (1978). *An introduction to bilinear time series models*. Vandenhoeck und Ruprecht Göttingen. Retrieved from http://www.getcited.org/pub/101926664

Grossman, S. (1976). On the efficiency of competitive stock markets where trades have diverse information. *The Journal of Finance*, *31*(2), 573–585.

Grossman, S. J., & Stiglitz, J. E. (1980). On the impossibility of informationally efficient markets. *The American Economic Review*, 393–408.

Gujarati, D. (2008). *Basic econometrics*. McGraw-Hill, New York

Hald, A. (1990). *A history of probability and statistics and their applications before 1750.* John Wiley & Sons New York.

Hall, S., Urga, G., & Zalewska-Mitura, A. (1998). *Testing for evolving stock market efficiency: With an application to Russian stock prices*. Citeseer. Retrieved December 13th, 2013, from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.41.1771&rep=rep1&type=pdf

Hinich, M. J. (1996). Testing for dependence in the input to a linear time series model. *Journal of Nonparametric Statistics*, *6*(2-3), 205–221.

Hsieh, D. A. (1991). Chaos and nonlinear dynamics: application to financial markets. *The Journal of Finance*, *46*(5), 1839–1877.

International Finance Corporation, (1999). *Emerging Markets Factbook and Database,* Washington D.C.: International Finance Corporation.

International Monetary Fund (2013). *Building momentum in a multi-speed world,* Regional Economic Outlook Sub-Saharan Africa, Washington D.C.

Islam, S. M., Watanapalachaikul, S., & Clark, C. (2007). Some tests of the efficiency of the emerging financial markets: An analysis of the Thai stock market. *Journal of Emerging Market Finance*, *6*(3), 291–302.

Jegadeesh, N. (1990). Evidence of predictable behavior of security returns. *The Journal of Finance*, *45*(3), 881–898.

Jegadeesh, N., & Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. *Journal of Finance*, *48*, 65–91.

Jegadeesh, N., & Titman, S. (2001). Profitability of momentum strategies: An evaluation of alternative explanations. *The Journal of Finance*, *56*(2), 699–720.

Jensen, M. C. (1978). Some anomalous evidence regarding market efficiency. *Journal of Financial Economics*, *6*(2), 95–101.

Johannesburg Stock Exchange Limited. (n.d.). *In Wikipedia*. Retrieved January 15, 2014, from http://en.wikipedia.org/w/index.php?title= SOUTH AFRICA_Limited&oldid=588012561

JSE Limited. (2014). *About us: JSE limited*. Retrieved December 31, 2013, from JSE Limited Website: http://www.South Africa.co.za/About-Us/History-Of-The-JSE.aspx

Kapetanios, G., Shin, Y., & Snell, A. J. (2003). *Testing for cointegration in nonlinear STAR error correction models*. Working Paper, Department of Economics, Queen Mary, University of London. Retrieved November 21st, 2013, from http://www.econstor.eu/handle/10419

Keim, D. (2006). *Financial market anomalies*. Chapter for the New Palgrave Dictionary of Economics.

Kemp, A. G., & Reid, G. C. (1971). The random walk hypothesis and the recent behaviour of equity prices in Britain. *Economica*, *38*(149), 28–51.

Kendall, M. (1953). The analysis of economic time series. *Journal of the Royal Statistical Society*, *Series A*(96), 11–25.

Kenny, C. J., & Moss, T. J. (1998). Stock markets in Africa: Emerging lions or white elephants? *World Development*, *26*(5), 829–843.

Laurence, M. (1986). Weak-fom efficiency in the Kuala Lumpur and Singapore stock markets. *Journal of Banking & Finance*, *10*, 431–445.

Lee, C. M. (2003). *Fusion investing: In equity valuation in global context*. Charlottesville VA: AIMR.

Lehmann, B. N. (1990). Fads, martingales, and market efficiency. *The Quarterly Journal of Economics*, *105*(1), 1–28.

Lim, K.-P., & Brooks, R. (2011). The evolution of stock market efficiency over time: a survey of the empirical literature. *Journal of Economic Surveys*, *25*(1), 69–108.

Lo, A. W. (2004). The adaptive markets hypothesis. *The Journal of Portfolio Management*, *30*(5), 15–29.

Lo, A. W. (2005). Reconciling efficient markets with behavioural finance: the adaptive markets hypothesis. *Journal of Investment Consulting*, *7*(2), 21–44.

