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Preliminary communication

EMPIRICAL EVALUATION OF WEAK-FORM EFFICIENT MARKET HYPOTHESIS IN UGANDAN SECURITIES EXCHANGE

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Abstract

An efficient stock market plays an important role in stimulating economic development through providing a channel for mobilising domestic savings and facilitating the allocation of financial resources from dormant to more productive activities. This paper evaluates the Ugandan Securities Exchange (USE) for evidence of a weak-form efficient market hypothesis in the context of random walk model, using both linear and non-linear models. The preliminary analysis from the USE daily returns, for the September 1, 2011 to December 31, 2016 period, shows negative skewness, leptokurtosis, and non-normal distribution. Estimates from the linear models show evidence of weak-form efficiency. Conversely, estimates from non-linear models show evidence against weak-form efficiency of the USE. The study concludes that USE returns may only be predicted using non-linear models and fundamental analysis. In other words, linear models and technical analyses may be clueless for predicting future returns.

Keywords: *Weak-form efficiency, random walk, linear and non-linear models, Ugandan securities exchange*

JEL Classification: *G14*

Introduction

An efficient stock market plays an important role in stimulating economic development through providing a channel for mobilising domestic savings and facilitating the allocation of financial resources from dormant to more productive activities (Emenike, 2009; Ntim, Opong, Danbolt and Dewotor, 2011; Maghanga and Quisenberry, 2015). Increased investment in productive activities, in turn, leads to employment creation,

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income generation, while a larger percentage of the population earning incomes, savings and consumption will result in a cycle of increased investment, increased production, and enhanced economic development. In addition, an efficient stock market encourages listed companies to observe better corporate governance through full disclosure requirements, hence leading to a greater transparency in the business sector and lower incidences of corruption. Even more so, an efficient stock market enhances the inflow of international capital through foreign portfolio investments. Understanding the level of stock market efficiency is thus very important for capital market authorities, stock market participants and scholars.

Efficient market hypothesis (EMH) is almost certainly the right place to start when thinking about stock market efficiency. The EMH states that in an efficient market, asset prices at all times fully reflect all available information (Fama, 1965). Thus, asset prices at any point in time are an unbiased reflection of all available information on the assets' expected future cash flow. Fama (1970) categorised market efficiency into three levels depending on how quickly information is impounded into prices: weak form EMH, semi-strong form EMH, and strong form EMH. The weak form efficiency, which is the lowest level of efficiency, asserts that stock prices already reflect all information that can be derived by examining market trading data such as the history of past prices, trading volume or short interest (Bodie, Kane and Marcus, 1999: 331). This implies that history of stock prices, trading volume or short interest is clueless for predicting future stock price changes. Semi-strong form EMH holds that security prices already fully reflect all publicly available information regarding the prospects of a firm. This means that market participants cannot consistently outperform the market by analysing published information, because such information is instantaneously adjusted into prices once it is released. Lastly, strong form efficiency posits that in addition to information on past prices and publicly available information, security prices reflect information available only to company's insiders. This study is concerned only with the weak form efficiency, which is the lowest level of market efficiency. Absence of weak form efficiency in the Ugandan Securities Exchange (USE) will imply absence of higher levels of efficiency, since as Wong and Kwong (1984) observe, the failure to prove weak form efficiency implies the failure to prove both semi-strong and strong form efficiency.

The enormous scholarly interest in stock market efficiency is built on the insight, now well researched, that there are close links between stock market efficiency and greater transparency in asset price discovery. Numerous empirical studies have examined weak form efficiency of stock markets in developed, emerging and developing countries (see for example, Kendal, 1953; Fama, 1965; Emenike, 2009; Lim, Huang, Yun, & Zhao, 2013; Alkhatib & Harasheh, 2014; Konak and Şeker, 2014;). Most of the studies conducted in developed economies agree that stock price changes are random and that past prices are not useful in predicting future price changes, particularly after transaction costs have been taken into consideration. The results of studies on weak-form efficiency from emerging markets have been mixed. In the Ugandan context, however, there is a dearth of empirical literature on stock market efficiency. This dearth of research, providing empirical evidence to support or dispute efficiency according to Simons and Laryea (2004), may explain why many African countries have not attracted much portfolio or equity investment as the Asian and Latin American countries. The very few available literature pieces provide conflicting evidence (see, Ssemuyaga, 2012; Watundu, Kaberuka, Mwelu and Tibesigwa, 2015). Watundu, *et al.* (2015) for example, conclude amongst others, that USE is weak-form efficient based on absence of first order serial correlation in the daily returns increments for the 2005–2012 period. They attributed their findings to few listed companies and less liquidity. Ssemuyaga (2012) concludes that the USE is inefficient at the weak form for the 2006 to 2010 period. These studies also failed to identify the version of random walk model examined. There is therefore a need for empirical evidence-based knowledge on the nature of weak-efficiency of the USE.

