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Forecasting Price of Irish Potatoes Volatility Using GARCH and VECM Models in Rwanda

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Abstract: **Irish potatoes is one of the most preferable foods produced and consumed by Rwandans, the fact that its price fluctuates famers suffer from the decrease of price that bring them a loss. This work contribute on the forecasting the volatility using GARCH models with nine (9) years (from January 2007 to May 2015) daily data on price of Irish potatoes, price of fertilizers (NPK), price of pest (dithan) and exchange rate (Rwf/Usd) to forecast the volatility of price of Irish potatoes, that will help alert farmers to be aware of the fluctuation of price of Irish potatoes in the studied areas. The methodology of this work is Generalized Auto-Regressive Conditional Heteroscedasticity GARCH and Vector Error Correction Model VECM to study and forecast the volatilities of price of Irish potatoes. In the study GARCH model is used to forecast the fluctuation of price of Irish potatoes. VECM cannot be used because the considered series are not correlated with fluctuation of price of Irish potatoes in the studied areas. Farmer are advised to work in cooperative so that they may look for market as team in time of harvest, they are also advised to look means haw they can store the harvest in time of price fall. Future researchers may look for other financial series that granger cause the fluctuation of Irish potatoes and use them in restricted auto regressive model to test their long run causality with volatility of price of Irish potatoes**.

Keywords: **Price of Irish potatoes, GARCH model, VEC Model, Volatilities, Forecasting.**

I. INTRODUCTION

Irish potatoes is the most important vegetable produced in Rwanda, this country is one among top eleven country that produce Irish potatoes in Africa(FAO,2008). Irish potatoes is produced in different areas of the country mostly in four districts namely, Musanze, Nyabihu, Burera in Northern Province and Rubavu in Western Province. Irish potatoes are cultivated on a large scale in the North West districts of the country and during bumper harvests, the production per hectare stands at between 20 and 30 tons per hectare. Most of the populations produce crops of Irish Potatoes to feed their family and for commercial purpose to satisfy the needs of their families.

Price volatilities have been a major impact on producers and consumers. According to Apergis and Rezitis (2011), volatility refers to variations in economic variables over time. Variation in prices become problematic when they are large and cannot be anticipated, therefore, creating a level of uncertainty which increases risks for producers, consumers and governments (FAO, 2011).

Fluctuating prices of Irish potatoes are forcing farmers out of commercial farming due to losses. Farmers have often complained that the produce fetches prices that are below the cost of production. The farmers said they invest in inputs such as fertilizers, seeds and chemical products to boost production but low prices of the produce lead to losses. An Irish potatoes farmer in Nyabihu, said farmers was losing interest in growing the crop due to unfair prices. "Some of us had started thinking of doing other businesses because we were not benefitting from growing Irish potatoes", he said. In Rwanda, the production of Irish potatoes is decreasing comparing to other roots and tubers, that accounting for 53.0% of the total harvest for 2013, they grew by 3.4% as result of an increase in sweet potatoes (+7.5%) and cassava (+8.5%) but the Irish potatoes goes by decreasing from +32% in 2010; + 21.1% in 2011 and +13.4% in 2012 up to -4.2% in 2013. (BNR, Second Quarter 2013)

The fluctuation of price of Irish potatoes may cause a problem first to farmers who fall in loss despite the effort in their investment in production of Irish potatoes, second to consumers of Irish potatoes who will not find fresh Irish potatoes produced in the country, they will need to import it from outside the country, and thirdly to the government that will spend money to import Irish potatoes and this is not in harmony with Rwandans vision 2020 that predict the agriculture to a modernized and more industrial and market oriented agricultural(MINAGRI, 2009).we have used GARCH family and Vector Error Correction models applied to nine years (from January 2007 to 31 May 2015) daily data from Ministry of Agriculture Database in Rwanda on price of Irish potatoes, price of fertilizers(NPK), price of pests (Dithan) and exchange rate (USD/RwF) from BNR database to study and forecast volatilities of price of Irish potatoes, and evaluate the granger causality of each of said series.

To alert farmer on the fluctuation of price of Irish potatoes and determine granger cause of price of fertilizers (NPK), price of pests (Dithan) and Usd/rwf exchange rate on price of Irish potatoes to provide advice on policy makers so that they may have good plan for policy of farming Irish potatoes in the studied areas, we have used the statistical model and statistical software that has not been tried to forecast the volatility of price of Irish potatoes to inform the future price fluctuation in the studied areas. This then provides insight to policy makers of new attempts that advance Statistical Modeling and prediction techniques. The study is limited in the studied areas, since it is using data in the studied districts and it comes as a contribution to an intervention to farmers who suffer from loss of benefit from their crops due to low price that comes randomly in the studied areas.

