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MODELLING THE LEVERAGE EFFECT AND VOLATILITY PERSISTENCE IN THE EAST AFRICAN SECURITIES EXCHANGES DURING GLOBAL SHOCKS

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Abstract:
The study examines volatility dynamics during the 2007/09 global financial crisis in three main East African Exchanges; Nairobi Securities Exchange, Kenya, Uganda Securities Exchange, Uganda and Dar-es-Salaam Stock Exchange, Tanzania. A modified Asymmetric Generalized Autoregressive Conditional Heteroscedastic (E-GARCH 4,1) model was used to test leverage effects and volatility persistence in the markets and the USA as the ground zero market. The data consisted of daily closing indices covering 2006-2010. The period was divided into three phases before the crisis, during and after the crisis. The study found that the leverage effect was eminent in the Ugandan and Tanzania markets. The effect is more prevalent in the Ugandan market in all three phases of the crisis, and the pre-crisis phase for the Tanzania market but absent in the Kenyan market in all the phases. Explosive volatility was observed in the Kenyan and Ugandan markets meaning that volatility takes a longer period to decay off in these markets.

JEL: E44; G10; G18

Keywords: leverage effect, volatility persistence, E-GARCH

1. Introduction

Capital markets are barometers for economic performance and integration as they are key channels for capital flows and portfolio investment opportunities for both domestic and international markets. Amid the increasing stock market liberalization and integration, both regional and global investors have benefitted immensely from the presented diversification opportunities across borders. On the flip side, a breakdown in the financial system has often resulted in panic, depleted investments further forcing

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investors to make delicate reinvestment decisions across borders, and worse off; loss of confidence in the markets.

United States financial space is considered among the most advanced and globally integrated market. The markets have experienced major financial shock that have had an impact on other world stock markets. The market crash of October 1987 precipitated increased volatility for equity markets across the globe, into effect investors sold stocks in haste and in big volumes out of panic. The world's major indices such as Australia, Hong Kong, Singapore and New Zealand were mostly affected by the adverse effects (Ciro, 2012). Before the Subprime attack, analysts had foretold on the risks and vulnerability of the U.S. financial system, and cautioned on its ability to withstand the effects of sudden and sustained correction in equity markets such as one experienced in 1987 (Adams, Mathieson, Schinasi, Chadha et al., 1999).

In 2007, the U.S. markets were hit by the Subprime crisis that resulted in a stampede in the worldwide financial system. The returns and value of stocks held by Individual investors and companies in financial institutions declined as the whole financial system in the U.S. experienced a breakdown. Madura (2011) highlights at a glance the wave impact of the meltdown on financial elements. Spanning from mortgage lenders and homeowners, investment banks, mortgage insurer's hedge funds, mutual funds and pension funds and in extremely renowned companies such as Lehman Brothers, Washington Mutual and IndyMac Bancorp went bankrupt. Consequently, the financial and the real sector were negatively influenced due to counterparty relationships or financial trading.

The interest by foreign investors in Sub-Saharan Africa Equity markets is growing rapidly and more so in East Africa ("Renaissance Capital", 2014). The MSCI 2013 global index return ranking classified the Kenyan stock market as the best-performing market in Africa and the fourth best-performing stock market in the world, with a 43.58 per cent return, coming after Bulgaria at 91.55%, UAE at 79.02% and Argentina at 68.97% (Africa Reporters Mod, 2014), thus becoming one of the most attractive markets in the region.

Kenya's position as Eastern Africa's financial hub has attracted substantive international investors. The foreign investor activity in the Nairobi Securities Exchange (NSE) surpassed local participation to hit 61% of total turnover towards the end of 2009 ("Foreign investors alter stockbrokers' fortunes", 2010), implying that the foreign investors (both institutional and individual) play a significant role at the NSE. The presence of international investors in domestic markets presents an implication for market expectations, the activities of foreign investors are considered to be more analytical of the investment environment, therefore their increased participation signifies a good outlook for the country, in the same way, a decreased activity may signal unfavourable position (Griffith-Jones, Gottschalk, & Cailloux, 2009).

Foreign participation in capital markets can be attributed to country-specific policy on the level of foreign investment restriction. The IFCI ranking rates the African stock markets low in terms of foreign investment restriction. In the East African region, the Ugandan Security Exchange is the freest, with no restriction on foreign ownership

(USE). Contrary, Tanzanian government restricts levels of each stock's foreign ownership to a total of 60% on its exchange with an aim of protecting and promoting the Tanzanians' participation in the market (Hoover, 2014).

