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Volatility Spillover of the Agriculture Sector on the Nairobi Securities Exchange

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Abstract This paper investigates the existence and magnitude of volatility spillovers among equities on the Nairobi Securities Exchange. The multivariate VARMA-GARCH model is used to test for spillover effects between four broad sectors of the NSE: Agricultural, Financial, Commercial and Services and Industrial. The significance of the parameters of the model are used as an indicator of the spillover effect between sectors. Based on the empirical results, the biggest volatility spillover is from the commercial and services sector to the broad industrial sector. There are also significant spillovers from the industrial and agricultural sectors to the financial and commercial and services sectors, as well as from the financial and commercial and services sectors to the broad industrial sector.

Keywords: *volatility spillovers, NSE, VARMA-GARCH*

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1. Introduction

In order to clearly define volatility spillover, the term 'volatility' must first be defined. [1] defines stock market volatility as a measure of the changeability or randomness of asset prices. Therefore a higher standard deviation would indicate higher volatility, while a lower standard deviation would indicate lower volatility. According to [2], Market volatility is inevitable: it is the nature of markets to move up and down over the short term. Following the same line of reasoning, and based on the work of [3], volatility spillage can be defined as transmission of volatility in one sector of the stock market to another sector i.e. volatility in one sector resulting in volatility in another sector.

While looking at the volatility in given sectors of a stock market, one needs to understand the classification of the sectors. There are various ways in which equities on a stock market can be grouped or subdivided. One common method of subdivision of equities is based on the sectors in which the relevant company operates. In Kenya, for example, the equities on the Nairobi Securities Exchange are sub-divided into 11 sectors, which include: Agricultural, Automobile & Accessories, Banking, Commercial & Services, Construction & Allied, Energy & Petroleum, Insurance, Investment, Investment Services, Manufacturing & Allied, and Telecommunication & Technology [4].

Dividing the stock market based on the industrial sector in which the company operates allows companies which have similar operations, regulation and governance issues to be grouped together. These companies are likely to be affected in the same way, if industry conditions, regulations, or economic conditions change. For example, if insurance regulation in Kenya changed significantly, insurance companies in Kenya, including those listed on the Nairobi Securities Exchange would be affected. Therefore, grouping of companies by sector in this way allows the analysis of individual industrial sectors as a whole.

This paper attempts to examine the existence of volatility spillover on the Nairobi Securities Exchange, and if it does exist, the magnitude of the spillover between sectors. In addition, it attempts to identify the sectors between which volatility spillover is the highest.

1.1. Volatility Spillovers in Stock Markets

There has been evidence of volatility spillovers in stock markets other than the Nairobi Stock Exchange. [3] were able to show evidence of this in their study of the Gulf Arab Stock markets. This paper attempts to contribute to stock market volatility spillover literature, focusing specifically on the Nairobi Securities Exchange. A study of the existence and magnitude of these spillovers in the Kenyan market could provide useful additional information to portfolio managers or investors who diversify based on industry/sector.

2. Stock Market Volatility and Volatility Spillover

2.1. Introduction

There has been extensive research done on stock market volatility as well as the econometric time series models used in modelling the volatility.

2.2. Stock Market Volatility

In one of the seminal works on stock market volatility, [1] defined volatility as a measure of the changeability or randomness of asset prices.. He went on to identify standard deviation as the most common measure of volatility because it summarizes the probabaility of seeing extreme values of return. His study was based on stock market volatility in the U.S. It provided an overview (at that point in time time) of stock market volatility and some of the issues that may have an impact on it such as computerized trading, trading in futures and options and trading volumes.

Similarly, [5], studied volatility on the U.S. stock markets. However, they focused on the effect of volatility changes on stock prices and returns. Their approach focused on the present value model of calculating share prices, more specifically, the discount rate that is used in the model. They were able to provide evidence that increases in volatility caused a decline in stock prices and a consequent increase in realized future returns, whereas a decrease in volatility resulted in a rise in stock prices and a lower realized future return. The implication of this study is that volatility is one of the factors that may contribute to the level of stock prices. Therefore an investor with equities in their portfolio should be wary of the impact that a significant increase or decrease in volatility can have on his/her portfolio.