Lo, A. W., & MacKinlay, A. C. (1988). Stock market prices do not follow random walks: Evidence from a simple specification test. *The Review of Financial Studies*, *1*(1), 41–66.

Lo, A. W., & MacKinlay, A. C. (1990). When are contrarian profits due to stock market overreaction? *Review of Financial Studies*, *3*(2), 175–205.

Luger, R. (2003). Exact non-parametric tests for a random walk with unknown drift under conditional hetereoscedasticity. *Journal of Econometrics*, *115*, 259–76.

Magnusson, M., & Wydick, B. (2002). How efficient are Africa's emerging stock markets? *Journal of Development Studies*, *38*(4), 141–156.

Malkiel, B. G. (2003). The efficient market hypothesis and its critics. *Journal of Economic Perspectives*, 59–82.

Markowitz, H. (1952). Portfolio selection. *The Journal of Finance*, *7*(1), 77–91.

Mecagni, M., & Sourial, M. S. (1999). *The Egyptian stock market-efficiency tests and volatility effects*. International Monetary Fund. Retrieved November 30th, 2013, from http://books.google.com/books?hl=en&lr=&id=pa6aUvcezsC&oi=fnd&pg=PA3&dq=Mecagni+and+Sourial+1999

Mlambo, C., & Biekpe, N. (2007). The efficient market hypothesis: Evidence from ten African stock markets. *Investment Analysts Journal*, (66), 5–18.

Moin, S. (2007). New frontier markets tempt investors. *African Review of Business and Technology*, *1*, 1–7.

Moss, T. J. (2003). Irrational exuberance or financial foresight? The political logic of stock markets in Africa. Retrieved December 12th, 2013, from http://www.cgdev.org/doc/expert%20pages/moss/Irrational%20Exuberance.pdf

Neumann, J. von and Morgenstern, O. (1944). *Theory of games and economic behaviour.* Princeton, NJ: Princeton University Press.

Nigeria Stock Exchange. (n.d.). *In Wikipedia*. Retrieved January 15, 2014, fromhttp://en.wikipedia.org/w/index.php?title=Nigerian_Stock_Exchange&oldid=590197912

Nisar, S., & Hanif, M. (2012). Testing weak form of efficient market hypothesis: Empirical evidence from South-Asia. *World Applied Sciences Journal*, *17*(4), 414–427.

Ntim, C. G., Opong, K. K., Danbolt, J., & Dewotor, F. S. (2011). Testing the weak-form efficieny in African stock markets. *Managerial Finance*, *37*(3), 195–218.

Olowe, R. A. (1999). Weak form efficiency of the Nigerian stock market: Further evidence. *African Development Review*, *11*(1), 54–68.

Olsen, R. A. (1998). Behavioural finance and its implications for stock-price volatility. *Financial Analysts Journal*, 10–18.

Omay, N. C., & Karadagli, E. C. (2010). *Testing weak form market efficiency for emerging economies: A nonlinear approach*. Retrieved November 15th, 2013, from http://mpra.ub.uni-muenchen.de/27312/

Osborne, M. F. (1959). Brownian motion in the stock market. *Operations Research*, *7*(2), 145–173.

Parkinson, J. M. (1984). The Nairobi stock exchange in the context of development of Kenya. *Savings and Development*, 363–372.

Rahman, A., & Saadi, S. (2008). Random walk and breaking trend in financial series: An econometric critique of unit root tests. *Review of Financial Economics*, *17*(3), 204–212.

Regnault, J. (1863). *Calcul des chances et philosophie de la Bourse*. Librairie Castel. Retrieved January 15th, 2014, from http://books.google.com/books?hl=en&lr=&id=Lpr1gh7QJjIC&oi=fnd&pg=PA1&dq=Regnault,+J.+(1863).+Calcul+des+chances+et+philosophie+de+la+bourse.+Paris:+Mallet-Bachelier+et+Castel

Roberts, Harry (1967). "statistical versus clinical prediction of the stock market". Unpublished manuscript, CRSP, University of Chicago, May.

Roberts, H. (1959). Stock market patterns and financial analysis: Methodological suggestions. *Journal of Finance*, *44*, 1–10.

Ross, S. A. (1976). The arbitrage theory of capital asset pricing. *Journal of Economic Theory*, *13*(3), 341–360.

Samuelson, P. A. (1965). Proof that properly anticipated prices flucturate randomly. *Industrial Management Review*, *6*(2), 41–49.