II. LITERATURE REVIEW

Volatility is the standard deviation of relative price changes (log-returns). Volatility expresses the magnitude of deviations from the expected price movement; any attempt to measure volatility empirically requires in addition the modeling of the price process, by modeling trends, seasonality, or cyclical components. In this work we are more interested on the volatility of the price of Irish potatoes in Rwanda.

Many researches have been conducted on volatility of Irish potatoes using autoregressive models;

Samuel C. Mwangi et al (2013), in their study *“Effects of Market Reforms on Irish Potato Price Volatility in Nyandarua District, Kenya”* through an analysis of a 20 years monthly time series data set they used an autoregressive heteroskedasticity model to study the volatility of Irish potatoes and they found that an increase in value of production lead to a reduction in uncertainty and risk associated with price volatility, they find also that seasonality of Irish potato production is a key factor influencing price volatility therefore they recommended an Irish potato regulation system to be put in place in order to reduce the Irish potato price volatility in Nyandarua district. Apergis and Rezitis (2011) examine in the case of Greece, the relationship between food price volatility and short-run deviation of some macroeconomic factors such as money supply, per-capita income, the exchange rate, and the deficit-to-income ratio in the GARCH and GARCH-X framework. The results showed the significant and positive effect to the volatility of relative food prices. Balcombe (2010) in his study “The nature and the determinants of volatility in agricultural prices”said that volatility transmission across price, oil price and exchange rate explain agricultural price volatility, this inspired us to insert exchange rate of major currency in Rwanda (RWF/USD) in a VECM to test the long run causality on price of Irish potatoes. Gerald (1996) has used the Autoregressive Conditionally Heteroscedastic (ARCH) model to study the food price variability; the study has shown that to enhance market performance, government may reinforce and increase cash crop production, in this work we will use Generalized Autoregressive Volatility to study the volatility of price of Irish potatoes. In their study Nzuma M.J. et al (2013), on *“Staple Food Price Volatility and Its Policy Implications in Kenya”* evaluated the trends in staple food price volatility in Kenya for Irish potatoes and maize, wheat relative to three other Eastern Africa countries (Ethiopia, Tanzania and Uganda) using the VECM model they tested the volatility of food prices during the global food crisis of 2007–2008. They estimated the conditional and unconditional price volatility and compared it with similar estimates from Ethiopia, Uganda and Tanzania. The results showed that Irish potato prices in Kenya are less volatile than markets in Ethiopia but more volatile than those in Uganda and Tanzania. Nkurunziza T. et al (2015), in their study on “ Policy reforms and efficiency analysis in domestic agricultural markets: *Evidence from an econometric analysis in Rwanda.”*Vector Autoregressive (VAR) and Vector Error-Correction (VEC) Models are used to appreciate food price transmission in monthly data of food price. Their findings state that the domestic agricultural markets functioning and the analysis of domestic food price volatility levels constitute the originality and a value. This study and forecast the volatility of price of Irish potatoes using GARCH family models using also the Vector Error Correction model, with price of fertilizers (NPK), price of pests (Dithan) and exchange rate(Rwf/Usd) variables to determine long run causality on volatility of Irish potatoes.

III. METHODOLOGY

When a variable is explained by its past values in terms of time we say that we have a **"time series"**, in this case the focus is to understand the past and present to forecast the future; $Y_t = \mu + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots + \alpha_p Y_{t-p} + \varepsilon_t$ in **Error Correction Model (ECM)** is a category of multiple time series models that directly ultimate the speed at which a dependent variable Y returns to equilibrium after a change in independent variables X. Engle and Granger (1987) suggested an appropriate model for Y, based two or more time series that are cointegrated. By regressing **Y**on **X** as $Y_t = \alpha + \beta X_t + Z_t$ where $Z_t = Y_t - \beta X_t - \alpha$, we can regress change in Y on lagged change in X as well as the equilibrium error Z_{t-1} plus any relevant short term effects $\Delta Y_t = \beta \Delta X_{t-1} - \gamma Z_{t-1}$ where coefficients β Capture the short term effects of X in the prior period on Y in the current period and γ Captures the rate at which the system Y adjusts to the equilibrium state after a shock. It link the short term to the long term error and it captures the speed of error correction and it is measures the level on which the error will be corrected in percentages. The work has used the VECM model using data of 14 years from 2010 to 2014 on price of Ice potatoes as dependent variable, usd/rwf exchange rate, pests (Dithan) and price of fertilizers as dependent variables. To determine the long run relationship between variables we have used the two step procedure proposed by **Engle and Granger** (Granger Causality) and the Johansen's procedure.