2.3. Volatility Spillover

2.3.1. Volatility Spillover between Countries

[6] developed theoretical results for the multivariate simultaneous generalized ARCH model, also known as the BEKK model. [7] used the BEKK model to investigate volatility spillovers between the Indian markets and the Hong Kong, Korea, Japan, Singapore and US markets. In this case spillover between the stock markets was of interest. Their study found that there is a positive volatility spillover between the Indian and the other markets, whereas there was a negative spillover between the Indian and US and Pakistan markets. An interesting observation from this study was that the volatilities of particular indices were affected most by those markets that opened just before them. This implies that the differences in the opening times of the stock markets is one of the factors to consider when analysing volatility spillover between markets.

Similarly, [8] used this BEKK model in their study of volatility spillover among sectors of international stock markets. Unlike [7], their study focused on spillover between similar sectors across multiple stock markets. More specifically, they analyzed volatility among five main sectors: Banking, Financial Service, Industrial, Real Estate and Oil. Their findings were that there was significant spillover among the Banking, Real Estate and Oil sectors. The results of this study appear to support the hypothesis that the level of stock market integration between these three sectors is relatively higher when compared with that of the industrial and financial services sectors. Furthermore, the results of the study contribute to the debate on country diversification versus sector diversification. This is because they call into question the universal applicability of the top-down approach to diversification, where assets are selected based on country first, then on sectors as a secondary criterion.

Taking a similar approach to [2,7], studied mean and volatility spillovers among five major national stock markets: Australia, Brazil, Germeny, Hong Kong & USA. However, they used a GARCH-M model instead. They found that past-market volatility shocks in the USA influenced current volatility in the Australian and German market with varying degrees of intensity. Not only were they able to show that volatility spillovers occurred, but they were also able to show the existence and extent of mean spillovers between the stock markets. The study of volatility spillovers between countries, could be used as a measure of which of the countries is the most influential. As an example, [2] were able to conclude that the US market is the most influential market among the markets under study.

2.3.2. Inter-sector Volatility Spillover

Using the VARMA-GARCH model developed by [3,9], were able to study shock and volatility spillovers among equity sectors of the Gulf Arab Markets. Focusing only on three major sectors (Service, Industrial and Banking), they were able to conclude from their findings that volatility spillovers were more widespread from the industrial sector to the service sector of the Saudi Arabia, Kuwait and Qatar markets.

The possibility of volatility leaking from one equity sector to another calls into question, the validity of industry diversification. If investors diversify based on industrial sector, intending to reduce the covariance between the stocks in their portfolio, a key issue to consider would be whether the volatility spillage between sectors is substantial enough to impact this covariance. The existence of significant volatility spillage between sectors would imply that there is some degree of integration between sectors. This would have implications on the diversification strategy employed.

Numerically/empirically, the volatility spillage between sectors can be represented as the interdependent conditional variance in a time series model such as the VARMA-GARCH model developed by [9]. The VARMA-GARCH model is a more recent and fairly more sophisticated multivariate model. It did, however, enable [3] to examine the conditional volatility and conditional correlation cross effects with meaningful estimated parameters and less computational complications, as compared to the BEKK model of [6].

2.3.3. Volatility Spillover between Large and Small Cap Stocks

Another way in which volatility spillover can be studied is by comparing spillovers between large and small capitalization stocks. This is the approach that was taken by [10], where they used the multivariate GARCH model of [11] to investigate return and volatility spillovers between large and small cap stocks in the UK. [11] developed the model for use in modelling short-run nominal exchange rates. [10] found that there were assymetric return and volatility spillovers between the two groups of stocks: the return and volatility spillover effects from the large stocks to the small stocks was more significant than the spillover effects from small stock to large stocks. The implication here is that when trying to predict the future movements of small cap stocks, the current dynamics of large cap stocks could contribute to the information used.

Various studies on the topic of volatility on the NSE have been done including those done by [12,13] and [14]. However, none have touched on the issue of volatility spillover between sectors. Furthermore, based on the study by [3] there has been evidence of inter-sector volatility spillover in other stock markets. This research attempts to contribute to literature on volatility on the NSE, particularly by providing information on volatility spillover between sectors.