According to Frontier Market Intelligence, the Kenyan market has no restrictions on the percentage of equity that foreign citizens may hold in a locally incorporated company; however foreign ownership of equity is delimited in some industries such as in insurance at 66.7%, telecommunications at 70% and companies listed on the Nairobi Securities Exchange at 75%, though, in a move to achieve emerging markets status, both the CMA and the treasury are fast-tracking the removal of the ownership cap and allow 100% foreign ownership of stakes in the market (Mwaniki, 2015).

This move will position the market for better integration with other global markets, similarly exposing it to global shocks. Market observers in the East African markets hold that when the Kenyan exchange experience increased volatility, foreign investors in the market opt for Uganda and Tanzania Exchanges for better returns or diversifications (Odhiambo, 2011).

Volatility in stock markets imposes an asymmetric behaviour to negative and positive shocks to returns. This behaviour is broadly explained by two phenomena; the leverage effect and the volatility feedback effect. The leverage effect explains that falling stock prices raise debt to equity ratio leading to higher volatility of equity, consequently shareholders perceive their future cash flows as being relatively riskier (Brooks, 2014). Under the volatility feedback effect, an increase in volatility results in negative returns (Campbell & Hentschel, 1992). Such that expected returns rise when share price volatility increases and fall when volatility rises assuming constant dividends

According to Bentes (2014), volatility in stock markets takes a longer time to decay off, meaning that a market does not respond immediately to information arriving in the financial system but reacts to it gradually over time. Therefore, shocks to the volatility process tend to have long-lasting effects making it easier to predict the markets, this is contrary to Efficient Market hypothesis suggested by Fama (1970). A number of studies have shown that most markets exhibit volatility persistence during market shocks consequently exposing them to speculators (Andersen, Bollerslev, Diebold, & Labys, 2001; Choi & Richardson, 2016).

This study examines the leverage effect in the East Africa's stock markets to assess the extent to which both positive and negative shocks influence the volatilities of the markets. Moreover, it assesses the long memory of shocks in the East African Equities by evaluating the extent to which older and most recent shocks predict future volatilities in the exchanges to determine their efficiency during volatile global periods.

2. Review of Literature

An analysis of emerging stock markets on the effect of volatility persistence on the accuracy of risk estimation during the global financial crisis indicates that long memory

property in volatility modelling provides reliable value at risk estimation and prediction (Mokni & Mansouri, 2011)

Dooley and Hutchison (2009); Dimitriou, Kenourgios, and Simos (2013) study on the emerging stock markets indicate a rise in volatility in these markets during crisis periods further supporting the much-debated hypothesis of 'Decoupling and Recoupling' (a notion that emerging markets' links tied with mature countries such as the US are disintegrated however, these links tend to recouple in times of strong shocks (Willett, Liang, and Zhang, 2011)

Chandra Pati & Rajib (2010) examined the time-varying conditional volatility and persistence of futures using ARMA-GARCH on the Indian National Stock Exchange. The study revealed that the negative shocks impacted more pressure to the futures market compared to the negative shocks of the same magnitude. Also, high volatility persistence was associated with higher trading volumes and suggested tighter regulatory restrictions as a remedy.

Uyaebo, Atoi, and Usman (2015) using asymmetric EGARCH and TGARCH models on selected countries, Nigeria, Kenya, Germany South Africa and China revealed the absence of leverage effect in both Kenya and Nigeria Markets, the study concludes that both markets react to the shocks faster during volatile moments. In the South African and Chines Stock Markets volatility recorded moderate reaction to shocks. A similar study by Niyitegeka and Tewar, (2013) on the South African market, using GARCH-type models reported the presence of volatility persistence and evidence of the asymmetric effect (Leverage effect).

Esman, Nyamongo and Misati (2010) modelled the time-varying volatility of equities in Nairobi Securities Exchange. The study found out that that volatility returns are highly persistent and the leverage effect is not significant. However, Owidi and Waweru (2016) using FIEGARCH model in the same market during bullish and bearish market cycles, showed the presence of an asymmetric effect. Similar findings are reported by (Ndwiga & Muriu, 2016)

Studies modelling time-varying volatility in the East African region have focused solely on the Kenyan market. Moreover, the studies report disputing findings. Due to the stock market interconnectedness in the East African region both fundamentally and in proximity, this study models the behaviour of the three markets during the global financial crisis and reveals the extent of the markets' predictability in the long run and the effect of both negative and positive shock to the region.