$H_0 : \beta_{xy1} = \beta_{xy2} = \ldots = \beta_{xyp} = 0$ at lag p

TABLE I: Granger causality test procedure

	Fail to reject $H_0 : \beta_{xy1} = \beta_{xy2} = \ldots = \beta_{xyp} = 0$	Reject $H_0 : \beta_{xy1} = \beta_{xy2} = \ldots = \beta_{xyp} = 0$
Fail to reject $H_0 : \beta_{yx1} = \beta_{yx2} = \ldots = \beta_{yxp} = 0$	$Y \not\Rightarrow X$ $X \not\Rightarrow Y$ (No Granger Causality)	$Y \not\Rightarrow X$ $X \Rightarrow Y$ (X Granger cause Y)
Reject $H_0 : \beta_{yx1} = \beta_{yx2} = \ldots = \beta_{yxp} = 0$	$Y \Rightarrow X$ $X \not\Rightarrow Y$ (Y Granger cause X)	$Y \Rightarrow X$ $X \Rightarrow Y$ (bi-directional Granger Causality, or feedback)

There are multiple ways to perform Granger causality tests between a pair of variables, so no result is unique or definitive, one may obtain different results with different lag lengths *p*. Moreover, including additional variables may change the outcome of the Wald tests that underpin Granger causality. In a three-variable VECM, there are three pairs of variables, (x_{1t}, y_t), (x_{2t}, y_t), and (x_{3t}, y_t) that can be tested for Granger causality in both directions:

Vector Error Correction Model:

A **Vector Auto Regressive (VAR)** model describes the evolution of a set of *k* variables (called endogenous *variables*) over the same sample period ($t = 1, 2, \cdots, T$) as a linear function of their past values. The variables are collected in a vector Y_t of dimension $k \times 1$, which has Y_{it} as the i^{th} element. A p[th] *order VAR*, denoted **VAR (*p*)**, has the following form; $Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + e_t$ where the *c* is a *k* × 1 vector of constants, A_i is a time-invariant $k \times k$ matrix and e_t is $k \times 1$ a vector of error terms has the **mean zero**, **constant variance** and there is **no serial correlation;** A *p*th-order VAR is also called a **VAR with *p* lags**. The process of choosing the maximum lag *p* in the VAR model requires special attention because inference is dependent on correctness of the selected lag order.The order of integration help us get another type of VAR model that we will be interested in this study ; we note that, for VAR all variables have to be of the same order of integration and we will put into the following cases: when variables are stationary at level we use Vector auto regressive (VAR) but when all variables are stationary after differencing the VECM is the appropriate model. The **Vector Error Correction Model (VECM)** is the restricted VAR. Variables are not stationary at level, they have first to be differenced **d** times so that they may be used in the model. We estimate a Vector Error Correction model system with one lag for with the evolution of 4 series with one cointegrating relation as follows;

$$\Delta y_t = \beta_{y0} + \beta_{yy}\Delta y_{t-1} + \beta_{y11}\Delta x_{1,t-1} + \beta_{y2}\Delta x_{2,t-1} + \beta_{y3}\Delta x_{3,t-1} + \gamma_y(Z_{t-1}) + \varepsilon_{yt}$$
$$\Delta x_{1t} = \beta_{10} + \beta_{1y}\Delta y_{t-1} + \beta_{11}\Delta x_{1,t-1} + \beta_{12}\Delta x_{2,t-1} + \beta_{13}\Delta x_{3,t-1} + \gamma_1(Z_{t-1}) + \varepsilon_{1t}$$
$$\Delta x_{2t} = \beta_{20} + \beta_{2y}\Delta y_{t-1} + \beta_{21}\Delta x_{1,t-1} + \beta_{22}\Delta x_{2,t-1} + \beta_{23}\Delta x_{3,t-1} + \gamma_2(Z_{t-1}) + \varepsilon_{2t}$$
$$\Delta x_{3t} = \beta_{30} + \beta_{3y}\Delta y_{t-1} + \beta_{31}\Delta x_{1,t-1} + \beta_{32}\Delta x_{2,t-1} + \beta_{33}\Delta x_{3,t-1} + \gamma_3(Z_{t-1}) + \varepsilon_{3t}$$

If the price of Irish potatoes is out of equilibrium (too high or too low), we expect some combination of adjustment in x_{1t}, x_{2t} and x_{3t} to move back toward "long run equilibrium". The error correction coefficients γ_y, γ_1, γ_2 and γ_3 measure these responses; we have used **VECM** Model to correct error in the VAR model of the price of potatoes, usd/Rwf exchange rate, price of pests (Dithan) and price of fertilizers (NPK).

