



Testing for Volatility and Market Efficiency of Uganda Securities Exchange

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Abstract

This study presents empirical evidence of volatility and market efficiency of Uganda Securities Exchange. Results indicate that the Uganda Securities Exchange exhibits a weak-form efficiency based on Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Augmented Dickey Fuller (ADF) and the serial correlation tests. This may be attributed to few listed companies and less liquidity hence the need to implement the over the counter facility, two tier market, more listing and promotion of collective investment schemes. Firms and individuals should be encouraged to buy or sell securities outside their face values, as a means of encouraging financial activities in the economy.

Keywords: Volatility; Efficiency; Securities Exchange; All Share Index and Stock Market.

Introduction

Background to the Study

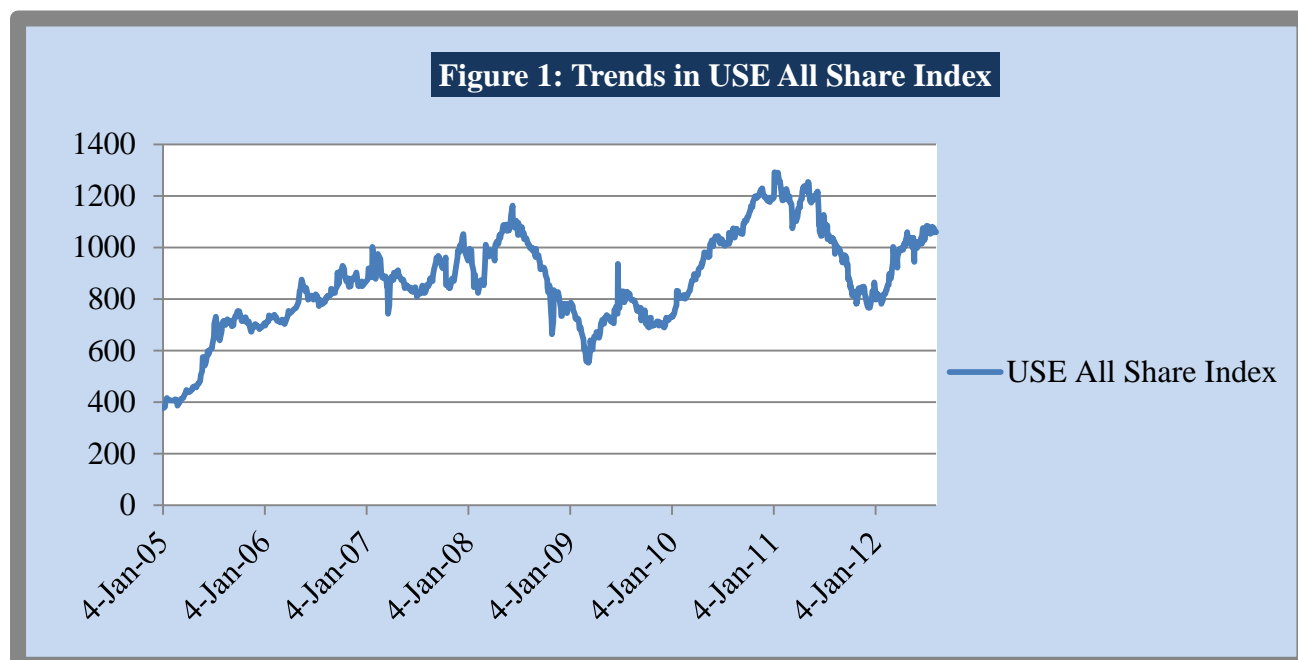
Financial markets in transition economies have developed significantly over the past two decades and some have developed to the extent that it is now possible for one to query their efficiency determined by their reaction to new information. In Africa, the stock market grew from eight stock exchanges in 1989, five in sub-Saharan Africa and three in North Africa, to over 20 stock exchanges by the year 2010. Uganda Stock Exchange being one of those which had come on board. Despite the increase in the number of stock exchanges in Africa, they still lack the depth, breath and liquidity levels are low. Participation is very narrow with Africans being the main participants with less foreign participation.

