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STATISTICAL ANALYSIS OF EXPORT PRICE VOLATILITY OF OIL SEED IN ETHIOPIA

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ABSTRACT

Ethiopian oil seeds and pulses are mostly organically produced, and are known for their flavor and nutritional value. The aim of this study is to model the export price volatility of oil seed Ethiopia using GARCH model. The data used are monthly observations of the export price of oil seed, food price index, import fuel oil price and exchange rate from January 1998 to June 2013. Unit root tests of the series under study reveal that all the series are non-stationary at level and stationary after first difference. GARCH models were employed to analyze the monthly export price of oil seed data. It was found that ARMA (2,1)-GARCH(1,1) with normal distributional assumption for the residuals were adequate model for the data considered in this study. Among the exogenous variables that are considered in this study, food price index and import fuel oil price had an impact on the volatility of the export price of oil seed in Ethiopia.

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INTRODUCTION

Trades in the foreign sales are important in forecasting of overall growth of a country. For some developing countries, export trade is such an important factor that an estimate of the foreign exchange earnings represents a first step in the formulation of development plans. As the export of a given country continue to expand, new profit opportunities develop not only to provide inputs for export sector but also to take the advantage of external economic benefits. For example, the volatility in export prices is an important source of national macroeconomic disturbance mainly due to the importance of exports in the composition of the economy. Generally speaking, price volatility may be derived from country specific factors as well as from various influences emanating from the global market place. In keeping with any open economy devoting a substantial proportion of its resources to export production; prices received for such exports are a crucial determinant of aggregate income and social welfare (Valadkhani *et al.*, 2005). Developing countries often face scarcity of foreign exchange earnings to stimulate economic growth, international trade thus tends to be unstable, which is the only source of foreign exchange for these countries.

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Moreover, these countries mostly import technology and capital goods. Sub-Saharan countries have similar economic structures low per capital income, largely agrarian economies with very small industrial sectors, relatively low growth rates, and a strictly binding foreign exchange constraint, responses to instability in export earnings are likely to be similar among the nations of sub-Saharan countries (Brempong, 1991). Oilseeds and wheat grains have witnessed unprecedented volatilities and price fluctuations in the recent past. Extreme volatility in commodity prices, particularly of food commodities, affects producers, consumers, traders, exporters and food procurement agencies of the central and state Government (Pandey, 1990). In Ethiopia Oilseeds are the second largest export items and support nearly 4 million small holder farmers, account for 7% of total area under grain crops, and 3% of the total grain production. Unlike any other grain crops in the country, around 50% of the oilseeds produced are marketed while 35% used or household consumption and 13% kept as a seed for the next season (CSA, 2013). Thus, the oilseeds sub-sector due to its commercial orientation could be a vital starting point in the commercialization of the agricultural sector, and hence transformation of the agricultural sector to high value crops. This study tries to use time series data analysis using GARCH family model to see the volatility of export price of oilseed in Ethiopia.

MATERIALS AND METHODS

Data: Data for the study were obtained from National bank of Ethiopia (NBE) and Central statistical agency (CSA). Monthly time series data on export price of oilseed (OILSEED), food price index (FOOD), import fuel oil price (OIL) and exchange rate (EXCHANGE) for the period from January 1998 to June 2013 were used for estimation process. The export price of oilseed, exchange rate and fuel oil price data are obtained from NBE and food price index data are obtained from CSA.

Statistical model: The Box-Jenkins time series model such as Autoregressive (AR), Moving Average (MA) and ARMA are often very useful in modeling general time series data. However; they all require the assumption of homoskedaticity (or constant variance) for the error term in the model. But, this may not be appropriate when dealing with some special characteristics in the financial and agricultural price time series and this causes the introduction to ARCH (Autoregressive Conditional Heteroskedasticity) model which was proposed by Engle (1982) and generalized by Bollerslev (1986) and Taylor (1986). Therefore, to come up with the objectives of the study, after identifying the presence of ARCH effects, separate GARCH and EGARCH models has been employed in this study to investigate the pattern of export price volatility and its determinants for oilseed with joint estimation of a mean and a conditional variance equation as model specification given below. Let Y_t be the returns of average monthly export price for oilseed under study at time t, $\varepsilon_t$be error term (residual) from mean equation with mean zero and conditional variance ${\sigma_t}^2$ and given the historical information on the average export price return series as $Y_1, Y_2, \ldots, Y_t$ under the presence of ARCH effect, for $GARCH(p, q)$ family model the conditional mean equation,

The $ARMA\ (p, q)$ mean model (Box-Jenkins, 1976) is given as:

$$Y_t = \mu + \sum_{i=1}^{p} \emptyset_i y_i - \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t$$

An Autoregressive Conditionally Heteroskedasticity model for the variance of the errors which is known as an ARCH (q) model proposed by Engle (1982), the conditional variance is given by:

$${\sigma_t}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}$$

We impose the non-negativity constraints $\alpha_0 > 0$ and$\alpha_i \geq 0, i = 1, 2, \ldots, q$.