The most used **information criteria** in lag selection are Akaike information criteria (AIC), Schwartz Bayesian information criteria (SBIC) and Hanna-Quin information criteria (HQIC) and their estimate follows;

$$AIC = \ln(\hat{\sigma}^2) + \frac{2k}{T}, \quad SBIC = \ln(\hat{\sigma}^2) + \frac{k}{T}\ln T, \quad HQIC = \ln(\hat{\sigma}^2) + \frac{k}{T}\ln[\ln T]$$

The AIC, SBIC and HQIC are computed for different lags and see the common lag for all criteria. In case all these information gives different lags to be used, we will follow "Persimony principle and choose the one that give the lowest lag.

Bollerslev (1986) proposes a useful model known as the Generalized ARCH model (**GARCH**). For a log return series (also called Log price relative) r_t let $a_t = r_t - \mu_t$. Then a_t follows a $GARCH(p,q)$ model if; $a_t = \sigma_t \varepsilon_t$, $\sigma^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i a_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$ Where $\{\varepsilon_t\}$ is a sequence of iid random variables with mean Zero (0) and variance one (1). The $GARCH(q,p)$ model satisfies the following constraints $\alpha_0 > 0, \alpha_i \geq 0,$ $\beta_j > 0$ and $\sum_{i=0}^{\max(p,q)} (\alpha_i + \beta_j) < 1$ is less than one. The α_i and β_j are referred to as ARCH and GARCH parameters, respectively. The unconditional σ_t^2 variance evolves over time t.The above model can be explained as follows;

$$\underbrace{\sigma^2}_{Conditional\ variance} = \underbrace{\alpha_0}_{\text{intercept}} + \underbrace{\sum_{i=1}^{q} \alpha_i a_{t-i}^2}_{ARC\ \text{effect}} + \underbrace{\sum_{j=1}^{p} \beta_j \sigma_{t-j}^2}_{GARCH\ \text{effect}}$$

It is easy to see that GARCH (p, q) model reduce to ARCH (q) provided that p=0. Under the normality assumption of ε_t, the log likelihood function of the vector α of GARCH model is the same as ARCH. We will use the generalized autoregressive heteroscedasticity model in this work to study and forecast the volatility of price of Irish potatoes.

IV. RESULTS

The study of any time series needs first to consider the time series properties of the data before any other test can be performed. A range of tests have been done to determine the statistical properties of the variables.

Statistics of price of Irish potatoes have been computed and the unconditional histogram of the Price of Irish Potatoes is highly peaked and moderately skewed. Jarque-Bera test(statistc:537.222 with p-value:0.00000) rejects the normality. The financial theory attributes the non-normality to serial correlations and heteroskedasticity in the log-returns series, the mean of 148 Rwf, minimum of 60Rwf and maximum of 500Rwf, the skewness is fixed at 0.759996, The Kurtosis is 4.374060 . Thus, we attempt to remove the serial correlations from the dataset.

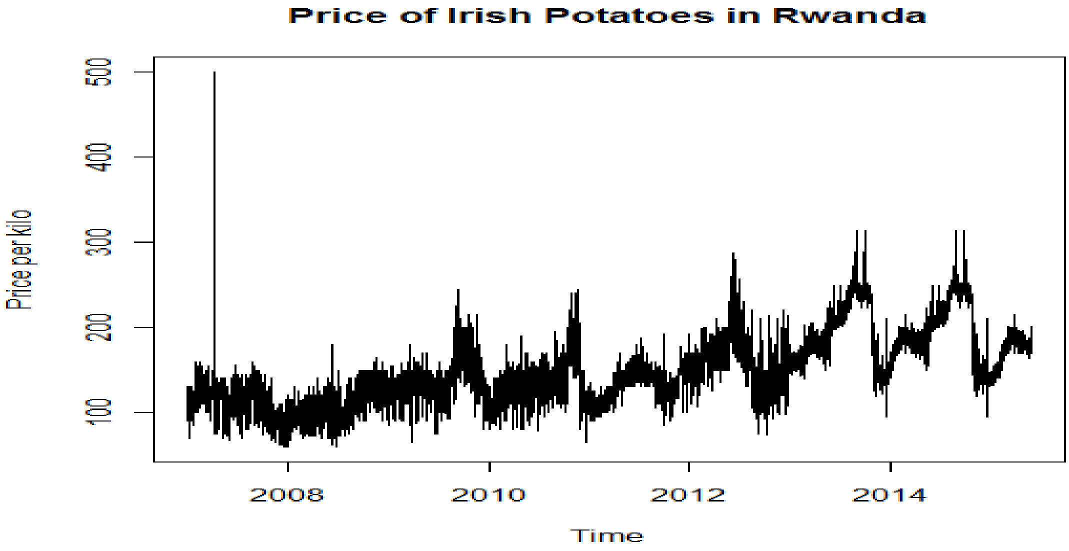

Figure 1: Graph of series of price of Irish Potatoes

The graph shows that the financial time series of Price of Irish Potatoes a seasonal and trend, it is not stationary in mean and in variance. To make it stationary, let's do the differencing the logarithm of price of Irish Potatoes and call it "dlPIP".