The purpose of this study therefore is to evaluate whether weak-form efficient market hypothesis holds for USE by analysing serial correlation (RWM 3) and independence (RWM 2) in the market's returns increments. This study is useful to the investors, regulators and participants of the USE as well as to future researchers. To the investors for example, the findings highlight the extent to which history of prices influences current securities indices on the bourse. To the regulators, the study provides a basis for formulating policies that will enhance USE efficiency, which will, in turn, boost investors' confidence in the market. The study is also useful to scholars as it provides recent evidence on the nature of weak-form efficiency of the USE. It will serve as reference material to future researchers. The remainder of the paper is organised as follows: the next section presents an overview of the USE and theoretical framework. Section three contains data and techniques of analysis, while section four provides results and discussions. Section five provides the conclusions.

2. Overview of USE and Brief Review of Empirical Literature

2.1. Overview of USE

The Uganda Securities Exchange (USE) was established in 1997 as a company limited by guarantee and incorporated in Uganda under the Ugandan Companies Act. The USE was licensed to operate as an approved Stock Exchange in June 1997 by the Capital Markets Authority (CMA) of Uganda under the Capital Markets (Licensing) Regulations 1996 and the Capital Markets Authority Amendment Act 2016. The Exchange is governed by the Uganda Securities Exchange Limited Rules 2003. The principal activity of the Exchange is to provide a central place for trading of securities and regulation of licensed brokers/dealers. It provides a credible platform for raising capital through the issuance of appropriate debt, equity and other instruments to the investing public. The Exchange therefore provides essential facilities for the private sector and government to raise money for business expansion and enables the public to own shares in companies listed on the Exchange (Uganda Securities Exchange, 2015).

The exchange opened to trading in January 1998. At that time, the exchange had just one listing, a bond issued by the East African Development Bank. Trading was limited to only a handful of trades per week. As of July 2014, the USE traded 16 listed local and East African companies[3] and had started the trading of fixed income instruments (Muhumuza, 2015). The exchange is a member of the African Stock Exchanges Association.

The USE launched the USE All Share Index (ASI) on the 31st of December 2001, with a base value of 100 basis points. The USE ASI tracks general market movement of all listed equities on the bourse regardless of capitalisation. The index is a market capitalization weighted average index with a base value of 100 points. The ASI is calculated on a daily basis, and adjusted for corporate actions, new listings, right issue and placing. As at 30 December 2017, the ASI stood at 1477 points.

During the first quarter of 2010, the USE automated a securities central depository, paving the way for clearing and settlement of securities to be done electronically. In the same year, the USE was the best performing stock exchange in Sub-Saharan Africa, with an All-Shares Index return of 74% between January and November 2010.

On 20 July 2015, the USE initiated its electronic trading platform, backed by three independent data servers, resulting in a T+3 trade settlement cycle from the previous T+5 cycle.

Trading of listed equity securities is conducted in sessions commencing at 9.00 a.m. and closing at 3.00 p.m. each day (USE Equity Trading Rule, 2015).

The transaction fee for equity trade is 2.1% of the trade value. This comprises the broker, 1.7%; the USE, 0.14%; the CMA, 0.14%; the compensation fund, 0.02%; and the Securities Central Depository 0.1% of the value of the trade (USE Fee, Charges and Penalties Rules, 2012).

