Assessing the Market Price Volatility of Vegetable in Sri Lanka

S.H.T. DE SILVA and H.M.L.K. HERATH

Department of Agribusiness Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka

ABSTRACT

Price risk is the unpredictable changes in prices of both inputs and outputs. Vegetable price in Sri Lanka show very high price fluctuations than other products which leads the market to a very risky situation. It is said that, mainly the retail prices are affected for this price fluctuations than wholesale or farm gate prices. Thus understanding the price risk in vegetables is timely important for taking better market decisions that avoids market failures. In this study, Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model together with Auto Regression Moving Average (ARMA) model as a mean model was applied to the monthly retail prices of selected 17 vegetables from 1985 to 2014 for modeling of time series data. It is revealed that for all vegetables under the investigation nominal prices have increasing trends while real prices have decreasing trends. Moreover it was found that all vegetables show stochastic volatility in both their nominal and real prices, which clearly confirmed the price risk apparent in the vegetable market. For most vegetables, ARMA(1,1)-GARCH (1,1) model found to be the most promising model which could explain the volatility in their retail prices and thus it can be used for forecasting future volatility.

KEYWORDS: ARMA-ARCH/GARCH model, Price risk, Price volatility, Vegetable prices

INTRODUCTION

Vegetable is a very important component of the daily diet of Sri Lankans, which is only next to rice as that of many Asian countries. The production and marketing of vegetables characterized by higher perishable nature, seasonality and bulkiness, economic conditions, pricing problems *etc.* (Verma *et al.*, 2002), which creates a high risk within the Sri Lankan vegetable market. Among these problems economic conditions and pricing problems have become the major dilemma in the industry. Sandika (2011) noted that generally the price fluctuation of vegetables is higher than other agricultural products such as cereals. According to Ranathilaka and Andri (2014), the average nominal retail price of vegetables in Sri Lanka has gone up by more than 300% during the period from 1985-2007. When considering farm-gate and wholesale prices, the retail price of the vegetables has drastically increased during the last few decades. This conclude that the retail prices are more volatile than the wholesale prices and farm-gate prices. Other than the nominal retail prices, real prices also plays a key role in volatility studies. Real prices are the adjusted prices to the inflation which helpful to the policy makers for better decision making.

Many research works have been identified several reasons behind these vegetable price fluctuations in the country like, weather condition, high middleman involvement in industry, lack of irrigation facilities, lack of good planting materials, higher market margin due to market rigidities *etc.* (Bowbrick, 1976; Mahaliyanaarachchi, 2004). And some other past research studies suggests that efficient pricing system would control price hicks in the agricultural sub-sector in Sri Lanka (Mahaliyanaarachchi, 2004). But, in Sri Lankan context, the studies regarding vegetable price volatility is not so common, even it reflects risk in vegetable market price.

Price volatility can be described as how quickly or widely prices can change in a certain time period. Price fluctuation of commodities is a very common phenomenon in any market system. Due to the recent frequent price fluctuations, price volatility is getting increased and it leads the stakeholders such as producers, consumers, marketers and policy makers to face problems in dealing with the commodity prices which create a very risky situation in the market. Risk awareness is generally very important in production, investment and marketing behavior of producers.

Volatility in prices are difficult to be figured out solely based on econometric models thus, an implication of an alternative model based on time series techniques. Auto Regressive Conditional Heteroscedasticity / Generalized Auto Regressive Conditional Heteroscedasticity (ARCH/GARCH) (Engle, 1982; Bolerslev, 1986) models are the most widely used time series technique for the volatility studies. With this background, this study was carried out to examine the price volatility and dynamic behaviors of 17 major vegetables found in the food basket including both Up-country and Low-country vegetables in Sri Lanka. The outcome of this study will be very helpful to the stakeholders involving in vegetable market for better decision making.