In the East African region, there are four securities exchanges which include Tanzania Securities exchange, Nairobi Securities exchange in Kenya, Rwanda Securities Exchange and the Uganda Securities Exchange. Among these, the Nairobi Securities Exchange established in 1954 is the leader and the oldest. Uganda Securities Exchange started its operations in 1998.

Uganda Securities Exchange is an organization that handles the country's stock exchange. It was instituted to develop and manage the security market in the most efficient way and take care of the development and functioning of the Uganda's capital market. It is headed by the governing council and has an appointed chairman and managing director. The functions of the Uganda Securities Exchange are various but basically it raises investment funds for the investment in long term products, liquidity generation as well as enhancement and growth of the financial sectors among others (USE, 2000). The growth in the number of companies listed since 1998 has not been very good with only two companies till march 2002 when a third company was listed and currently having 14 companies listed. The listed companies include British American Tobacco Uganda (BATU), Bank of Baroda Uganda (BOBU), Development Finance Company of Uganda Ltd (DFCU), East African Breweries Limited (EABL), Jubilee Holdings Limited (JHL), Kenya Airways (KA), New Vision Printing and Publishing Company Ltd (NVL), Stanbic Bank Uganda (SBU), Uganda Clays Limited (UCL), Equity Bank Limited (EBL), Kenya Commercial Bank Group (KCB), National Insurance Corporation (NIC), Nation

Media Group (NMG), and Centum Investment Company Ltd (CENT). Eight of these listed companies are local equities of which six are cross border listings. There are also two listed and approved corporate bonds; the EADB Bond and Standard Chartered Bank Bond maturing in 2013 and 2015 respectively (USE, 2012).

According to the USE (2010) report, despite the challenges which included the continued volatility and ongoing uncertainty brought about by the global financial crisis, the USE has maintained its resilience and delivered a modest recovery from the depressed performance recorded in 2009. The performance of USE has been unstable over the years with less increase and stagnant growth as shown by the fluctuations in the USE All Share Index (ALSI) in figure 1.



These fluctuations and stagnant growth in the ALSI raise the question on how efficient the USE has been hence the need to test for its volatility and efficiency.

Besides ensuring market efficiency is one of the mandatory roles of USE hence the need to ascertain if market efficiency has been achieved. A few studies have been carried out on the efficiency of USE but covered a shorter period. Birakwate (2008), studied the USE efficiency for the period 2004-2007 using non-parametric Wald- Wolfowitz run test and found out that the USE market was not efficient in the weak-form. A parametric method is used in this study. Testing market efficiency is important to investors and policy makers dealing with emerging equity markets USE being one of them. An efficient capital market is necessary and useful for a functioning market economy.

Objective of the Study

The general objective of this study is to test for volatility and market efficiency of the Uganda Securities Exchange. Specifically, the study tests for the presence of volatility clustering in ALSI and for the weak-form efficiency of the Uganda Securities Exchange.

Study Hypotheses

The following are the study hypotheses

- i) That there is no volatility clustering in ALSI.
- ii) That Uganda Securities Exchange does not exhibit weak-form efficiency.

Study Scope

The study covers the daily All Share Index for the period 2005 – 2012. This index incorporates all adjustments involving daily stock market prices for each company as well as the turnover.

Literature Review

The market efficiency hypothesis (EMH), according to Fama, (1970), explains the relationship between information and share prices in the capital market. An efficient market is where information is quickly circulated to the market such that it is reflected in the stock market prices. This implies that information is disseminated quickly and the market responds quickly in such a way that it does not give room for arbitrage. This implies that the response of prices to information should be instant.

The EMH implies that current stocks prices reflect all the known information, useful for their prediction. The information channels are efficient as long as the information is spreading rapidly and new information becomes public quickly. The new information leads to purchasing and selling which affects the price until it corresponds to the new value of the company. Therefore, the information is quickly assimilated to the new stock price. According to Worthington and Higgs, (2006), the share price may be at any time reflect a correct estimation of the future share prices, described as a random walk behavior which is an imperative allusion for investors.