2.4. Portfolio Risk

Previous study have shown that the crucial factor determining portfolio risk for a given level of return is the correlation between the returns of the securities that make up that portfolio, [15]. Stock groupings by sector have been used as a basis for some portfolio diversification strategies. The key indicator in the formulation of these strategies is the extent of covariation between stocks of different sectors. Various studies into the factors driving covariation of stock returns have been done. These include studies done by [16,17,18,19] and [20] all of whom concluded that country diversification was a superior strategy as compared to industry diversification. However, against the backdrop of this series of studies, [21], using a mean-variance spanning approach, concluded that a superior diversification strategy is one which is based on country as well as industry motivated portfolios. This indicates that industry diversification plays some role in portfolio risk management. If investors ideally diversify based on industrial sector, the main goal being to reduce the covariance between the stocks in their portfolio, a key issue to consider would be whether the volatility spillover between sectors is substantial enough to impact this covariance. The existence of significant volatility spillover between sectors would imply that there is some degree of integration between sectors.

In their study, [3] were able to examine the extent to which the volatility in one sector of the stock exchange can result in volatility in another sector within a certain period. In addition, they were able to show the extent to which past volatility of a sector can result in volatility of the stock in the current period. The approach taken by [3] in their study was to put all the individual sectors into major sector groupings (Service, Industrial and Banking) rather than studying each individual sectors in the market. This was done perhaps to take into account the possible integration between some sectors. Based on the results of previous studies, evidence of some integration between some sectors has already been found. A good example of this type of integration is in the financial sector. [22], in their study of U.S. Banks and Insurers were able to show that there are significant information spillovers between the two sectors, implying that there is some level of integration between them. This research will attempt to take a similar approach, putting the individual sectors into broader sector groupings rather than the 11 individual sectors on the NSE.

2.5. Conceptual Framework

The major issues discussed in the literature review, related to the study are stock market volatility, diversification and stock market volatility spillover. One of the models previously used in a similar study is the VARMA-GARCH model where the conditional variance is the variable used as an indicator of the extent of volatility spillover between sectors. This volatility spillover could be used as an indicator of sector integration. Based on that, the conceptual framework for this study is represented by the diagram below:

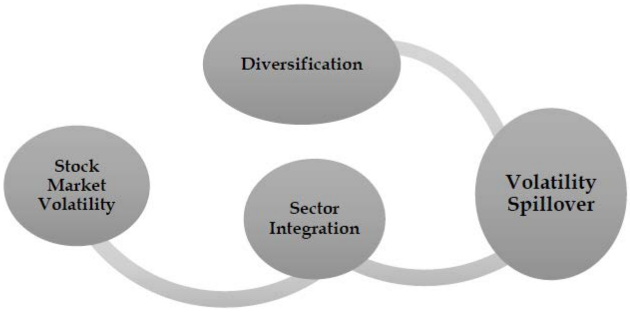

Figure 1. Conceptual Framework

3. Data and Methodology

The paper utilizes a quantitative, explanatory approach, making use of a (VARMA-GARCH) time-series model to determine the extent of volatility spillover between sectors.

Firstly, share price data from the various sectors of the NSE is collected and then sector-based indices of returns are calculated. Based on availability of data, the study uses share prices covering a seven year period. Thereafter, these indices are analyzed using the model to produce estimates for the mean and variance equations. A hypothesis testing approach, employing p-values, is used to determine the significance of the model parameters that indicate volatility spillover.

The population in this study is the Nairobi Securities Exchange. Furthermore, the sample is the equity market, more specifically, the equities in the traditional sectors of the NSE. This excludes recently formed sectors such as the growth and enterprise market (GEMS) which only has one stock.

3.1. Data Collection

The type of data used for this study is numerical/quantitative. Furthermore, the data is obtained entirely from secondary sources. This study uses daily share price information as well as the shares in issue in the various sectors of the Nairobi Stock Exchange.