Generalized by Bollerslev (1986) as GARCH (p, q) which allow the conditional variance to be dependent upon previous own lags as model, then the full model for $GARCH(p, q)$ has two parts the mean model and the conditional variance model given below;

$${\sigma_t}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i} + \sum_{j=1}^{p} \beta_j {\sigma^2}_{t-j}$$

where $\alpha_0, \alpha_i \geq 0, \beta_j \geq 0\ for\ i = 1, 2, \ldots, q\ and\ j = 1,2, \ldots, p$ ensure that the variance is always greater than zero and the restriction $(\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j < 1)$ is necessary and sufficient condition for the stability of the conditional variance equation (Cryer and Chan, 2008). GARCH-X model proposed by Hwang and Satchell (2005) for modeling aggregate stock market return volatility includes a measure of the lagged cross-sectional return variation as an explanatory variable in the GARCH conditional variance equation. GARCH-X model where the basic GARCH specification of Bollerslev (1986) is augmented by adding exogenous repressors to the volatility equation:

${\sigma_t}^2(\vartheta)$ is the volatility process given by:

$${\sigma_t}^2(\vartheta) = \alpha_0 + \alpha {y_{t-1}}^2 + \beta {\sigma_{t-1}}^2 + \gamma {x^2}_{t-1}$$

For some observed covariate x_t which is squared to ensure that ${\sigma_t}^2(\vartheta) > 0$ and where $\vartheta = (\alpha_0, \theta')'$, with $\theta = (\alpha, \beta, \gamma)'$, is a vector of parameters.

Procedures for Model Building

The basic frameworks that were followed in order to investigate the pattern of export price volatility and its determinants on, oilseed were follows the following Box and Jenkins approach:

- Test for the presence of unit root (non-stationary) case
- Test for ARCH effects
- Model order selection for GARCH family model
- Model parameter estimation
- Model adequacy checking

RESULTS AND DISCUSSION

Descriptive Statistics: The data in this study consist of monthly export price of oilseed (in birr per metric ton), monthly food consumer price index, monthly import fuel oil price (in US dollar) and monthly exchange rate (in birr against US dollar) in Ethiopia for the period spanning from January 1998 to June 2013.

Table 1. Descriptive statistics for macroeconomic variables

	OILSEED	FOOD	OIL	EXCHANGE
Mean	7492.542	40.331	57.647	10.456
Median	5996.285	28.600	57.538	8.919
Maximum	22209.55	102.100	123.259	18.887
Minimum	3177.640	17.300	9.824	6.709
Std. Dev.	4144.374	23.741	34.434	3.308

From the result Table 1 above, the mean value of the export price of oilseed, food price index, fuel oil price and exchange rate over the study period were 7492.542, 40.331, 57.647 and 10.456, respectively. Moreover, the maximum and minimum values of the export price of oilseed were 22209.55 and 3177.640, respectively.

Test for Stationarity: The time series under consideration should be checked for Stationarity before one attempts to fit a suitable model. The Stationarity of each series can be tested using the Augmented Dickey-Fuller test and the Phillips-Perron test. The results of ADF and PP tests with intercept but no trend and with intercept and trend both at level and first difference for the series are presented in Table 2 and Table 3. Test results presented in Table 2 indicate that the null

Table 2. ADF and PP Unit root test results (At level)

Series	Include test equation	Test statistic		Prob.*		Test critical value		
		ADF	PP	ADF	PP	1% level	5% level	10% level
OILSEED	Intercept	2.612	3.042	0.999	0.999	-3.466	-2.877	-2.575
	Trend and intercept	0.227	0.380	0.998	0.999			

Table 3. ADF and PP Unit root test result the return series of the export price of oilseed

Series Name	Include test equation	Test statistic		Prob.*		Test critical value		
		ADF	PP	ADF	PP	1% level	5% level	10% level
Return series of oilseed	Intercept	-12.730	-12.759	0.000	0.000	-3.466	-2.877	-2.575
	Trend and intercept	-12.881	-12.884	0.000	0.000	-4.009	-3.434	-3.141

Table 4. Mean equation for monthly return export price of oilseed

Parameters	Coefficients	Std. error	t-statistic	p-value
Constant	0.017	0.003	5.389	0.000
AR(1)	0.602	0.073	8.218	0.000
AR(2)	0.313	0.072	4.339	0.000
MA(1)	-0.984	0.016	-62.177	0.000

Table 5. Maximum likelihood Parameter Estimates of the Volatility Models for Selected Orders with the Incorporated Exogenous Variables for oilseed