3. Data Methodology

The study used a causal research design to test the test the relationship between shocks and volatility of the markets. Daily indices closing data for the markets was obtained from Bloomberg. The data covered a period of four years from 2006 through 2010. Due to the inability of common linear structural models such as CLRM to capture or explain relevant features common in financial time series data such as volatility clustering,

leptokurtosis and leverage effects the ARCH family model was best to explain the intrinsic non-linear features or changing volatility in the financial time series data. The standard GARCH (p, q) model could have been an option for the study, but the model is limited due to its two main weaknesses; the non-negativity requirement could have been violated and the incapacity to explain the leverage effects (volatility to shocks displays an asymmetric response rather than a symmetric one) (Brooks, 2014). Hence the Exponential GARCH Model was adopted for the study.

3.1 EGARCH p,q conditional variance model specification

$$\boldsymbol{ln(h_t) = \omega + \varphi ln(h_{t-1}) + \alpha \left(\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right) - \varphi_4 \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}} \qquad \textbf{1.1}$$

According to Brooks (2014), E-GARCH model guarantees the positivity of dependent $\boldsymbol{h_t}$ (conditional variance) even if the parameters happen to be negative since log $\boldsymbol{h_t}$ is estimated. Coefficient $\boldsymbol{\alpha}$ Measures GARCH effect or symmetric effect of the model, $\boldsymbol{\varphi}$ capture the persistence in conditional volatility in any period, moreover if the relationship between volatility and return is negative, a negative parameter $\boldsymbol{\varphi_4}$ explains the leverage effect (a negative shock has a larger effect on volatility of returns compared to a positive shock of the same magnitude).

The estimated models were evaluated for fitness by the following diagnostic checks; Ljung-Box test statistic for serial correlation in the residuals (Ruppert & Matteson, 2015). The non- normality test was conducted by the Jarque Bera statistic to confirm whether the residuals are normally distributed, normality test ensures that the inferences made about the coefficient estimates are not wrong. The estimated model was specified as follows:

$$\mathbf{lnh_{EAmkti,t} = \alpha_0 + \varphi_3 z_{t-q} + \varphi_4[|z_{t-n}| - E(|z_{t-n}|)] + \ni_1 ln\left(h_{EAmkti,t-P}\right) + S_1 r^2_{usa,t-n} + C_2 r^2_{usa,t-n} SP_{crisis,t-n}} \qquad \textbf{1.2}$$

Where:

$\mathbf{lnh_{EAmkti,t}}$ = Logged Conditional variance of an East Africa market i at time t
$\boldsymbol{i = Ke - NSE \quad 2 = Ug - USEI \quad 3 = Tz - DSE}$

$\mathbf{z_{t-q}}$= ARCH q term,

$[|\mathbf{z_{t-n}}| - \mathbf{E}(|\mathbf{z_{t-n}}|)]$ = Difference between absolute residuals and expectation of absolute residuals;

$\mathbf{ln\left(h_{EAmkti,t-p}\right)}$ = GARCH p; the sum of ARCH term ($\boldsymbol{\varphi_3}$) and GARCH ($\boldsymbol{\ni_1}$) explains persistent of shock in the markets

$\mathbf{r^2_{us,t-n}}$ = USA market variable, depicts volatility spillover effect from the USA markets to an East African Market *i*.

$\mathbf{r^2_{us,t-n} SP_{crisis,t-n}}$ = Interactive term USA variable; explains volatility contagion during the crisis period ($\mathbf{SP}_{crisis,t-n}$=1 during the crisis moment and 0 otherwise),

t denotes time t and **q**, ***q and n*** refers to lags

4. Preliminary Tests

Table 1: ARCH Effect Test

Kenya_NSE	F-statistic	2.645566	Prob. F(4,969)	0.0323
	Obs*R-squared	10.52196	Prob. Chi-Square(4)	0.0325
USA_S&P500	F-statistic	52.76352	Prob. F(4,988)	0.0000
	Obs*R-squared	174.785	Prob. Chi-Square(4)	0.0000
Tanzania_TSI	F-statistic	3.315668	Prob. F(4,933)	0.0235
	Obs*R-squared	14.63254	Prob. Chi-Square(4)	0.0262
Uganda_USEI	F-statistic	7.565523	Prob. F(4,834)	0.0402
	Obs*R-squared	36.254332	Prob. Chi-Square(4)	0.0426

In estimating a GARCH-type model, a test for determining whether the ARCH effect is present is a precondition to ensure that GARCH model is suitable for the data (Brooks, 2014). The output above (Table 1) shows the Engle test results. Both the F-version and the LM-statistic are significant for all the indices, suggesting the presence of ARCH.

A multivariate information criterion was employed to determine the appropriate lag length. From the output below, Schwarz information criterion select 2 lags, Hannan-Quinn information criterion 3 lags and both Final prediction error and Akaike information criterion select 4 lags. Hence 4 lags are preferred for model estimation Table 1 above.