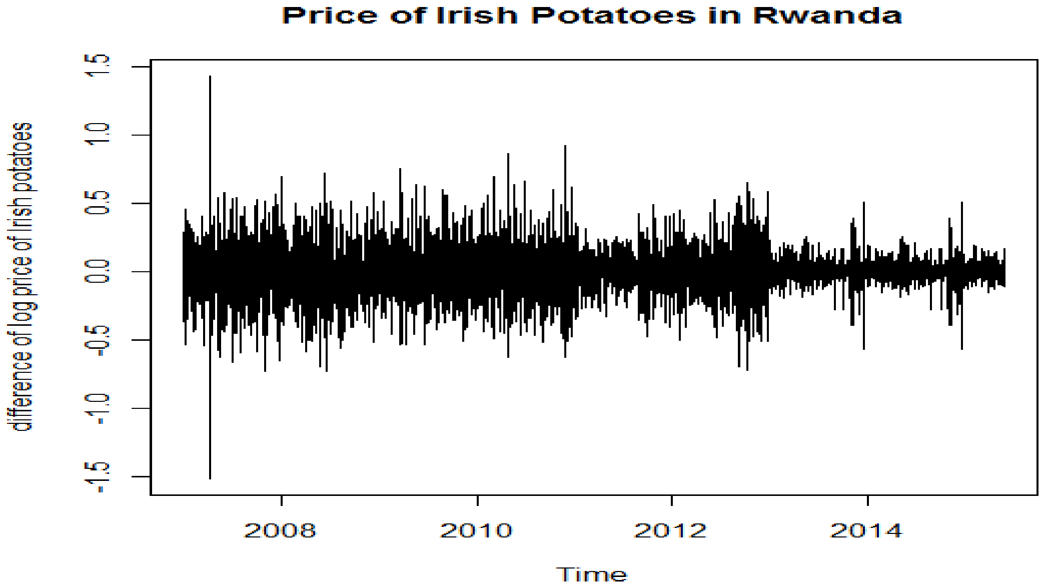

Figure 2: Difference of log price of Irish Potatoes

The financial time series becomes stationary in mean and in variance after differencing once the logarithm of its term values. The graph shows that the high volatility tends to be followed by high volatilities and low volatility is followed by low volatility; it is an indication of **volatility clustering** consequently the appropriate model for this financial time series is **GARCH** model. We have fitted the GARCH (1, 1) model using the difference of logarithm of Price of Irish Potatoes (DLPIP) in R software and the following summary of the model have been found

Table II: Coefficients of GARCH (1, 1) model of Price of Irish Potatoes

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)
a_0	**2.184e-04**	5.083e-05	4.297	1.73e-05
a_1	**1.165e-01**	8.161e-03	14.2779	2e-16
b_1	**8.851e-01**	7.120e-03	124.311	2e-16

Coefficients in above table are significant (they are ready to be used in the model) since the p-values less than 5% is see for all coefficients and it allows us reject the null hypothesis that coefficients equal to zero. From the table we write the following GARCH (1, 1) model; $garch(1,1)$: $\sigma_t^2 = 0.0002184 + 0.156a_t^2 + 0.8851\sigma_{t-1}^2$

For the diagnostic tests we have used Jarque bera (Khi-square=61.07, p-value=5.462 e-14) Test, Box-Ljung test (Khi-square=111.4445, p-value=2.2 e-16); all confirmed that coefficient are consistent and can be used in the model.

MODEL CHECKING:

To check the efficacy of the model we test ARCH effect, the serial correlation, the mean zero of residuals. The normality of residuals using histogram, qq-plot and the ACF and PACF have been used for all these tests.