Given the disseminated information set, financial theory is based on three forms of efficiency. These include; Weak-form efficiency which holds if the asset price immediately incorporates the information contained in the asset history; Semi-strong efficiency which holds if all the public information is incorporated into the asset price; and Strong-form efficiency which holds if all the information, public or private is incorporated into market prices. This paper will focus on weak-form market efficiency.

There a number of recent studies focused on emerging equity markets and they give different results depending on the country and the applied methodology.

For weak-form efficiency, market stock returns are unpredictable. Testing of this efficiency form is assimilated with tests concerning the predictability of stock returns. If stock prices are not generated by a random walk process, meaning there are recurrent patterns in asset prices, then the future returns may be predicted by the historical sequence of returns. Campbell et al., (1997) assert that a useful rating, regarding the predictability of asset returns, generates the following random walk hypotheses; random walk hypothesis (RW1) with independent and identically distributed increments; random walk hypothesis (RW2) with independent but not identically distributed increments; and the weakest form of the random walk hypothesis include processes with dependent but uncorrelated increments (RW3). Tests used in most studies are applied to RW1 and RW3 hypotheses. This paper will also verify the efficiency of Uganda's capital market by using RW1 and RW3.

The use of the ordinary regression models has been criticized by different researchers in modeling stock market data. Bodicha (2003) applied regression models to the NSE data and found out that the regression models are only appropriate for short term prediction and not for long term forecasting. However, Mills (1999) suggests that analysis of the general linear regression model forms the basis of every standard econometric model. Mills applied the simple linear relationship in modeling the expected risk and return in holding a port folio.

Ntim *et al* (2011) used Variance-ratio tests based on ranks and signs to examine the weak-form efficiency of the 32 stock price indices. On average, it was found that irrespective of the test employed, the returns of all the 24 African continent-wide stock price indices examined in the study were less non-normally distributed compared to the eight individual national stock price indices examined. The authors also report evidence of the African continent-wide stock price indices having significantly better weak-form informational efficiency than their national counterparts. Variance- ratio tests however do not capture volatility clustering.

Worthington and Higgs (2006) have studied the weak-form market efficiency of twenty-seven emerging markets in different regions. The serial correlation tests conclude that most emerging markets are weak-form inefficient.

Kvedaras and Basdevant (2002) tested the efficiency of financial markets in the three Baltic States. Results showed that financial markets were with some turbulence and approaching weak form of efficiency. They concluded that efficiency of capital markets in emerging economies increase over time, as a result of gradual liberalization. Harrison and Paton (2004) examined the evolution of stock market efficiency in the Bucharest Stock Exchange using a GARCH model on daily price data. They found strong evidence of inefficiency in the Bucharest Stock Exchange, the lagged stock price index being a significant predictor of the current price index. The level of inefficiency appeared to diminish over time.

According to Todea, (2005), testing the efficiency of emerging markets should take into account characteristics like infrequent trading, high volatility and the non linearity of the share price variation. These would provide guidance on the methodology to use and avoid the use of linear models that may lead to ambiguous results.

Fama (1965), concludes that the interaction between stock returns and market performance is strongly related to the efficient market hypothesis. According to Yong (2005), attempts by stock brokers, chartists and fundamentalists to develop trading functions to consistently beat the market are exercised in futility since the efficiency market hypothesis gives useful information on how current stock return which is already contained in the most recent previous stock data.

Data and Methods of Estimation

Daily data capturing data for trading days on USE All Share Index was used. The All Shares Index captured data for 14 listed companies for the period Jan. 04, 2005 to Aug. 07, 2012 from USE data base. The USE All Shares Index is considered as the best performance measure of the overall equity market since it's a weighted market capitalization index representing performance of eligible listed companies.

This study used serial correlation tests and Unit root tests to test for independence of the All Share Index. The GARCH model was used to test for predictability and persistency of stock returns. These tests have been used to make conclusions about the efficiency of the USE.