Table 2: Optimal Lag selection

VAR Lag Order Selection Criteria
Endogenous variables: NSE USEI TSI SP500
Exogenous variables: C
Sample: 1 997
Included observations: 799

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3440.535883	NA	0.065259	8.622117	8.645563	8.631125
1	-3273.758574	331.4673	0.044744	8.244702	8.361933	8.28974
2	-3188.771832	168.0589	0.037648	8.07202	8.283035*	8.153087
3	-3138.148902	99.59856	0.034523	7.985354	8.290153	8.102451*
4	-3109.694321	55.69833	0.033463*	7.954179*	8.352762	8.107306
5	-3094.925031	28.76222*	0.033567	7.957259	8.449628	8.146416

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

5. Results

Table 3: Volatility Persistence ($\varphi_3 + \exists_1$)

	Pre-crisis	In-crisis	Post-crisis
Kenya	Low (0.181)	**Explosive (1.04)**	Moderate (0.5892)
Uganda	Moderate (0.6231)	**Explosive (1.35)**	High (0.7568)
Tanzania	High (0.7027)	Weak (0.34)	Low (0.1434)

The volatility persistence is measured by the sum of the ARCH and GARCH terms, a value close to 1 shows the markets exhibit volatility persistence and at unit, indicates that volatility is explosive. During the crisis period, the Persistence measure **$(\varphi_3 + \exists_1)$** for both Uganda and Kenya are explosive (above unit) 1.35 and 1.04 respectively, meaning that when volatility in the markets increases it takes longer period before it decays off. The results show that Ugandan market has the highest volatility persistent level and lowest in the Tanzania market. The persistence coefficients in the pre-phase are fairly below unit meaning that volatility in the markets is not highly persistent during the normal periods in both financial markets. However, the Tanzanian market indicated relatively higher values during this period and this could be attributed to its infant stage (The market commenced in 2006). Moreover, the degree of persistence in the conditional variance after the crisis indicate relatively lower volatility persistence compared to other phases, however the Ugandan coefficient is higher relative to other markets.

Table 4: Leverage Effect (φ_4)

	Pre-crisis	In-crisis	Post-crisis
Kenya	No (0.0882)	No (0.1499)	No (0.0342)
Uganda	**Yes (-.3432)**	**Yes (-0.3076)**	**Yes (-0.3168)**
Tanzania	**Yes (-0.0064)**	No (0.03025)	No (0.0526)

The estimates show strong evidence of leverage effect for the Ugandan market in all the three phases of the crisis meaning that negative shocks to the market have higher impact compared to positive market shocks of the same magnitude. Similarly, on the pre-crisis phase, the leverage effect, coefficient is negative for Tanzania, indicating that a negative shock to the market too result in increased volatility. Therefore, the results associate high significant levels of asymmetric effect to the Ugandan Market and none on the Kenyan Market.

4. Conclusions

Volatility is persistent if it lasts for months and market volatility is correlated to volatility in market fundamentals such as inflation, interest rates and debt levels in the corporate sector (National Bureau of Economic Research, 1990). During the crisis period the Kenyan and Uganda Markets demonstrated explosive volatility, 1.04 and 1.35, respectively (Table 3). The contrary is observed during the other phases; nevertheless, the Ugandan Market

indicated relatively larger values throughout the phases. Meaning volatility in Kenya and Uganda Markets exhibit long memory in volatility.

The hypothesis for leverage effect states; $H_0= \gamma >0$; downward movement in the market is not followed by relative higher volatilities against $H_0= C_1 \neq 0$. The leverage effect is evident in the Ugandan market in all the three phases as indicated by the negative significant coefficients Table 4. Tanzania market shows evidence for leverage effect during the pre-crisis period only while the contrary holds for Kenya. This indicates that a sharp drop in share price (negative shock) tends to increase volatility than an increase in the price of a share price (positive shock) in the Ugandan and Tanzania Markets.

5. Implications of the Study and Areas for Further Research

It was noted that there was high leverage effect in the Uganda and Tanzanian Exchanges, Finally, sustained level of stock market volatility was witnessed on both the Kenyan and Ugandan Market. This implicates the markets with market inefficiency meaning that it is possible for one to predict the markets' behaviour. This in turn invites speculators to the markets who escalate volatility levels making it unbearable for genuine investors to make a comeback. This study recommends for a policy to have more foreign institutional investors rather than individual or foreign retail investors, since it is relatively easier to control institutional behaviour as they are bound to international company and commercial laws.

Conflict of Interest Statement

The author has no conflicts of interest to disclose.