The equities market of the USE comprises the Main Investment Market Segment[4] (MIMS) and the Growth Enterprise Market Segment (GEMS). The MIMS is the main market for established and large companies looking to raise funding, whereas the GEMS was introduced in recognition of the fundamental role of Small and Medium Sized Enterprises (SMEs) as a major driver of Ugandan economy and ultimately the overall financial system of Uganda. While the eligibility criteria on MIMS are stringent, the eligibility criteria for raising financing through the GEMS are significantly less stringent compared to those on the MIMS (USE Growth Enterprise Market Segment Rules, 2012). Companies on the MIMS segment must have a minimum share capital of Ush. 1 billion and net assets of Ush. 2 billion. The initial listing fees for MIMS, for example is 0.2% of the value of the security to be listed, but 0.1% for GEMS. Similarly, the annual listing fee for MIMS is 0.05% of market capitalization of the issuer subject to a minimum of 200 currency points and a maximum of 5,000 currency points, whereas it is 0.05% of market capitalization of the issuer subject to a maximum of 1000 currency points for GEMS (USE Fee, Charges and Penalties Rules, 2012).

The Fixed Income Securities Market (FISM) Segment provides a platform for fixed

3 See appendix I for details of listed companies.

4 The MIMS segment of the USE currently has 16 listed equities comprising of 8 locally listed equities and 8 equity securities which are cross listed from the Nairobi Securities Exchange in Kenya.

income securities. The FISM segment aims at providing a separate independent market for companies wishing to raise financing through issuance and listing of fixed income securities, such as corporate bonds, preference shares and debenture stocks. It also provides the market for investors wishing to trade the above securities at the exchange. The segment also lists other short-term financial instruments such as treasury bills and commercial papers. The FISM Segment currently has 6 corporate bonds and 39 Government of Uganda Treasury Bonds listed. The listing fees in FIMS is 0.1% of the value of securities to be listed subject to a minimum of 200 currency points, and the annual listing fee is 0.025% of market capitalization of the outstanding listed securities subject to a minimum of 150 currency points (USE Fee, Charges and Penalties Rules, 2012).

The Exchange has eight (8)[5] Securities Central Depository Agents (SCDAs) who are also licensed to act as both broker/dealers and Investment Advisors.

2.2. Efficient Market Hypothesis and Random Walk Hypothesis

The theory underpinning the examination of USE returns for evidence of weak-form efficiency is the Random Walk Hypothesis (hereafter, RWH). A random walk, according to Malkiel (1999: 24), is one in which future steps or directions cannot be predicted on the basis of past actions. When the term is applied to the stock market, it means that short-run changes in stock prices cannot be predicted. Investment advisory services, earnings predictions, and complicated chart patterns are useless. RWH holds that the news arrives randomly, and, because markets are efficient, security prices adjust to the arrival of news (Strong, 2003: 244). In other words, the direction, as well as the size of change in a stock price, is random and cannot be predicted from past information about share prices. Campbell, Lo and Mackinlay (1997, 31-33) summarize three versions of RWH based on the characteristics of increments. Random walk I (hereafter *RW1*) implies that price increments are independent and identically distributed. This implies that increments are uncorrelated and any nonlinear functions of the increments are also uncorrelated. The assumption of identically distributed increments, however, is not plausible for financial assets prices over long periods of time spans because of the changes in probability distributions of financial assets returns resulting from changes in the economic, technological, institutional and regulatory environment surrounding the asset prices (Emenike, 2016).

As a result of implausibility of identically distributed increments, Random walk II (*RW2*) assumes independent but not identically distributed (*inid*) increments and thus allows for heteroscedasticity in increments. The *RW2* therefore allows for unconditional heteroscedasticity, which is a particularly useful feature of time variation in volatility of many financial assets. Relaxing the identical distribution assumption in *RW2* does not change the main economic property of increments, that is, prediction of future price increments cannot be estimated using past price increments (Campbell, Lo & Mackinlay, 1997: 33).

5 See Appendix I for the list.

Random walk III (*RW3*) is obtained by relaxing the independence assumption of *RW2* to include processes with dependent but uncorrelated increments. It only imposes a lack of correlation between subsequent increments.

3. Data and Techniques of Analysis

3.1. Data

Daily observations of the Ugandan Securities Exchange (USE) all-share indexes were obtained from the USE https://www.investing.com/indices/african-indices. The daily closing indices ranged from 01 September 2011 to 31 December 2016, totaling 1263 observations. This study period was chosen based on data availability, and captures increasing securities listing, as well as automation in securities depository and trading. The USE indexes were transformed to daily and monthly returns series by taking the first difference of the natural log series as follows:

$$R_t = Ln(I_t - I_{t-1})*100 \quad (1)$$

where R_t is a vector of the USE returns, I_t is the closing value of the indexes at time *t*, I_{t-1} is the previous day closing value of the indexes, and Ln is the natural logarithm.