Based on the methodology of [3], the stocks in the 11 individual sectors are grouped together to create broader sectors. The banking, insurance, investment and investment services stocks are all be grouped into one broad financial sector, the agricultural and commercial and services sectors stand on their own as broad sectors and finally the broad industrial sector is made up of the construction and allied, automobiles and accessories, energy and petroleum, manufacturing and allied and telecommunications sectors.

3.2. Data Analysis

3.2.1. Market Cap Weighted Index

Since no developed and published sector indices exist for the Kenyan market, the share price and shares in issue are used to develop a market capitalization weighted index for each sector. A market capitalization index is chosen because data for the shares in issue is readily available. To calculate the daily level of the market cap weighted index, the product of the share price and shares in issue is summed up for each share for each day in the seven year period.

Thereafter, the log of daily returns is calculated for the various indices. The general formula of the log returns is:

$$R_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right)$$

Where $R_{i,t}$ is the return of index i at time t, $P_{i,t}$ is the level of index i at time t and $P_{i,t-1}$ is the level of index i at time t-1.

The indices of sector returns are then used in the VARMA-GARCH model to analyze the inter-sector volatility.

3.2.2. Empirical Time-Series Model

The multivariate technique that is employed is the vector autoregressive moving average GARCH (VARMA-GARCH) model developed by [9]. According to [3], this method enabled the examination of the conditional volatility and correlation cross effects with meaningful estimated parameters and less computational complications as compared with other methods such as the BEKK model of [6].

3.2.3. Model Specifics

The model used in the study is specified below as equations (1) and (2), with a table below each equation to explain the key variables.

From the VARMA-GARCH model developed by [9], and the work of [3] on the Gulf Arab Stock Markets:

The equity sectors in the VARMA-GARCH system are indexed by i, and n is the total number of sectors.

The mean equation for the i[th] sector in this system is AR(1), and is given by:

$$\boldsymbol{R_{i,t}} = \boldsymbol{a_i} + \boldsymbol{b_i R_{i,t-1}} + \varepsilon_{i,t}, \tag{1}$$

$$\varepsilon_{i,t} = h_{i,t}^{1/2}\eta_{i,t}$$

- a_i and b_i are constants

The interdependent conditional variance is specified as:

$$\boldsymbol{h_{i,t}} = \boldsymbol{c_i} + \sum\nolimits_{j=1}^{n} \boldsymbol{\alpha_{ij}\varepsilon_{j,t-1}^2} + \sum\nolimits_{j}^{n} \boldsymbol{\beta_{ij} h_{j,t-1}} \tag{2}$$

Which is a generalization of the [11] univariate GARCH process, where $h_{i,t}$ is the conditional variance at time t, $h_{j,t-1}$ refers to own past variance for i = j, and past conditional variances of the sectors in the market or system for $i \neq j$.

- c_i is a constant.

From Equation (2), the conditional variance for the i[th] sector is impacted by past shocks and past conditional variances of all the sectors in the market, thereby capturing interdependencies or spillovers. Therefore, this specification allows for the cross-sectional dependency of conditional volatilities among all the sectors.

The past shock and volatility of one sector are allowed to impact the future volatilities not only of itself but also of all the other sectors in the system.

The VARMA-GARCH model is capable of providing numerical estimates for the mean equation, the variance equation and constant conditional correlations for each of the chosen sectors. The variance equations, for each of the sectors, can be represented as a function of the past volatilities of the sector itself as well as that of other sectors in the market.

The null hypothesis is that there is no volatility spillover between sectors. Therefore if coefficients from the VARMA-GARCH are statistically significant, it means that there exists a volatility spillover. The hypothesis test will be done at the 5% level using p-values for the coefficients. The difference/distance between the p-value and 5% can be used to check the strength of the significance or non-significance. This is used to check the magnitude of the spillover effect. The ***** coefficient will be of most interest since it represents the GARCH effects of past volatilities.