Savit, R. (1988). When random is not random: An introduction to chaos in market prices. *Journal of Futures Markets*, *8*(3), 271–290.

Scott, J., Stumpp, M., & Xu, P. (1999). Behavioural bias, valuation, and active management. *Financial Analysts Journal*, 49–57.

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance*, *19*(3), 425–442.

Shiller, R. J. (1979). The volatility of long-term interest rates and expectations models of the term structure. *The Journal of Political Economy*, *87*(6), 1190.

Shiller, R. J. (1984). Stock prices and social dynamics. *Brookings Papers on Economic Activity* 2, 457-498.

Shiller, R. J. (1989). *Market volatility*. Cambridge: MIT press.

Shiller, R. J. (2003). From efficient markets theory to behavioural finance. *Journal of Economic Perspectives*, 83–104.

Simons, D., & Laryea, S. A. (2006). Testing the efficiency of selected African stock markets. *Finance India*, *20*(2), 553–571.

Smith, A. (1759). *The theory of moral sentiments*. London: printed for A. Millar, and A. Kincaid and J. Bell.

Smith, G. (2007). Random walks in middle eastern stock markets. *Applied Financial Economics*,Vol. 17, pp. 587-96.

Smith, G., & Jefferies, K. (2005). The changing efficiency of African stock markets. *South African Journal of Economics*, *73*(1), 54–67.

Smith, G., Jefferies, K., & Ryoo, H. J. (2002). African stock markets: multiple variance ratio tests of random walks. *Applied Financial Economics*, *12*, 475–84.

Smith, V. L. (1998). The two faces of Adam Smith. *Southern Economic Journal*, 65(1), 2-19.

Stock Exchange of Mauritius. (2014). *About SEM: Stock exchange of Mauritius*. Retrieved January 2, 2014, from Stock Exchange of Mauritius Website: http://www.stockexchangeofmauritius.com/sem-at-a-glance

Stock Exchange of Mauritius. (n.d.). *In Wikipedia*. Retrieved January 15, 2014, from http://en.wikipedia.org/w/index.php?title=Stock_Exchange _of_Mauritius&oldid=583395363

Urrutia, J. L. (1995). Tests of random walk and market efficiency for Latin American emerging equity markets. *Journal of Financial Research*, *18*(3), 299–309.

Verheyden, T. (2013). *A tale of market efficiency: A Methodological Digress.* Retrieved from http://www.capitant.be/assets/files/thesis/thesis12.pdf

Working, H. (1934). A random-difference series for use in the analysis of time series. *Journal of the American Statistical Association*, *29*(185), 11–24.

Worthington, A. C., & Higgs, H. (2004). Random walks and market efficiency in European equity markets. *Global Journal of Finance and Economics*, *1*(1), 59–78.

Wright, J. H. (2000). Alternative variance-ratio tests using ranks and signs. *Journal of Business & Economic Statistics*, *18*(1), 1–9.

Yartey, C. A., & Adjasi, C. K. (2007). *Stock market development in sub-Saharan Africa: critical issues and challenges* (Vol. 7). International Monetary Fund. Retrieved October 12th, 2013, from http://books.google.com/books?hl=en&lr=&id=WCYYvpJvvGQC&oi=fnd&pg=PA3&dq=yartey+-+stock+market+&ots=XaYlvSStWV&si

Yartey, C. A. (2008). *The determinants of stock market development in emerging economies: Is South Africa different?* Washington, D. C: International Monetary Fund, African Dept.

World Bank (2011). World development indicators on online (WDI) database. Washington, DC: World Bank. Retrieved from http://www.worldbank.org.

World Federation of Exchanges, (2008) available at: www.worldexchanges.org/WFE/home.asp?menu¼436&document¼4822/ (accessed 10 May 2013).