About the Author

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Appendix

Table 1a: In-crisis EGARCH (p, q) Model Estimation

		KENYA	UGANDA	TANZANIA
	Conditonal Variance Equation			
α_0	Constant	-2.627398*** [0.283692]	-0.276866*** [0.030416]	-1.050427*** [0.087131]
φ_3	Internal Influences	0.856532*** [0.069767]	0.729061*** [0.024751]	0.075321*** [0.004928]
φ_4	Leverage Effect	0.149993*** [0.034293]	-0.307602*** [0.016879]	0.030249*** [0.004311]
$(\varphi_3 + \ni_1)$	Volatility Persistence	1.0498637	1.35976	0.346719
	Residual Diagnostic (Model Fit Test)			
J-B	Normality Test	J-B- 12480.79 P-Value :0.000	J-B- 4729266 P-Value :0.000	J-B- 10430677 P-Value :0.000
Ljung Box	Serial Correlation	**QLB310 Ho: True**	**QLB279 Ho: True**	**QLB311 Ho: True**
ARCH test	ARCH Effect test	R-Squared-0.24719 P-Value-0.06191	R-Squared-0.00344 P-Value-0.9532	R-Squared-0.000197 P-Value- 0.9888

*Notes: *, **, *** signify significance at 10% , 5% and 1% in that order; The figures in parentheses refers to standard errors of the estimators ; J-B - Jarque and Bera statistic (1980) Normality test ; Ljung Box - serial correlation Test; Ho:- There is no Serial correlation; QLB:- Ljung Box at lag k*

Table 1b: Pre-crisis EGARCH (p, q) Model Estimation

		KENYA	UGANDA	TANZANIA
Parameters	**Conditional Mean Equation**			
	Conditonal Variance Equation			
α_0	Constant	-3.044885*** [0.52395]	0.058924 [0.099824]	-0.679884*** [0.070579]
φ_3	Internal Influences	0.785911*** [0.088228]	0.532108*** [0.074932]	0.037648*** [0.003493]
φ_4	Leverage Effect	0.049383** [0.060085]	-0.343296*** [0.058865]	-0.006429*** [0.002495]
$(\varphi_3 + \ni_1)$	Volatility Persistence	0.181005	0.623076	0.70269
	Residual Diagnostic (Model Fit Test)			
J-B	Normality Test	J-B- 454546.5 P-Value :0.000	J-B- 4313742 P-Value :0.000	J-B- 31953833 P-Value :0.000
Ljung Box	Serial Correlation	**QLB310 Ho: True**	**QLB279 Ho: True**	**QLB311 Ho: True**
ARCH test	ARCH Effect test	R-Squared-0.01346 P-Value-0.9075	R-Squared-0.00414 P-Value-0.9487	R-Squared-0.00112 P-Value- 0.9734

*Notes: *, **, *** signify significance at 10% , 5% and 1% in that order; The figures in parentheses refers to standard errors of the estimators ; J-B - Jarque and Bera statistic (1980) Normality test ; Ljung Box - serial correlation Test; Ho:- There is no Serial correlation; QLB:- Ljung Box at lag k*

Table 1c: Post-Crisis Model Estimation

		KENYA	UGANDA	TANZANIA
	Conditonal Variance Equation			
α_0	Constant	-3.426557*** [0.5449]	-0.0103 [0.082717]	-1.165838*** [0.06594]
φ_3	Internal Influences	0.802655*** [0.097923]	0.492343*** [0.084678]	0.044297*** [0.005488]
φ_4	Leverage Effect	0.034179 [0.068482]	-0.316833*** [0.072543]	0.052682*** [0.00422]
$(\varphi_3 + \ni_1)$	Volatility Persistence	0.589186	0.756824	0.143424
	Residual Diagnostic (Model Fit Test)			
J-B	Normality Test	J-B- 181187 P-Value :0.000	J-B- 427114 P-Value :0.000	J-B- 28242098 P-Value :0.000
Ljung Box	Serial Correlation	**QLB310 Ho: True**	**QLB279 Ho: True**	**QLB311 Ho: True**
ARCH test	ARCH Effect test	R-Squared-0.01864 P-Value-0.8914	R-Squared-0.004371 P-Value-0.9473	R-Squared-0.001023 P-Value- 0.9745

*Notes: *, **, *** signify significance at 10% , 5% and 1% in that order; The figures in parentheses refers to standard errors of the estimators ; J-B - Jarque and Bera statistic (1980) Normality test ; Ljung Box - serial correlation Test; Ho:- There is no Serial correlation; QLB:- Ljung Box at lag k*