Table 1. Mean Equation

Variable	Explanation
$\boldsymbol{R_{i,t}}$	The return of the i[th] sector of the n x 1 vector R_t, defined as the log differences
$\boldsymbol{\eta_{i,t}}$	An innovation: an independent and identically distributed random shock
$\boldsymbol{h_{i,t}}$	the conditional variance of the i[th] sector at time t

Table 2. Variance Equation

Variable	Explanation
$\sum_{j=1}^{n} \boldsymbol{\alpha_{ij}\varepsilon_{j,t-1}^2}$	the short run persistence (or the ARCH effects of past shocks)
$\sum_{j}^{n} \boldsymbol{\beta_{ij} h_{j,t-1}}$	the contribution to the long run persistence (or the GARCH effects of past volatilities).

4. Results

4.1. Empirical Results

The descriptive statistics of the index series used in the model are given Table 3 below.

From the descriptive statistics, it is noted that the broad financial services sector has the highest mean return as whereas the commercial and services sector has the lowest. This indicates that the financial stocks had strong performance over the period considered.

In terms of variance, the agricultural sector has the highest value whereas the broad industrial sector has the lowest. This is an indicator that stocks in this sector were relatively stable over the period.

Recall that the formulae for the mean and variance equations of the VARMA-GARCH are:

$$R_{i,t} = a_i + b_i R_{i,t-1} + \varepsilon_{i,t}, \quad (3)$$

and

$$h_{i,t} = c_i + \sum_{j=1}^{n} \alpha_{ij} \varepsilon_{j,t-1}^2 + \sum_{j}^{n} \beta_{ij} h_{j,t-1}. \quad (4)$$

Estimates for the mean equation and the α parameters of the variance equation are given in Table 5 and Table 6 (Appendix II).

The β parameters in the third part of the variance equation are of most interest because they relate to the lagged conditional variance, $h_{j,t-1}$ in other sectors when $i \neq j$ and own lagged conditional variance when i=j. This conditional variance is an indicator of spillover effects.

The constant, c_i and β parameter estimates for the VARMA-GARCH are given in Table 4 below.

Table 3. Descriptive Statistics

	AGRICULTURE	FINANCE	COMMERCIAL AND SERVICES	INDUSTRIAL
Sample Mean	0.035731	0.043758	0.000223	0.017419
Standard Error	1.475078	0.989079	1.436493	0.950187
SE of Sample Mean	0.033075	0.022178	0.03221	0.021305
t-Statistic (Mean=0)	1.080314	1.973078	0.006928	0.817586
t-statistic Signif Level (Mean=0)	0.280134	0.048625	0.994473	0.413692
Variance	2.175856	0.978277	2.063512	0.902855
Skewness	0.681123	0.925056	2.509806	0.182954
Kurtosis (excess)	5.886587	17.44354	36.920673	7.272479
Jarque-Bera	3025.569335	25500.63668	115058.0657	4394.2678

Table 4. VARMA-GARCH Estimates for c_i and β parameters

	C (constant)	β1 [AGR]	β2 [FIN]	β3 [CS]	β4 [IND]
AGR [1]	0.09496677	0.695957199	0.049773698	0.744833932	1.103229584
T-Stat	1.8312	9.522	0.10374	1.33725	1.37938
P-value	0.067220358	0.000000000	0.917386152	0.181294104	0.167932843
FIN [2]	0.033122342	2.703274014	0.343786905	0.237779297	-0.529691232
T-Stat	1.18383	3.48008	3.48773	1.61451	-2.33314
P-value	0.236621965	0.000512078	0.000497736	0.106575622	0.019740121
CS [3]	0.310802676	4.038367476	-0.18201298	-0.123113405	2.431923485
T-Stat	2.30355	3.03645	-0.45683	-7.38861	2.63447
P-value	0.021350700	0.002424929	0.647843176	0.000000000	0.008492315
IND [4]	0.203081338	0.7185186	-0.223567375	-0.286628239	0.613577166
T-Stat	4.6424	1.93544	-2.0406	-6.18151	7.71602
P-value	0.000003669	0.053078047	0.041422532	0.000000001	0.000000000

4.2. Analysis

From Table 4, the significance of parameters at the 5% level can be analysed to check for spillover effects. Recall that the null hypothesis is as follows:

H_0: There is no volatility spillover between sectors

The intercept/C parameters are not significant in all sectors except for the industrial sector. However, the p-value for the intercept for the agricultural sector is close to 5%, indicating that it is almost significant.