Theoretical Framework

Efficiency implies that stock prices fully reflect all available information including all historical, public and private information. This assumes that asset prices and returns are determined by supply and demand in a competitive market having rational traders who collect relevant information in determining asset prices or returns and adjust prices immediately. Thus, changes in All Shares Index reflect new information and as long as new information is immediately incorporated, then the stock market is efficient. This implies that no information at any future time period should help to improve the forecast of returns. This therefore implies that forecast errors are independent of previous information (orthogonality property).

If all relevant information is available and the only change is arrival of news then,

$$ALSI_{t+1} - E(ALSI_{t+1}) = \varepsilon_{t+1} \quad \text{-----} \quad (1)$$

Where $ALSI_{t+1}$ is All Share Index for tomorrow, $E(ALSI_{t+1})$ is expected tomorrow's ALSI and ε_{t+1} are forecast

errors. Since prices are expected to reflect all the available information, then $E(\varepsilon_{t+1}) = 0$ implying that there is no forecast bias in the stock prices thus the expected price is equal to the observed price. Similarly, the expected ALSI is expected to be equal to the expected ALSI. By Equation (1), the efficient market hypothesis assumes a random walk where subsequent ALSI changes reflect random walk departures from previous ALSI. Therefore, if information is immediately reflected in the stock prices, then tomorrow's price/ALSI change will reflect only tomorrow's news and will be independent of today's price/ALSI change. Weak form efficiency tests whether all information contained in the historical price are fully reflected in current stock prices (ALSI). Fama (1991) redefines this type of efficiency to test for return predictability including forecasting returns with fundamental variables.

Estimation Procedure

The pure random walk model assumes that current stock prices are independent of previous stock prices modified by current shocks hence current ALSI is independent of previous ALSI. Evidence that supports the random walk model also forms evidence that supports weak-form efficiency. A random walk procedure was used to analyze the relationship between ALSI today and ALSI yesterday using the Augmented Dicky-Fuller test for unit root. If ADF test according to Dickey and Fuller (1981), results do not reject the presence of unit root in the past ALSI series, then the stock market will be weak-form efficient.

A pure random walk is represented as $ALSI_t = \delta ALSI_{t-1} + \varepsilon_t \quad \text{-----} \quad (2)$

Where, $ALSI_t$ is the ALSI at time t, δ is the coefficient of yesterday's ALSI, $ALSI_{t-1}$ is ALSI in period $t-1$, and ε_t represents shocks to the system at time t.

If $\delta = 1$, the ALSI is a pure random walk variable implying stock market efficiency

There is need to de-trend the data by subtracting $ALSI_{t-1}$ on both sides to obtain;

$$\Delta ALSI_t = \beta ALSI_{t-1} + \varepsilon_t \quad \text{-----} \quad (3)$$

Where, $\beta = \delta - 1$.

Given that the ALSI series may glide over time either upwards or downwards, and may include the deterministic trend of the mean itself is a function of time, then deterministic trend (T) is included. Thus equation (3) now becomes;

$$\Delta ALSI_t = \delta_0 + \delta_1 T + \beta ALSI_{t-1} + \varepsilon_t \text{ ----- (4)}$$

Equation (4), is the Dickey Fuller unit root test. To avoid auto-correlation in the residual process, this test is augmented by lagged values of the dependent variable hence the Augmented Dickey- Fuller equation unit root test which produces white noise residuals.

Thus,

$$\Delta ALSI_t = \delta_0 + \delta_1 T + \beta ALSI_{t-1} + \sum_{i=1}^n \gamma_i \Delta ALSI_{t-1} + \varepsilon_t$$

Where, $\Delta ALSI_{t-1}$ represents lagged values of dependent variable

Hypothesis testing is based on the significance of β .

If $\beta = 0$, it implies that ALSI follow a random walk and any shock to the system will be explosive. This confirms that future ALSI cannot be predicted from past ALSI proving the weak-form efficiency of the stock market.