3.2. Techniques of Analysis

To analyse the weak-form efficiency of the USE indexes, following Emenike (2016), I applied linear and nonlinear tests for serial dependence on the residuals of the USE random walk model, specified thus as follows:

$$R_t = \mu + \phi R_{t-i} + \varepsilon_t \quad (2)$$

where, μ is the drift parameter or the expected price change, ϕ is an autoregressive parameter that accounts for serial dependence in the returns, and ε_t is the residual term that assumed to be uncorrelated (for random walk 3), and independent but identically distributed (for random walk 2). Therefore, any shred of evidence of linear and/or nonlinear dependence in the USE daily or monthly returns series will be viewed as evidence against market efficiency. Such evidence will equally hold for higher levels of efficiency since, as Wong and Kwong (1984) observe, the failure to prove weak form efficiency implies the failure to prove both semi-strong and strong form efficiency.

The linear serial dependence tests applied in this study are autocorrelation function (ACF) and Ljung-Box Q (LBQ) tests, whereas autoregressive conditional heteroscedasticity Lagrange multiplier (ARCH-LM) test is the nonlinear dependence test. The ACF measures linear dependence between returns at the current period and the past periods. It is used to examine whether the serial correlation coefficients are significantly different from zero under the null hypothesis ρ_1=0 versus the alternative hypothesis $\rho_1 \neq 0$.The lag-*i* sample autocorrelation of r_t is specified thus as follows:

$$\rho\ell = \frac{\sum_{t=\ell+1}^{T}(r_t - \bar{r})(r_{t-\ell} - \bar{r})}{\sum_{t=1}^{T}(r_t - \bar{r})^2}, \quad 0 \leq \ell < T - \tag{3}$$

Where, $\rho\ell$ is the serial correlation coefficient of the returns of lag ℓ, *T* is the number of observations, r_t is the return for period *t* specified in equation (1), $\bar{r}$ is the sample mean of return, and ℓ is lag of the period. If r_t is an uncorrelated sequence, its *p*-value is greater than α, the significance level. Hence, the null hypothesis of uncorrelated USE returns series would be rejected if the p-value of r_t is less than 0.05. This would indicate market inefficiency in the context of Random-walk version three.

To test jointly that several autocorrelations of r_t are zero, the Ljung-Box (1978) modification of Box and Pierce (1970) portmanteau (Q) test is applied. Ljung-Box Q involves subjecting the squared error series to standard tests of serial correlation based on autocorrelation structure using portmanteau tests as follows:

$$Q_{LB}(m) = T(T+2)\sum_{\ell=1}^{m}\frac{\hat{\rho}_{\ell}^{2}}{T-\ell} \tag{4}$$

Where *T* is the sample size, *m* is the number of autocorrelation used in the test. Under the condition that r_t is an *inid* sequence, the Q-statistic is asymptotically a chi-square random variable with degrees of freedom equal to the number of autocorrelation (*m*).

The null hypothesis is that the first *m* lags of ACF of ε_t^2 are zero (Tsay, 2005: 101). The decision rule therefore, is to reject the null hypothesis of uncorrelated USE returns series if the *p*-value is less than or equal to 0.05.

Unit root tests were used to determine whether USE series exhibit random walk or mean-reverting behaviour by showing the order of integration of increments. However, as Rahman and Saadi (2008) observed, unit root is a necessary pre-requisite for the RWH, it is not a sufficient condition. The presence of a unit root specifically is not sufficient to imply a random walk since the return series must also be serially uncorrelated or serially independent. The Augmented Dickey-Fuller (Dickey and Fuller, 1979) and Phillips-Perron (Phillips and Perron, 1988) are used to test for random walk in USE increments. The ADF test is thus estimated as follows:

$$\Delta Y_t = \alpha_o + \beta_t + \alpha_1 Y_{t-1} + \sum_{\ell=1}^{n} b_1 \Delta Y_{t-1} + \varepsilon_t \tag{5}$$