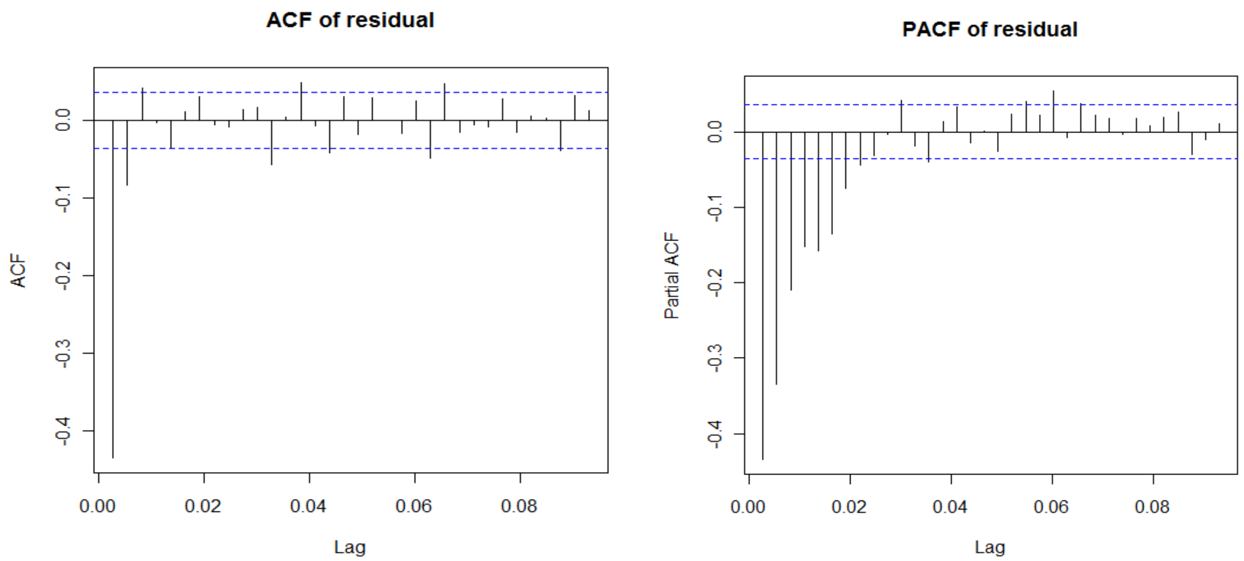

Figure 3: ACF and PACF of residual

The ACF and PCF confirm that there is **no ARCH effect in residuals**.

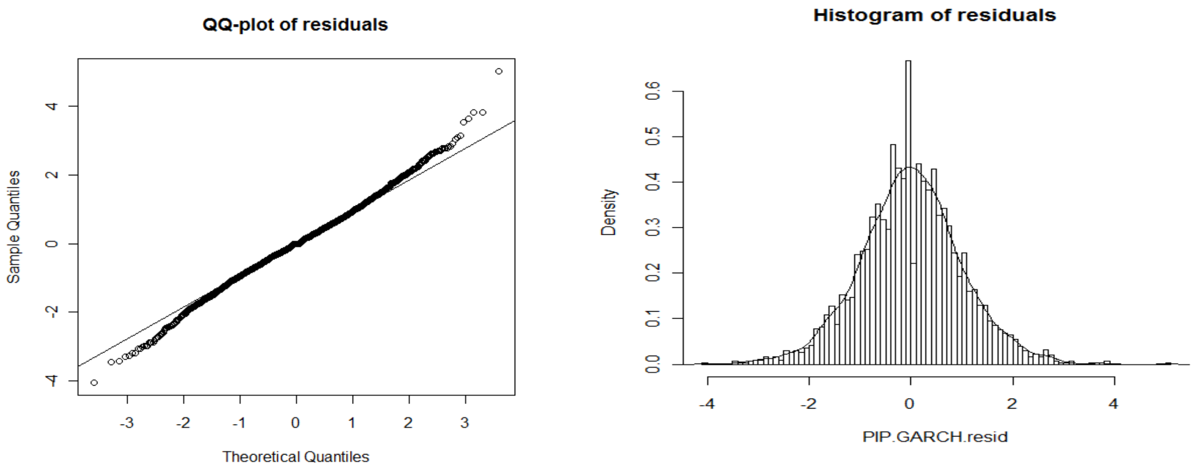

Figure 4: The QQ-plot and Histogram of residual

The Q-Q plot and the histogram of residuals shows that there is no serial correlation and that residuals are normally distributed with mean zero. Observe that residual are normally distributed and their mean is zero; it means that there is **no serial correlation**, reason why we can have right to use the selected model GARCH(1,1) to forecast. We use the predicted model to forecast 180 days (six months) step ahead and the following figure illustrate the forecast volatility at 95% confidence interval and constructed confidence interval for the predicted volatility is shown in the figure.