Looking at the agricultural sector, none of the β parameters is significant except for the parameter indicating own volatility spillover, which is to be expected, and is disregarded when assessing inter-sector volatility spillover. Therefore we have insufficient evidence to reject the null hypothesis at the 5% level and it is reasonable to conclude that there are no significant spillovers from the broad financial, industrial and commercial and services sectors to the agricultural sector.

Looking at the broad financial sector, all β parameters are significant except for the one relating to the commercial and services sector. Therefore we have sufficient evidence to reject the null hypothesis in the case of the agricultural and industrial sectors and it is reasonable to conclude that there are significant spillovers from the agricultural and industrial sectors to the financial sector. It is also notable that the p-value for the β of the agricultural sector (0.000512078) is lower/farther away from the 5% level than the value for the industrial sector (0.106575622). This indicates the stronger significance for the agricultural sector than the industrial sector showing a bigger spillover effect from the agricultural sector e.g. If the test was carried out at the 0.5% level, the agricultural parameter would be significant and the industrial parameter would not. In the case of the commercial and services sector we have insufficient evidence to reject the null hypothesis and it is reasonable to conclude that there is no significant spillover effect from the commercial and services to the financial sector at the 5% level.

Looking at the commercial and services sector, only the β parameters of the agricultural and broad industrial sectors are significant. Therefore in the case of the agricultural and industrial sectors, we have sufficient evidence to reject the null hypothesis and it is reasonable to conclude that there is volatility spillover from the agricultural and industrial sectors to the commercial and services sector. Furthermore, the p-value for the β parameter for the agricultural sector (0.002424929) is lower than that of the industrial sector (0.008492315) indicating a bigger spillover effect from the agricultural sector. In the case of the financial sector, we have insufficient evidence to reject the null hypothesis and it is reasonable to conclude that there is no significant volatility spillover from the financial to commercial and services sector at the 5% level.

Looking at the broad industrial sector, all the β parameters except for the agricultural sector parameter are significant. Therefore in the case of the financial and commercial and services sectors we have sufficient evidence to reject the null hypothesis and it is reasonable to conclude that ther are volatility spillovers from the financial and commercial and services sectors to the industrial sector. The lowest p-value for the parameters is 0.000000001 for the commercial and services sector followed by 0.041422532 for the broad financial sector. Therefore there is a bigger spillover effect from the commercial and services sector. In the case of the agricultural sector, we have insufficient evidence to reject the null hypothesis at the 5% level and it is reasonable to conclude that there is no volatility spillover from the agricultural to the industrial sector at the 5% level.

5. Conclusion

5.1. Comparison of Inter-sector Volatility Spillovers

A number of conclusions can be drawn from the study. The agricultural sector is not impacted much by shocks in other sectors as noted from the analysis. This is good indicator on how agriculture can contribute effectively to the financial market in developing countries without great influence from financial market crisis.

There is spillover from the financial and commercial services sector since most sectors are depended on the financials for expansion, capital and any production input. Other sectors will be affected by changes in financial sector. This also implies that Kenya is moving towards the financial services country like the US and UK, where the financial sectors influences the economy greatly.

This is also due to the agriculture sector consisting of firms that are depended on the horticulture – flower firms and beverages – Tea and coffee. These are Kenya's main imports. Therefore, the exchange rate and how the foreign market perform affects the imports. These dynamics may influence the volatility spillover in the Nairobi Securities Exchange. The portfolio managers will need to be very keen in interpreting the portfolio performance by considering external market factors.

However, there is significant spillovers from the industrial and agricultural sectors to the financial sector and to the commercial and services sector. The agricultural sector having a bigger spillover effect. This indicates the care that agriculture need to be given.

Finally there is significant spillover from the financial and commercial and services sectors to the industrial sector with a bigger spillover effect from the commercial and services sector.

5.2. Implications for Policy and Practice

This paper shows that with respect to diversification, investment analysts in developing markets need to make adjustments to diversified portfolios in times of high volatility in the sectors from which there is a high volatility spillover.

It is however important to note that the sectors are made up of various different stocks whose performance impact overall sector performance differently. It might be interesting to look at volatility spillovers among the various individual stocks and how they might impact diversification.