The null hypothesis is that Yt is a random walk, which implies that $\alpha_1 = 1$, against the alternative that the series is mean-reverting, which implies that $\alpha_1 < 1$. Dickey and Fuller (1981) provide cumulative distribution function of the ADF statistic. If the computed absolute value of the coefficient of α_1 is less than the ADF critical tau values, reject the null hypothesis that $\alpha_1 = 1$, in which case Yt is stationary. Otherwise, accept the null hypothesis, in which case Yt is a random walk. Phillips-Perron non-parametric test is used to confirm the result of the ADF test. One of the advantages of the PP test over ADF is that it is robust to general forms of heteroscedasticity in error term (ε_t). Another advantage is that the user does not have to specify a lag length for the test regression.

ARCH-LM test is the Lagrange Multiplier test of Engle (1982). The basic idea of ARCH model is that the shock ε_t of an asset return is serially uncorrelated but dependent (Tsay, 2005: 102). Bollerslev, Chou and Kroner (1992) observe that the *LM* test for the null hypothesis of $\alpha_0 = \dots \alpha_q = 0$ can be calculated as *TR2* from the regression of $\varepsilon_{t-1}^2, \dots, \varepsilon_{t-q}^2$. We therefore, apply the ARCH-LM, in accordance with Emenike (2016), as a test for nonlinear dependence in residuals of r_t, and thus:

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 - i + \dots + \alpha_m \varepsilon_{t-m}^2 + \varepsilon_t, \quad t = m+1, \dots T \qquad (6)$$

The decision rule is to reject the null hypothesis of weak-form efficiency, in the sense of RW2 (no ARCH effect), if the *p*-value is less than the level of significance (0.05).

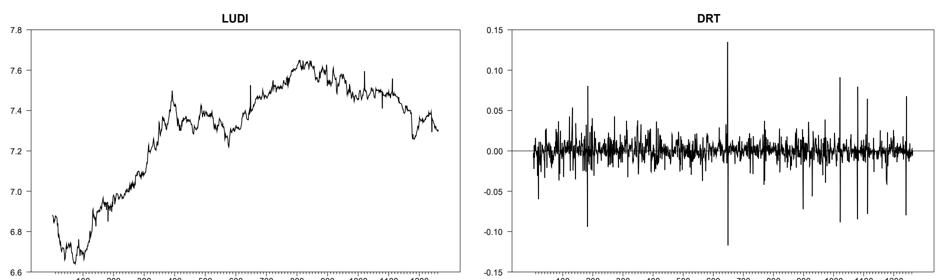
4. Empirical Results and Discussions

4.1. Preliminary Analysis

Figure 1 shows the time plot of log-level and return series of the USE all-share index for the 01 September 2011 to 31 December 2016 period. A look at the plot suggests that the levels of the USE series are not stationary: the series appear trending. Another noticeable feature of *Figure 1* is the downward slope at the end of September 2011, and upward spike movement thereafter. The series achieved its highest point within the first quarter of 2015, before moving downward. The downward movement is corroborated by USE (2015) which reveals that total equity listing fees decreased by 26% to Ushs.726 million from Ushs.986 million in 2014. Brokerage commission decreased by 60% to Ushs.520 million from Ushs.1.3 billion in 2014, and other operating income decreased by 16% to Ushs.938 million from Ushs.1.12 billion. On the other hand, the time plot of the return series of USE all-share index shows that the series fluctuate around their mean value, though with few major spikes. Notice that the return series show mean reversion tendency. This is easily seen in the ability of each series to return to the mean after a deviation. Mean reversion is an indication of stationarity.