The weakness with unit root test is its failure to distinguish between stationary series and series with very small random walk component. However, Fama and French (1988), suggest a mean reversion test to capture the slowly decaying temporary component of stock prices/ ALSI explaining the long temporary swings that take ALSI away from fundamental values. These reversals are attributed to irrational bubbles implying that financial markets display excess volatility such that they under or over react to new information. Reversals are also consistent with time varying expected equilibrium return generated by rational pricing in an efficient market.

The conditional mean return and conditional variance define the Integrated GARCH model.

- i) The conditional mean $ALSI_t = \alpha_t + \varepsilon_t$
- ii) The conditional Variance $h_t = \theta_0 + \sum_{i=1}^p \beta_i \varepsilon_{t-1}^2 + \sum_{i=1}^q \gamma_i h_{t-j}$

Where, $\theta_0 > 0; \beta_i > 0; \gamma_i > 0$. These conditions ensure that h_t is positive.

α_t - is conditional mean ALSI.

γ_i 's - are coefficients that capture persistency of volatility

β_i 's - are measures that capture volatility clustering.

- a) If $\sum_{i=1}^p \beta_i + \sum_{i=1}^q \gamma_i = 1$, it defines an integrated variance model implying that current shocks persist indefinitely in conditioning future variance.
- b) If $\sum_{i=1}^p \beta_i + \sum_{i=1}^q \gamma_i < 1$ but close to unity, then shocks to volatility are more persistent and have slower decay.
- c) If $\sum_{i=1}^p \beta_i + \sum_{i=1}^q \gamma_i > 1$, the system is explosive given that volatility increases over time.

According to Nyong, (2005), the GARCH model is considered consistent with the volatility clustering in financial returns data where large changes in returns are accompanied with further large changes.

Serial correlation was also used to test for weak form efficiency by testing the assumption that with random walk process, the error terms are identically and independently distributed (*iid*).

$$ALSI_t = \beta + \rho ALSI_{t-1} + \varepsilon_t$$

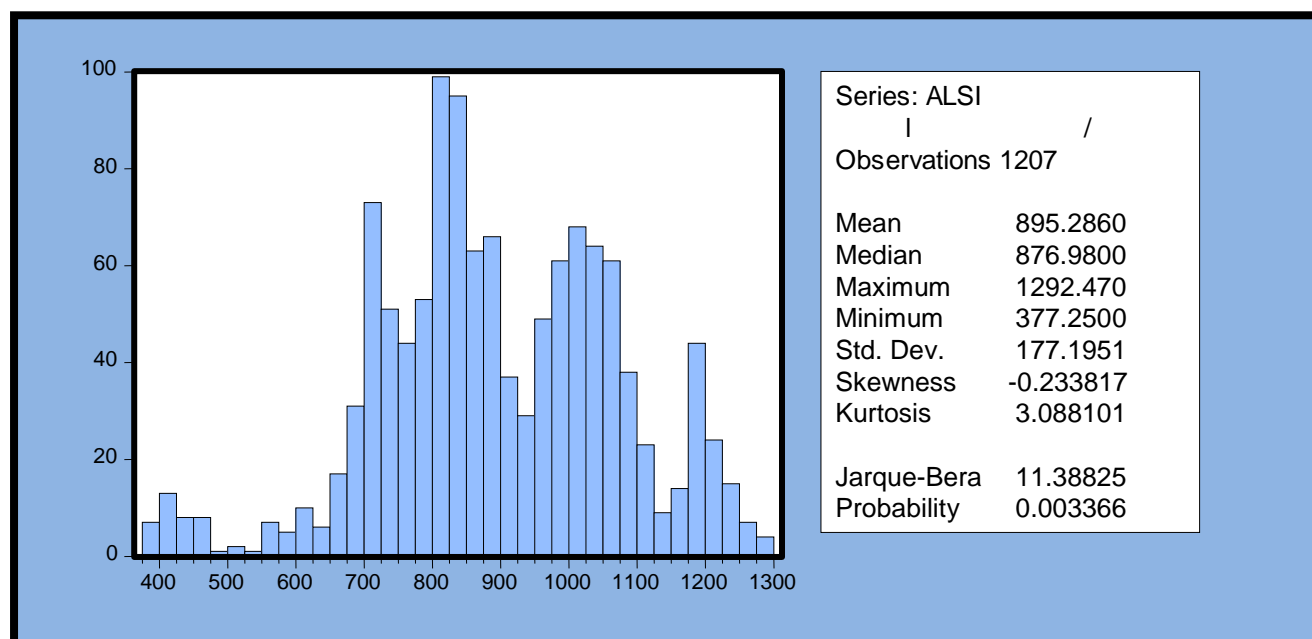
Where $\beta = \lambda(1 - \rho)$ and is a constant term