Parameters	Variables	Coefficients	Std. error	Statistic	P-value
	Constant	0.016	0.003	5.101	0.000*
Mean equation	AR(1)	0.643	0.082	7.821	0.000*
	AR(2)	0.285	0.076	3.734	0.000*
	MA(1)	-0.986	0.007	-136.974	0.000*
	Constant	0.018	0.003	6.001	0.000*
	ARCH(-1)	0.081	0.075	2.089	0.020**
Variance equation	GARCH(-1)	-0.221	0.260	-2.889	0.030**
	Food price index	-0.003	0.002	-2.384	0.001*
	Import Fuel oil	-0.001	0.004	-2.823	0.004*
	Exchange rate	0.020	0.016	1.294	0.195

Note: * and ** indicates significant at 1% and 5% level, respectively

hypothesis that the series in levels contain unit root could not be rejected for the series. If a time series data is non-stationary, it is necessary to look for possible transformations that might induce Stationarity. In practice, researchers usually transform financial data series into return forms. Table 3 summarizes the unit root test of the return series for the export price of oilseed. The table shows that the null hypothesis of unit root would be rejected. Hence the return series of the export price of oilseed are stationary.

Specification of the mean equation: To specify the conditional mean equation for the series, comparison of various$AR(p)$, $MA\,(q)$ and $ARMA\,(p,q)$ models are performed and the one with smallest information criteria is selected. In this study, AR (0-3) and MA (0-3) were considered since the return series show insignificant spikes for all of the lags. Among the various ARMA models considered, ARMA (2, 1) model possesses minimum AIC and BIC and exhibits no serial correlation. Therefore, ARMA (2, 1) model is the best-fit model for the conditional mean equation for the return series of the export price of oilseed. The maximum likelihood estimation method for monthly return series of export price of oilseeds are summarized in Table 4 below.

Test for ARCH effects: To proceed with volatility modeling ARCH effects (whether or not volatility varies over time) in the residuals from the selected ARMA (2, 1) model should be tested. The confirmation of the presence of ARCH effect indicates that the volatility in the average monthly return export price of oilseed is time varying and appropriateness of employing GARCH model.

Specification of Volatility Model: Once the ARCH effects are determined, then the optimal lag specifications for GARCH family models were determined prior to the construction of the final model to investigate the determinants of export price volatility. After testing for different orders of p and q of GARCH family, it was found that GARCH (1, 1) with normal distributional assumption for residuals, possess minimum AIC and/or SBIC. Thus, this model is a best-fit model to describe the volatility of the return series of the export price of oilseed in Ethiopia. The coefficient estimate of food price index is negative and statistically significant at the 1% level, that is, food price index has a significant influence on the export price volatility of oilseed. This indicates that an increase in food price index leads to a decrease in the monthly export price volatility of oilseed. This result is consistent with the findings of Zheng *et al.* (2008). From Table 5, the coefficient of fuel oil price is negative and statistically insignificant. This shows that fuel oil price has no significant effect on the export price volatility of oilseed. Among the explanatory variables which are considered in this study, the coefficient of exchange rate (in birr against US dollar) was negative and statistically insignificant. This result is inconsistent with the findings of Abule (2012) and Serge (2006). The results from the variance equation show that the coefficient of the ARCH (-1) term were statistically significant at the 5% level. This shows that the current month export price volatility of oilseed was affected by its 1-month lagged shocks. Similarly, the GARCH (-1) term is statistically significant at the 5% level. This indicates that the current month export price volatility of oilseed was affected by its 1-month lagged price volatility.

Diagnostic checking of the fitted model: For diagnostic checking of the presence of remaining ARCH effect in the residuals, ARCH LM test and Ljung-Box Q-test are used. The p-values of both tests are greater than 5%. These results imply that we do not have enough evidence to reject the null hypothesis that there is no ARCH left in the residuals. Additionally, the Jarque-Bera statistic is used to test the normality of the residuals in the fitted model. The result shows that the normality of the residuals in the fitted model is not rejected. Therefore, we conclude that the residuals of the fitted model are normally distributed.

Conclusion

In this paper, we have examined GARCH family models for the export price of oilseed. The conditional mean equation was estimated using ARMA model and the conditional variance equation using GARCH family models with different error distributions. After examining different competitive models ARMA (2, 1)-GARCH (1, 1) model with normal distributional assumption for the residuals provides the best-fit model for the export price volatility of oilseed in Ethiopia. Among the exogenous variables that are considered in this study, food price index and import fuel oil price had a significant effect on the volatility of the export price of oilseed in Ethiopia. Moreover, the ARCH and GARCH terms were found to be statistically significant. These show that the current month export price volatility of oilseed is affected by the recent past shocks and volatility.

Recommendation: The focus of this study was estimating the export price volatility of oilseed in Ethiopia. Further studies may employ multivariate models such as seasonal or dynamic conditional correlation multivariate model to analyze the time varying correlation of export price of oilseed with other variables. Additionally, there are also other variable that might affect the volatility of the export price of oilseed in Ethiopia.

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