Descriptive statistics for USE returns are presented in *Panel A of Table 1*. The annualized average rate of return for the USE is 7.8% for the study period. Notice the significant difference between the minimum and maximum returns for the study period. These indicate the dispersion between returns in the USE. Dispersion is captured by the standard deviation, which measures investment uncertainty. The annualized standard deviation of USE return is 19.42%. The skewness of a normal distribution is zero. The bias towards positive or negative returns is represented by the skewness of the distribution. If returns distribution is positively skewed, it implies that there is higher probability of large positive returns than negative returns (Ivanovski, Narasanov & Ivanovska, 2015), and vice versa. Notice from *Panel A of Table 1* that skewness coefficient (-0.14) is negative and significant at 5%. This denotes that USE returns distribution is non-symmetric. Kurtosis provides summary information about the shape of a return distribution. The excess kurtosis of a normal distribution is 0. From *Panel A of Table 1*, the USE returns have heavy tails and are peaked. A major implication of heavy tails is that investors can make very high returns and lose large amount of their investments as well (Emenike, 2015). In line with this finding, for example, the UCHM posted the highest drop in price in the second quarter of 2016 to close the quarter at *Ush 94 (US $ 0.03)* from *Ush 170 (US $ 0.05)*, a drop of 45% (Capital Market Authority, 2016). This result is the Jarque-Bera test which firmly rejects normality implying that the USE daily returns series is not normally distributed.

Figure 1. Time series graph of level and return series of Uganda Securities Exchange Index for the period Sep. 1, 2011 to Dec. 31, 2016



Source: Authors' calculation

Panel B of Table 1 displays the autocorrelation functions (ACF) of the USE returns series and the Ljung-Box Q-statistic adopted in evaluating significance of the ACF up to lags 40. The ACF test was conducted to determine if the USE returns series are serially correlated. Information on autocorrelation in the returns series is required to specify and estimate correct random walk model (Emenike, 2015). Estimation of correct random walk model is necessary for robust statistical inference and empirical analysis. The ACF and Ljung-Box Q-statistic indicate that the USE returns series are serially correlated at the 5% significance level, up to lags 40. Autocorrelation in the USE returns series implies that an autoregressive (AR) random walk model should be estimated so as to erase serial dependence in the residuals.

Table 1. Preliminary Statistics for Uganda Securities Exchange Returns

Panel A: Descriptive statistics for USE returns							
Variable	Mean	Min. rtn.	Max. rtn.	Std. Dev.	Skewness	Kurtosis	J-B Stat.
Returns	0.0003 (0.799)	-0.1171	0.1349	0.0145	-0.1417 (0.040)	16.8828 (0.000)	14992.15 (0.000)
Panel B: Autocorrelation function and Ljung-Box Q statistics for USE returns							
Lags	1	5	10	15	20	30	40
Returns	-0.1421 [25.577] (0.000)	-0.0038 [27.154] (0.000)	0.0091 [28.782] (0.001)	0.0233 [31.701] (0.007)	-0.0116 [35.099] (0.019)	0.0213 [45.754] (0.032)	0.0358 [59.558] (0.023)
Panel C: Schwarz/Bayesian information criterion (BIC) lag analysis for USE returns							
Lags	0	1	2	3	4	5	12
Returns	-8.450	-8.465*	-8.459	-8.454	-8.448	-8.442	-8.405
Panel D: Unit root tests for USE daily series							
	Augmented Dickey Fuller				Phillip-Perron		
		Level	returns			level	Returns
Variables	5% critical value	calculated	computed		5% critical value	calculated	Computed
ASI	-2.8642	-1.5922	-40.949**		-2.8642	-1.5702	-41.004**

Note: The Ljung-Box Q statistics for the autocorrelation functions are displayed as [.], and *P*-values are displayed as (.). Std. Dev. and J-B Stat are the standard deviation and Jarque-Bera statistics for the USE daily returns. Min and max rtn are the minimum and maximum daily returns. * and ** indicate 5% and 1% significance levels.
Source: Authors' calculation

Consequently, Schwarz/Bayesian information criterion (BIC) lag analysis was estimated to identify appropriate autoregressive lag length, and the results are displayed in *Panel C* of *Table 1*. Observe that the BIC recommends autoregressive lag one (*AR*1) for the USE returns.

As it is necessary to check for the stationarity property of a variable prior to empirical analysis, we test for the presence of unit roots in the log-level and first difference of the USE series using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The Schwarz/Bayesian information criterion (BIC) was adopted for lag analysis of the ADF. From the 5 lags estimated, the BIS lags 1 and 0 were selected for the level and return series respectively. The results of the ADF and PP unit root tests presented in *Panel D* of *Table 1*, indicate that USE returns series is integrated of order one or *I* (1). Hence, unit root results of ADF and PP show that USE return series is stationary.