$ALSI_{t-1}$ is the ALSI for previous day and ε_t is the error term with zero mean and not serially correlated. In this model we test the hypothesis that $\rho = 0$ meaning that there is no serial correlation and if it holds, then the market exhibits weak-form efficient. Positive serial correlation implies short - run predictability and it is observed when $0 < \rho < 1$. Negative serial correlation implies long-run predictability and it is observed when $0 > \rho > 1$.

Model Estimation and Discussion of Results

Prior to estimation of the model, a normality test of the series was carried out to check if the series are normally distributed. A Jarque-Bera test was used to test the null hypothesis that the series are normally distributed and results are as in figure 2. Since the probability of the Jarque-Bera statistics is significant, then, we reject the null hypothesis and conclude that the series are not normally distributed. This is expected for financial time series data.

Figure 2: Normality Test



Unit Root Test

The Unit root test was used to determine if the series were stationary and in this study, the Augmented Dickey-Fuller test statistic was used as shown in Table 1. The Results show that the ADF- Statistics (2.716) in absolute terms is less than the critical values at all levels of significance implying that the series are not stationary hence rejecting the hypothesis of stationary series. These results therefore imply that the process has a random walk at all levels of significance and thus is weak-form efficiency.

NB: ALSI is not stationary in levels, but after differencing the series once, it becomes stationary at all levels as shown in Appendix.

Table 1: Results of the Unit Root Test of ALSI Series in Levels

Null Hypothesis: ALSI has a Unit Root				
Lag Length1: (Automatic based on SIC, MAXLAG=22)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller Test Statistic			-2.715621	0.2303
Test Critical Values:	1% level		-3.965680	
	5% level		-3.413545	
	10% level		-3.128823	
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ALSI(-1)	-0.009878	0.003638	-2.715621	0.0067
D(ALSI(-1))	-0.090254	0.028670	-3.148045	0.0017
C	8.829894	2.884221	3.061449	0.0023
@TREND(4/01/2005)	0.001050	0.001847	0.568481	0.5698

GARCH Model Estimation

According to results in table 2, the value of the sum of ARCH (0.315170) and GARCH (0.563129) is 0.878299 which is less than one (1) implying that shocks to volatility are more persistent for a long period but with slower decay rate. Thus the shocks in ALSI are mean reverting in that their value will in the future converge to the mean value as volatility decreases.