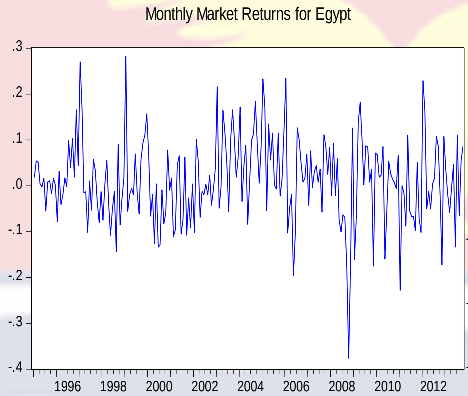
Zimbabwe Stock Exchange. (2013). *About us: Zimbabwe stock exchange*. Retrieved December 31, 2013, from Zimbabwe Stock Exchange Website: http://www.zimbabwe-stock-exchange.com/about/about-us/

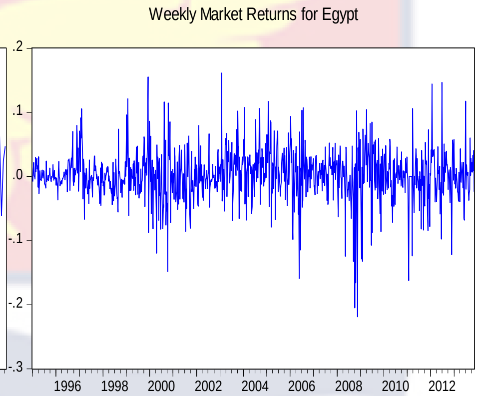
Zimbabwe Stock Exchange. (n.d.). *In Wikipedia*. Retrieved January 15, 2014, fromhttp://en.wikipedia.org/w/index.php?title=ZimbabweStock_Exchange&oldid=590089584

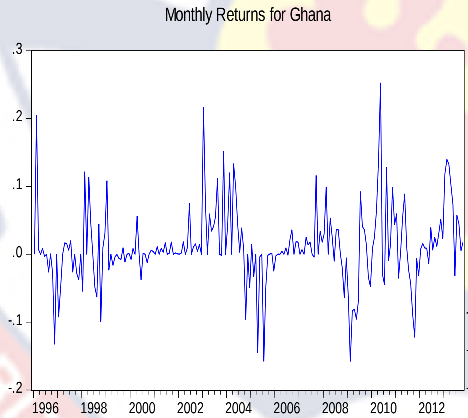
APPENDICES

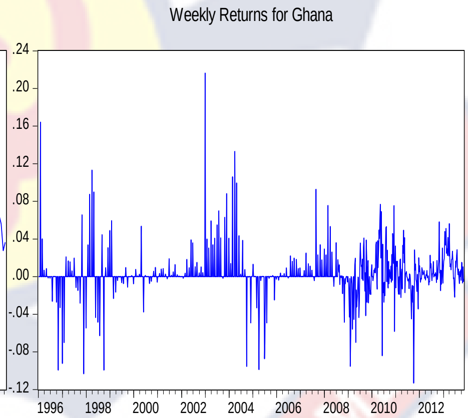
APPENDIX A

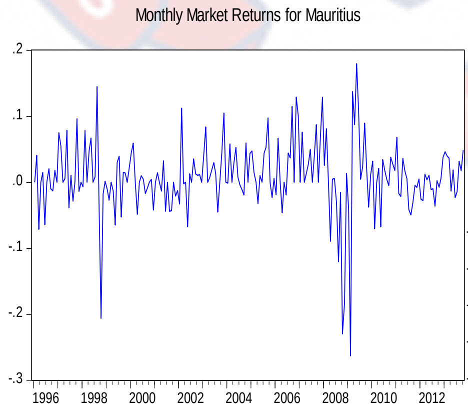
Plot of Stock Market Returns Used in the Study