4.2. Measuring Weak-Form Efficiency of USE Returns

This section presents the results of the linear and nonlinear tests for serial dependence estimated using the increments from the USE random walk model. *Panel A* of *Table 2* shows the estimates of the random walk model. We see from *Panel A* that the coefficient of drift parameter is not significant, implying that the expected price change may not be predictable. The autoregressive term is negative and significant, supporting indication of a serial dependence identified in *Panel B* of *Table 1.* The essence of estimating the random walk model is to increment for the random walk hypothesis tests. The results are presented in the following panels.

Panel B of *Table 2* displays autocorrelation function, Ljung-Box Q (LBQ) statistic and p-value of the LBQ estimated for stock returns increments of the USE from lags 1 to 40. The *p*-value of the Ljung-Box Q coefficients for the lags 1 to 40 of the USE returns increments are all greater than the 5% significance level. Therefore, we can accept the null hypothesis of no autocorrelation in the returns series of the USE with 95% confidence. The absence of a serial dependence in the USE returns increments is an indication of stock returns unpredictability, and evidence in support of weak-form efficiency. This finding is similar to Watundu *et al.* (2015) who conclude amongst others, that USE is weak-form efficient, based on absence of first order serial correlation in the daily returns series. The finding, however, shows absence of a serial correlation at higher lags, which strengthens the evidence for RW3 weak-form efficiency.

Panel C of *Table 2* shows the results of the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests conducted to ascertain whether USE RWM increments are random walk or stationarity. The null hypothesis of the ADF test is USE series is a random walk. If the computed absolute tau value is less than the ADF critical tau values, reject the null hypothesis of random walk. Otherwise, accept the null hypothesis. Notice from *Panel D* of *Table 2* that the computed *tau* (τ) statistic (-35.46) is less than the 5% critical tau (τ) value (-2.86). Since the computed τ value is lesser than the conventional critical tau values, we accept the alternative hypothesis of stationarity in USE return increments at the 5% level of significance. These results therefore, support evidence of weak-form efficiency of the USE. The result of PP unit roots test is similar to that of ADF. This method, however, does not show the version of random-walk accepted.

Panel D of *Table 2* displays results of the autoregressive conditional heteroscedasticity Lagrange multiplier (ARCH-LM) test conducted to examine the residuals from USE RWM for evidence of nonlinear dependence. Under the null hypothesis of no heteroscedasticity in return series, asymptotic significance corresponding to the p-value should be greater than or equal to the significance level, in this case 5%. Notice from *Panel D* of *Table 2* that the p-value of the ARCH-LM coefficients for the residuals, up to lags 20, is less than the significance level of 0.05. Hence, we can reject the null hypothesis of no nonlinear dependence in the USE returns, with 95% confidence, since *p*-value is less than the significance level (0.05). This indicates that the USE returns are second order serially dependent. In other words, the ARCH-LM test indicates evidence against RW2 for the USE returns.

A major implication of the results is that predictability of the USE returns, at least in the short-term, may be improved by applying nonlinear modeling strategy, but whether exploitation will be profitable after transaction costs is unknown.

USE (2015) outlined some important transformations in USE recently in order to include trading system automation to replace the manual trading system in July 2015, reduction in the settlement period from 5 working days to 3 working days in compliance with IOSCO international standards, and improved regulations[6] to conform to the automated trading environment and new settlement period. In addition to these worthy

6 USE reviewed and improved equity trading rules in 2015, and Capital Market Act was also amended in 2016 to enhance market regulation and investors' protection.

feats, there is a need to increase the number of equity listings. The sixteen listed equities are poor, and as USE (2015) observes, activity on the equity segment was dominated by activity from UMEME and STANBIC accounting for 82.51% and 8.71% of the total turnover, respectively. There is also a need to enhance the participation of national (both individual and institutional) investors. USE (2015), for example, reports that the proportion of equity transactions executed by foreign investors averaged 87% on the bourse. This implies that the local East African investors contributed only 13% of equity transactions in 2015. These measures will boost the efficiency of the USE.