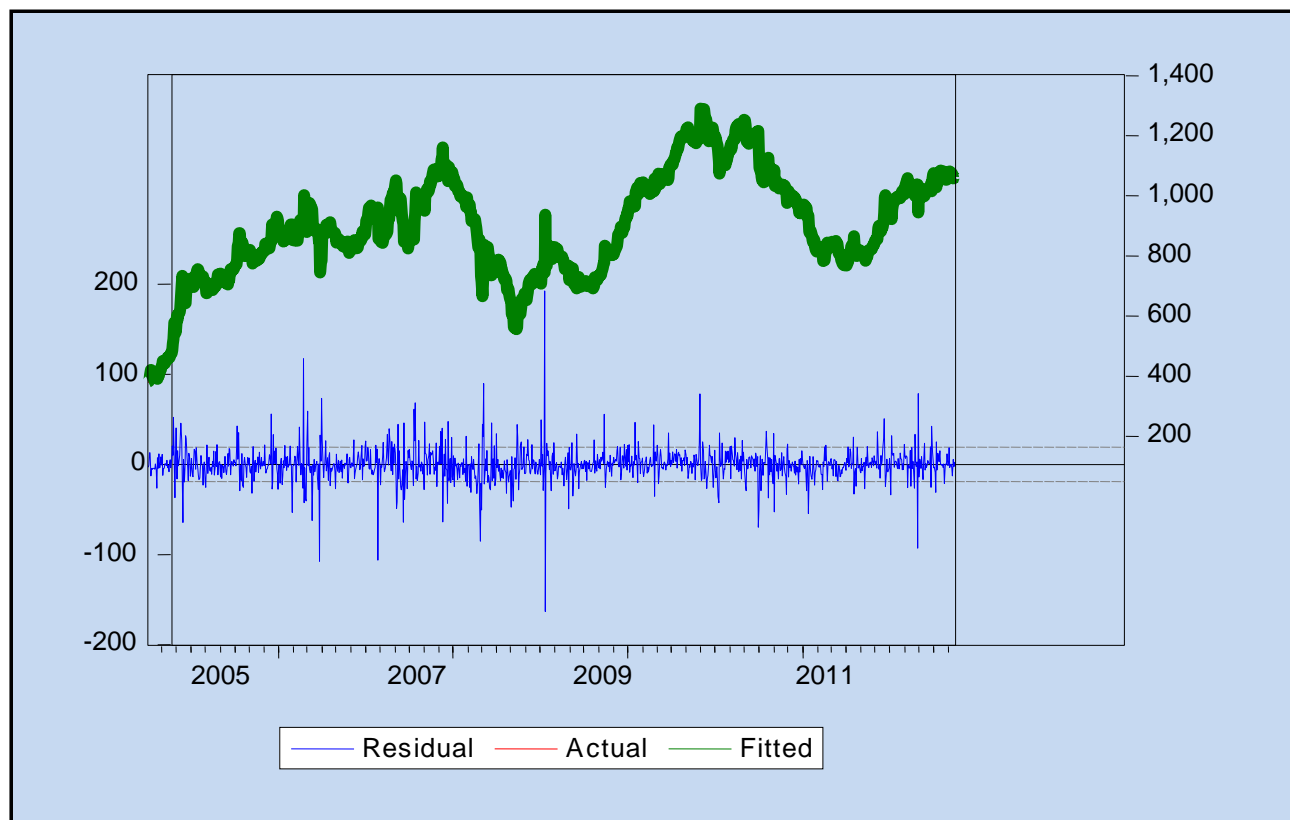
Table 2: Results of the GARCH Model

Method: ML - ARCH (Marquardt)				
Included Observations: 1206				
Convergence Achieved After 56 Iterations				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	7.153414	2.349483	3.044676	0.0023
ALSI(-1)	0.992890	0.002509	395.7215	0.0000
Variance Equation				
C	65.16572	5.289801	12.31912	0.0000
ARCH	0.315170	0.026028	12.10902	0.0000
GARCH(-1)	0.569129	0.022459	25.34031	0.0000
Adjusted R-squared	0.988401	S.D. dependent var		176.6388
Sum squared resid	434638.4	Schwarz criterion		8.583236
F-statistic	25672.28	Durbin-Watson stat		2.184706
Prob(F-statistic)	0.000000			

The Durbin- Watson value in table 2 is approximately 2 indicating that there is no serial correlation and therefore USE stock market is weak-form efficient.

Figure 2 presents a graph of the residuals, the actual ALSI index and the fitted values. The graph shows that the residuals are not stationary. The graph displays the daily percentage changes in the ALSI over the periods 2005-2012. There are clearly periods of small fluctuations and periods of large fluctuations. This implies that there is volatility clustering which reflect investor uncertainty which may be attributed to uncertainty about the fundamentals in the economy.