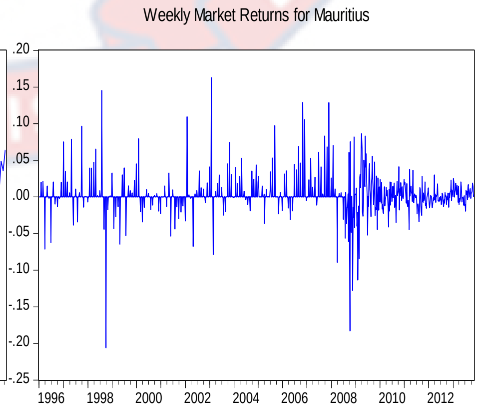












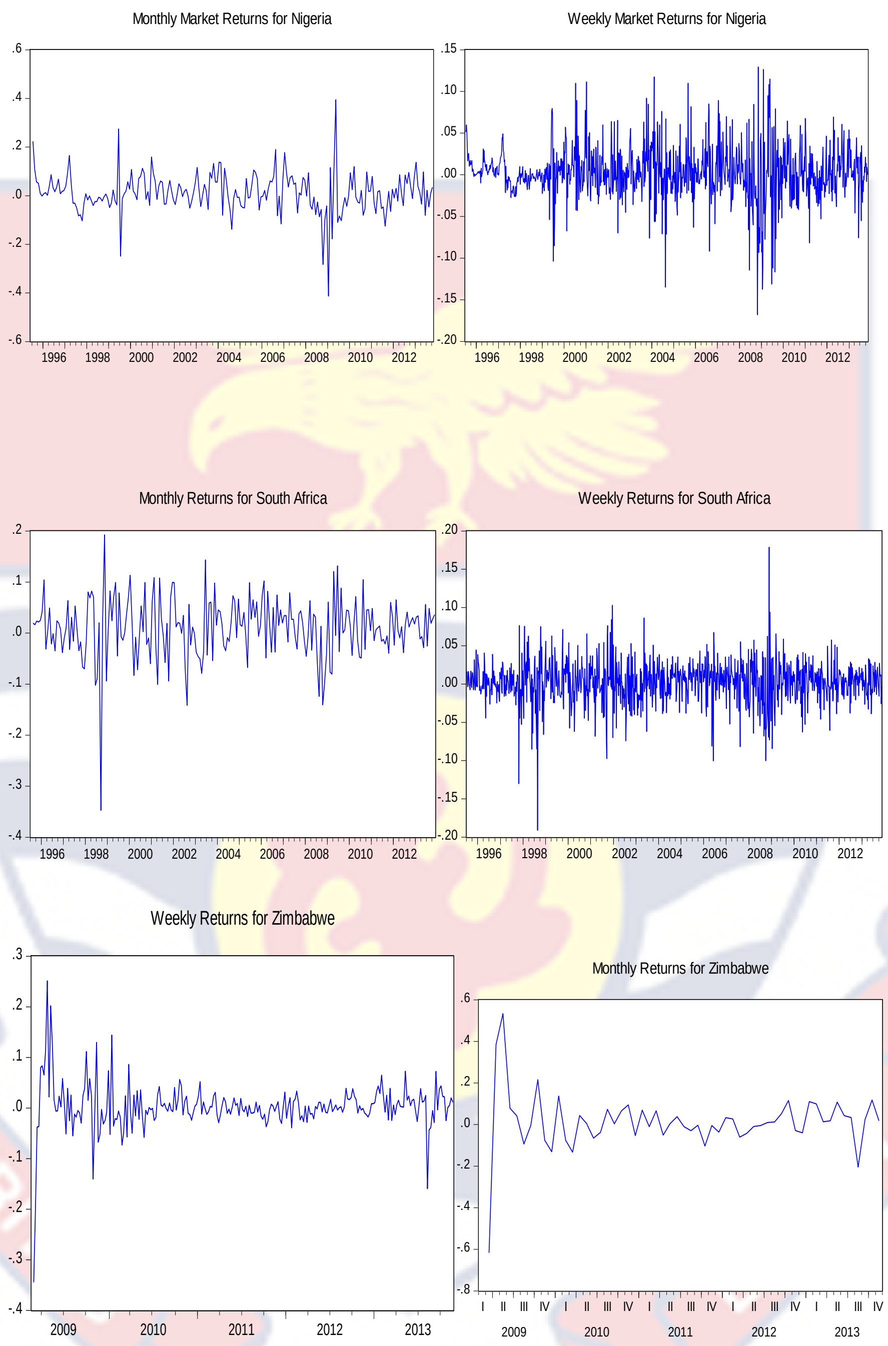


Figure A1: Plot of stock market returns series

Source: Computed and presented from stock market indices in Datastream using E-views 7

APPENDIX B

Table B1: Summary Statistics of Stock Market Returns

Descriptive Statistics	Observations	Max	Min
Weekly Egypt	985	.161426	-.218816
Monthly Egypt	226	.28223	-.37595
Weekly Ghana	933	.216261	-.113177
Monthly Ghana	214	.252192	-.157805
Weekly Mauritius	933	.162816	-.206003
Monthly Mauritius	214	.179849	-.262810
Weekly Nigeria	959	.129354	-.167944
Monthly Nigeria	220	.394786	-.412610
Weekly South Africa	959	.178746	-.191069
Monthly South Africa	220	.192334	-.347241
Weekly Zimbabwe	248	.251183	-.34475
Monthly Zimbabwe	57	.533235	-.616927

Source: Computed from stock price indices in Datastream using E-views 7