Table 2. Weak-form Efficiency Analyses for NSE Sectors Returns

Panel A: Estimates of USE Random walk model (RWM)

Parameters	coefficient	std. error	t-statistics	p-value
μ	0.0003		0.9391	0.3478
ϕR_{t-1}	-0.1421		-5.0971	0.0000

Durbin-Watson 1.9995; $F(1,1259)$ 25.9805, significance level of F 0.000

Panel B: Autocorrelation function and Ljung-Box Q statistics for USE RWM residuals

Lags	1	5	10	15	20	30	40
Residuals	0.0002 [0.0005] (0.994)	-0.0004 [0.557] (0.989)	0.0129 [2.303] (0.993)	0.0153 [5.071] (0.991)	-0.0190 [9.143] (0.981)	0.0174 [19.742] (0.923)	0.0414 [37.637] (0.577)

Panel C: Unit root tests estimates for USE RWM residuals

	Augmented Dickey Fuller		Phillip-Perron	
	5% critical value	Computed	5% critical value	Computed
Residuals	-2.8643	-35.4623**	-2.8642	-35.4908**

Panel D: ARCH-LM test for test for nonlinear dependence in RWM residuals

Lags	1	3	6	9	12	15	20
Residuals	221.740 (0.000)	87.908 (0.000)	43.902 (0.000)	29.270 (0.000)	21.865 (0.000)	17.527 (0.000)	13.624 (0.000)

Note: The *p*-values are displayed in (.), and the Ljung-Box Q statistic for the autocorrelation functions are displayed in [.]. ** indicates significance at the 1% level.
Source: Authors' calculation

5. Conclusions

This paper evaluates the nature of random walk weak-from efficiency of the Ugandan Securities Exchange for the period ranging from 01 September 2011 to 31 December 2016, using the autocorrelation test, Ljung-Box Q test, unit roots tests, and ARCH-LM test. The preliminary analyses show that the USE return is zero, indicating that positive and negative returns cancel each other. It also shows negative skewness and leptokurtosis in the return series. Results of the linear models estimated using ACF and Ljung-Box Q statistics suggest evidence of random walk (3) weak form efficiency for USE. This is evident in the absence of a serial correlation in the returns increments. The results of non-linear model analysis conducted using the ARCH-LM provide evidence against random walk (2) in USE returns. The key implication is that the prediction of USE returns requires a superior fundamental analysis of their intrinsic values. These findings add to the accumulating knowledge on the stock market efficiency of USE, and underscore the need for financial market regulatory authorities to formulate policies that will enhance market efficiency.

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Appendix I
Listed Equities in the USE

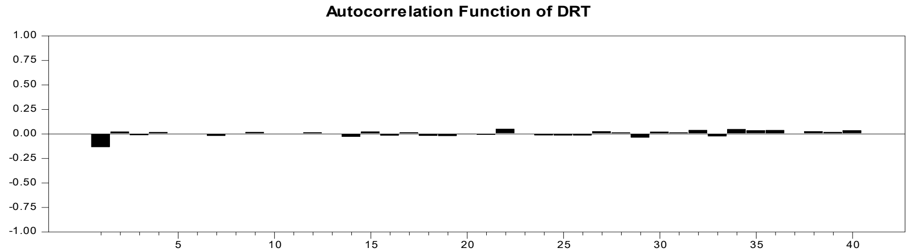
The Main Investment Market Segment of the USE currently has 16 listed equities comprising of 8 Locally Listed Equities;

BATU	UG0000000022	British American Tobacco Uganda
BOBU	UG0000000055	Bank of Baroda Uganda
DFCU	UG0000000147	Development Finance Company of Uganda Ltd
NVL	UG0000000162	New Vision Printing and Publishing Company Ltd
SBU	UG0000000386	Stanbic Bank Uganda
NIC	UG0000000758	National Insurance Corporation
UCL	UG0000000014	Uganda Clays Limited
UMEME	UG0000001145	Umeme Limited

It also has 8 Equity Securities which are cross listed from the Nairobi Securities Exchange (Kenya) as below:

EBL	KE0000000554	Equity Bank Limited
KCB	KE0000000315	Kenya Commercial Bank Group
EABL	KE0009081092	East African Breweries Limited
JHL	KE0000000273	Jubilee Holdings Limited
KA	KE0009081084	Kenya Airways
NMG	KE0000000380	Nation Media Group
CENT	KE0000000265	Centum Investment Company Ltd
UCHM	KE0000000489	Uchumi Supermarkets Limited

Appendix II
Autocorrelation Function for USE Returns



Appendix III
Autocorrelation Function for Regression Residuals from USE Return Series