Figure 2: Time Plot of Residuals, Actual and Fitted ALSI index



Conclusions and Policy Recommendations

Empirical results from this study show the presence of volatility clustering in ALSI as well as weak-form efficiency of the Uganda Securities Exchange. This may be attributed to few listed companies and less liquidity hence the need to implement the over the counter facility, two tier market, more listing and promotion of collective investment schemes

Given the high large volatility in USE, investors are likely to be worse-off. Expected returns need to be raised by using strategies designed towards reaping abnormal returns by exploiting information and actions that enhance inefficiency in stock markets. Firms and individuals should be encouraged to buy or sell securities outside their face values, as a means of encouraging financial activities in the economy.

References

- [1] Birakwate F. G. (2008), "Measuring Stock-Market Efficiency: Evidence from Uganda Securities Exchange", Makerere University, Kampala, Uganda.
- [2] Bodicha, H.H. (2003). "Forecasting of market share prices for selected companies at the Nairobi Stock Exchange based on econometric models", Egerton University, Naroibi Kenya.
- [3] Campbell J.Y., Lo A.W. and MacKinlay A.C. (1997), "The Econometrics of Financial Markets", Princeton University Press, Princeton.
- [4] Dickey, D and Fuller, W. (1981), "Likelihood Ratio statistics for Autoregressive time Series with a unit Root" *Econometrica*, Vol.49, pp.1057-72

- [5] Fama E. F (1991), “Efficient Capital Markets II”, *Journal of Finance*, 5: 1575-1617, Blackwell Publishing for the American Finance Association.
- [6] Fama E.F. and French K.R (1988), “Dividend Yields and Expected stock returns”. *Journal of Financial Economics* 22: 3-25. University of Chicago, Chicago, USA.
- [7] Fama E. F (1970), “Efficient Capital Markets: A Review of Theory and Empirical Work”. *Journal of Finance*, 25: 383-417.
- [8] Fama E. F. (1965), “The Behaviour of Stock Market Prices”, *Journal of Business*, Vol. 38, No. 1, pp. 34-105.
- [9] Kvedaras V. and Basdevant O., (2002), “Testing the Efficiency of Emerging Markets: the Case of the Baltic States”.
- [10] Ntim, Collins, Opong, K.K. , Danbolt, J. , and Dewotor, F.S. (2011), “Testing the weak-form efficiency in African stock markets”. *Managerial Finance*, 37 (3). pp. 195-218.ISSN 0307-4358 (doi:10.1108/03074351111113289)
- [11] Nyong, MO 2005, ‘Predictability and Volatility of Stock Returns in three Emerging Markets: Nigeria, South Africa and Brazil’. *Nigerian Journal of Economics and Development Matters*. 2 (1): 12-29.
- [12] Todea, A., (2005), “The informational efficiency of the stock market – empirical studies on the Romanian market,” *Casa Cărții de Știință, Cluj-Napoca*, pg. 101-108. Uganda Securities Exchange, (2012),”USE Annual Report”, Kampala , Uganda.
- [13] Uganda Securities Exchange, (2010),”USE Annual Report”, Kampala , Uganda.
- [14] Uganda Securities Exchange, (2007),”USE Annual Report”, Kampala , Uganda.
- [15] Worthington, A. C. and Higgs, H.,(2006), “Efficiency in the Australian stock market, 1875-2006: A note on extreme long-run random walk behavior”, School of Accounting & Finance, University of Wollongong, Working Paper 5.

Appendix:

Unit Root Test of ALSI in First Difference				
Null Hypothesis: D(ALSI) has a Unit Root				
Lag Length: 0 (Automatic based on SIC, MAXLAG=22)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-38.08794	0.0000
Test critical values:	1% level		-3.965680	
	5% level		-3.413545	
	10% level		-3.128823	
*MacKinnon (1996) one-sided p-values.				
Included observations: 1205 After Adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ALSI(-1))	-1.093757	0.028717	-38.08794	0.0000
C	1.582618	1.096779	1.442969	0.1493
@TREND(4/01/2005)	-0.001595	0.001573	-1.014252	0.3107
S.E. of regression	18.98723	Akaike info criterion		8.727897
Sum squared resid	433339.1	Schwarz criterion		8.740580
F-statistic	725.3455	Durbin-Watson stat		2.000047
Prob(F-statistic)	0.000000			