The spillover from the financial and commercial sector implies the possible change of Kenya's economy being depended on the financial services. This means that the portfolio managers have to look at the various financial risk with great interest.

It is also worth noting that the agriculture sector highly depend on the horticulture and beverages. These are main imports of Kenya. Therefore, the exchange rate and foreign market dynamics may influence the volatility spillover in the Nairobi Securities Exchange. The portfolio managers will need to be very keen in interpreting the portfolio performance by considering external market factors

As [3] argued that investors and portfolio managers need to pay attention not only to the individual volatilities of the sectors in the stock market, but also the interactions and volatility transmissions between sectors. In addition, according to [10], information about volatility spillover effects is useful for applications in finance that rely on estimates of conditional volatility, for example option pricing, portfolio optimization, value at risk and hedging. Based on this it would be reasonable to check if volatility spillovers do exist; and if they do, a portfolio manager would need to consider whether it would impact their portfolio or risk management strategy significantly. Hence this paper on the existence and magnitude of the spillovers in the Kenyan market has provided useful additional information that could improve portfolio management practices in Kenya.

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Appendices

Appendix I: List of NSE companies by sector

AGRICULTURAL
1 Eaagads
2 Kakuzi
3 Kapchorua
4 Limuru Tea
5 Rea Vipingo
6 Sasini
7 WTK

AUTOMOBILES & ACCESSORIES
8 C & G
9 CMC
10 Marshalls

BANKING
11 Sameer

12 Barclays
13 CFC
14 DTK
15 Equity
16 HFCK
17 I&M
18 KCB
19 NBK
20 NIC
21 StanChart
22 Co-op

COMMERCIAL & SERVICES
23 Express
24 Hutchings
25 KQ
26 Longhorn
27 NMG
28 Scan
29 Standard
30 TPS EA
31 Uchumi

CONSTRUCTION & ALLIED
32 ARM
33 Bamburi
34 Crown
35 E.A.Cables
36 EAPCC

ENERGY & PETROLEUM
37 KenGen
38 Kenol
39 KPLC
40 Total
41 Umeme

INSURANCE
42 BAICL
43 CIC
44 Jubilee
45 Kenya Re
46 Liberty
47 Pan Africa

INVESTMENT
48 Centum
49 City Trust
50 Olympia
51 TCL
INVESTMENT SERVICES
52 NSE

MANUFACTURING & ALLIED
53 A.Baumann
54 B.O.C
55 BAT
56 Carbacid
57 EABL
58 Eveready
59 Orchards
60 Mumias
61 Unga

TELECOMMUNICATIONS
62 Access Kenya
63 Safaricom

GEMS
64 Home Africa

Appendix II: VARMA-GARCH Estimates

Table 5. VARMA-GARCH Estimates for the Mean Equation

	AGRICULTURE	FINANCE	COMMERCIAL AND SERVICES	INDUSTRIAL
C	0.010999863	0.025125891	-0.084449811	-0.010989174
AR (1)	0.006291307	0.29565923	0.234544586	0.204039244

Table 6. VARMA-GARCH Estimates for Alpha Parameters

	α1 [AGR]	α2 [FIN]	α3 [CS]	α4 [IND]
AGR [1]	0.125785706	0.051944024	-0.035943977	-0.043003396
T-Stat	4.71898	1.75605	-1.87998	-1.07779
P-value	0.000002536	0.079233921	0.060256997	0.281258310
FIN [2]	2.703274014	0.343786905	0.237779297	-0.529691232
T-Stat	3.48008	3.48773	1.61451	-2.33314
P-value	0.000512078	0.000497736	0.106575622	0.019740121
CS [3]	4.038367476	-0.18201298	-0.123113405	2.431923485
T-Stat	3.03645	-0.45683	-7.38861	2.63447
P-value	0.002424929	0.647843176	2.17326E-13	0.008492315
IND [4]	0.7185186	-0.223567375	-0.286628239	0.613577166
T-Stat	1.93544	-2.0406	-6.18151	7.71602
P-value	0.053078047	0.041422532	0.000000001	0.000000000