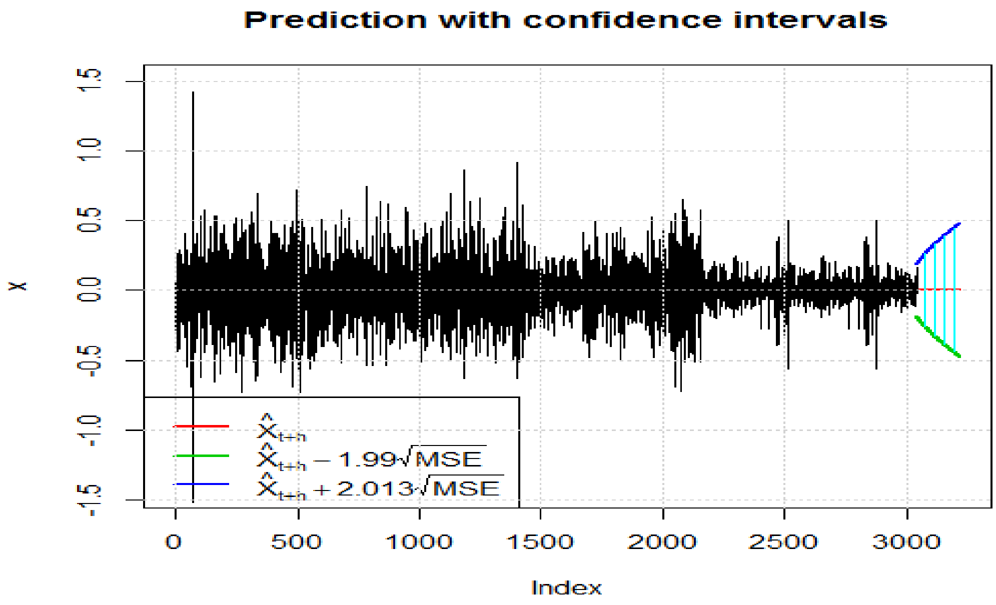

Figure 5: Prediction of volatility of Irish potatoes using GARCH model

The predicted volatility shows us the price of Irish will continue to fluctuate even in 6 months ahead and the magnitude of the fluctuation is decreasing and will lie in the given interval.

Vector error correction model (VECM)

We have undertaken a VECM Lag Order selection process. The results for various selection criteria is listed in a table output of Eview as shown bellow,

TABLE III: Lag order selection criteria

Endogenous variables: Y X3 X2 X1

Lag	LogL	LR	FPE	AIC	SC	HQ
0	11990.18	NA	4.13e-09	-7.953670	-7.945692	-7.950801
1	13143.45	2302.707	1.94e-09	-8.708326	-8.668438	-8.693982
2	13687.89	1085.633	1.37e-09	-9.058984	-8.987187	-9.033165
3	14042.65	706.4649	1.09e-09	-9.283777	-9.180070	-9.246483
4	14234.99	382.4971	9.71e-10	-9.400787	-9.265170	-9.352017
5	14355.63	239.6070	9.06e-10	-9.470225	-9.302698	-9.409981
6	14466.07	219.0513	8.51e-10	-9.532894	-9.333457	-9.461174
7	14538.92	144.2877	8.20e-10	-9.570614	-9.339268*	-9.487419
8	14593.80	108.5634*	7.99e-10*	-9.596416*	-9.333159	-9.501746*

** indicates lag order selected by the criterion*

From the table most of information criteria; LR (sequential modified LR test statistic (each test at 5% level)), AIC (Akaike information criterion), HQ (Hannan-Quinn information criterion), FPE(Final prediction error) confirm the lag 8 as the appropriate lag to be used in the model alone Schwarz decade the results of other criteria but we take the common lag confirmed by many of Information criteria.

JOHANSET TEST OF COINTEGRATION:

Pretest: Variables are not stationary at level, but when we convert the variables into first differenced they becomes stationary.

The first is to test for the stationary of price of variables, and this is can be done using the **ADF** procedure. If a variable is non-stationary and differencing it only once makes it stationary, then it is said to be integrated of order one *I(1)*, and if it is stationary, it is said to be integrated of order zero, I(0).

Stating Null Hypothesis as follows:

H_o: no stationality (the existence of unit root)

H_1: Existence of stationality (No unit root)

TABLE IV: Unit root test at level

Series	**ADF test statistic**	**Test critical value**	**Conclusion**
Price of Irish Potatoes	-0.414171	-1.940930	Non-stationary
Price of Fertilizer (NPK)	0.216799	-1.940930	Non-stationary
Price of Pests (Dithan)	0.370035	-1.940928	Non- stationary
Exchange rate (Rwf/Usd)	2.076433	-1.940928	Non-stationary

Under null hypothesis that there is no unit root test we see ADF test as shown in the table above; since the Augmented Dickey Fuller statistic test statistics of all considered series are greater than the critical value (-1.940930) at 5% level , we accept the null hypothesis in fever of null hypothesis. That is the financial time series considered are not stationary at level.

TABLE V: Unit root test at the first differencing

Series	**ADF test statistic**	**Test critical value**	**Conclusion**
Price of Irish Potatoes	-12.44041	-1.940930	stationary
Price of Fertilizer (NPK)	0.216799	-1.940930	Non-stationary
Price of Pests (Dithan)	-19.74577	-1.940930	Non- stationary
Exchange rate (Rwf/Usd)	-12.52577	-1.940930	Non-stationary

The Augmented Dickey Fuller statistic tests for all series are less than the critical value (-1.940930) at 5% level, we reject the null hypothesis in fever of unit root test. That all the financial time series took into considerations are stationary after one differencing. We confirm that all these four series are not stationary at level but they are all stationary after one differencing. Therefore we can proceed to the second step of checking the existential of the VEC model.

For sake of elasticity of the data we use logarithm of the given series after differencing and construct a linear combination of these three series that is a VCEM model where Price of Irish potatoes is the Dependent variable Y, the price of dithan "X1" , the price of NPK "X2", and the exchange rate (Usd/Rwf) "X3" the independent variables

TABLE VI: Johansen test

HYPOTHESIZED NUMBER OF C.E.(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.384928	5020.494	47.85613	1.0000
At most 1 *	0.366703	3546.896	29.79707	1.0000
At most 2 *	0.339668	2161.831	15.49471	1.0000
At most 3 *	0.257693	903.5130	3.841466	0.0000

** denotes rejection of the hypothesis at the 0.05 level; Trace test indicates 4 Cointegrating Equation(s) at the 0.05 level*

The null hypothesis in the first column of the table states first that there is no model (none); this hypothesis is rejected since the trace statistic is greater than the critical value. It is also done in the same way for the three other null hypotheses

(Ho: there exists at most 1, at most 2, at most 3 equations) the null hypothesis is rejected at 0.05 levels since the trace statistic is greater than the critical value. We **conclude** that our 4 series; price of Irish potatoes, price of fertilizers (NPK), price of pests (Dithan), and exchange rate (Rwf/Usd) does not have long run associationship, consequently it is not possible to run the restricted VAR (i.e. VECM) using this four series (variables).

The above results moves us to test the **Granger causality** to examine the Granger cause of the price of Irish potatoes (Y), fertilizers NPK (X1), price of pests Dithan (X2) and exchange rate Rwf/Usd (X3).

TABLE VII: Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic	P-value	Decision
X1 does not Granger Cause Y	0.99528	0.3697	Accept the null hypothesis
Y does not Granger Cause X1	0.47703	0.6207	Accept the null hypothesis
X2 does not Granger Cause Y	0.13658	0.8723	Accept the null hypothesis
Y does not Granger Cause X2	0.04459	0.9564	Accept the null hypothesis
X3 does not Granger Cause Y	0.66391	0.5149	Accept the null hypothesis
Y does not Granger Cause X3	0.48215	0.6175	Accept the null hypothesis

In all these six cases the Null hypotheses is accepted, it means that there is no Granger Cause between the price of Irish Potatoes (dependent variable Y) and price of fertilizers NPK (X1), price of pests Dithan (X2) and exchange rate USD/RWF (X3) in the studied areas, reason why we do not need develop Vector Error Correction Model (VECM) the conditions are not satisfied for the construction of this model.

V. CONCLUSION AND RECOMMENDATION

The fluctuation of price of Irish potatoes, being a great problem to farmers, GARCH models has the ability to forecast and inform on volatility at certain probability and farmers are informed that fluctuation of the price of Irish potatoes will persist in six months ahead they need be ready looking for different strategies to store the harvest of Irish of potatoes and sell it when prices are high so that they may get interests from their farming activity. The volatility of fertilizers especially NPK1515 doesn't granger cause the volatility of Price of Irish potatoes; the volatility of pests (Dithan) does not have a long run associationship with the volatility of Irish potatoes and the exchange rate (USD/RWF) doesn't granger cause the volatility of Irish potatoes in the studied areas.

Due to results from this work we provide **recommendations** to **Ministry of Agriculture; t**o use statistical models (GARCH for example) to forecast volatility and provide information to farmers so that they be ready, and based on results of forecasting they may elaborate strategic plans that will help farmers overcome fluctuation of prices of Irish potatoes , to cooperate with other country looking for the market of Irish potatoes so that farmers get where to sell their production in time of harvest and plan for implementation of factory that transform Irish potatoes into others consumable or useful product and farmers will get easily where to sell the harvest on favorable price. **Farmers** need think on how they can store the harvest when the price of Irish potatoes are law, and then sell it when prices increase and work in cooperatives so that they may look for together the market where to sell their product as a cooperative.To **future researcher** to look for other series like Irish potatoes productions in tones, the elements of weather and some other series that may Granger Cause the fluctuation of price of Irish potatoes and use them in a restricted Vector Auto regressive to examine the long run and short run associationship between them and the fluctuation of Irish Potatoes.

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