METHODOLOGY

Theoretical Framework

Autoregressive Conditional Heteroscedasticity (ARCH) models are used to describe a changing, possibly volatile variance. A GARCH (Generalized Autoregressive Conditionally Heteroscedasticity) model is further generalization of an ARCH model which uses values of the past squared observations and past variances to model the variance at time t. Estimated parameters of ARCH/ GARCH models are consistent of the mean model on the data is correctly specified thus, an implication of a ARMA-ARCH/GARCH model where Auto Regressive Moving Average (ARMA) model is the mean model. ARMA-ARCH/GARCH model on y_t can be given as;

$$y_t = \mu + \sum_{i=1}^{p} \theta y_{t-1} + \sum_{i=1}^{q} \phi z_{t-1} + z_t \quad (1a)$$
$$z_t = h_t e_t, \quad (1b)$$
$$h_t^2 = f(.) \quad (1c)$$

Where $f(.)$ is either an ARCH process or a GARCH process which are depicted in equation (2) and (3). The $t = m+1, \dots, T$ and ε_t is the error term which is a standard Gaussian white noise; $e_t \sim iid\ N(0,1)$.

$$h_t^{\,2} = \omega + \sum_{i=1}^{p} \alpha_i z_{t-1}^{\,2} \quad (2)$$
$$h_t^{\,2} = \omega + \sum_{i=1}^{p} \alpha_i z_{t-i}^{\,2} + \sum_{j=1}^{q} \beta_j h_{t-j}^{\,2} \quad (3)$$

p and q are non-negative integers and z_t are innovations or error terms of the $\{y_t\}$ series. ω is the constant and α_i, β_j are the ARCH and GARCH parameters respectively. And this comes with the assumptions of $\omega > 0$, $\alpha_i \geq 0$ and $\beta_j \geq 0$.

Collection of Data

Monthly retail prices of 17 vegetables (green bean, carrot, leeks, beetroot, knolkhol, raddish, cabbage, tomato, ladies fingers, brinjal, pumpkin, cucumber, bitter gourd, snake gourd, luffa, long bean and ash plantain) were used for the analysis which are commonly included in the food basket. Retail prices (1985-2014) were collected from Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI). Colombo Consumer Price Index (CCPI) and Gross Domestic Production (GDP) deflator of Sri Lanka for the period under investigation was collected from the sources available at the Central Bank of Sri Lanka.

Conversion of Nominal Prices into Real Prices

Nominal prices were converted into the Real prices by using both CCPI (1985-2014) and GDP deflator (1985-2013) with the purpose of identifying, if there is any inflation effect on prices. CCPI was available in two base years (1952 and 2006/07) on monthly basis while GDP deflator was available on annual basis using 2002 as the base year. The procedure adapted by the Perera and Herath (2014) was used for the price conversions.

Preliminary Analysis

Preliminary analysis were carried out by constructing Time Series Plots, Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) plots for both Nominal and Real price data. Auto Regressive Lagrange Multiplier (ARCH-LM) test (Engle, 1982), Mcleod Li test (Li and McLeod,1981) and BDS (Bowbrick *et al.*,1976) test were used for identification of volatility clustering appeared in both Real and Nominal price time series. Null hypothesis of all these three tests implies that no ARCH effects in data set. Moreover a Trend Analysis was done on both nominal and real data to understand further the effect of inflation on prices.

Model fitting and selection was done using 'ugarchspec' and 'ugarchfit' functions available in 'rugarch' package in R (3.2.3). Further, best fitted model was selected based on the least Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Diagnostic checking of the selected models was done by testing for stochastic volatility in Residuals/Standard residuals of the fitted ARMA-ARCH/GARCH models.

RESULTS AND DISCUSSION

Based on the time series plots, it was noticed that, nominal prices of all vegetables showed an increasing trend over the time, while real prices showed different price behaviors from each other. For an example, time series plots of raddish, tomato and cucumber are depicted in Figure 1. Cucumber real prices, show in general a decreasing trend over the time. A similar behavior of real prices can be observed in long bean, luffa and pumpkin. And real prices of raddish shows somewhat steadiness until late 1990s and started to show a decreasing trend. This pattern can be seen in all up country vegetables except Tomato. Tomato real prices continuously increases up to late 1990s and thereafter it shows a decreasing trend. Ash plantain, bitter gourd, snake gourd, brinjal and ladies fingers show the same price behavior as tomato in real price. Consequently, it can be inferred that the increasing trend apparent in nominal price are due to the impact of increasing inflation of the country.

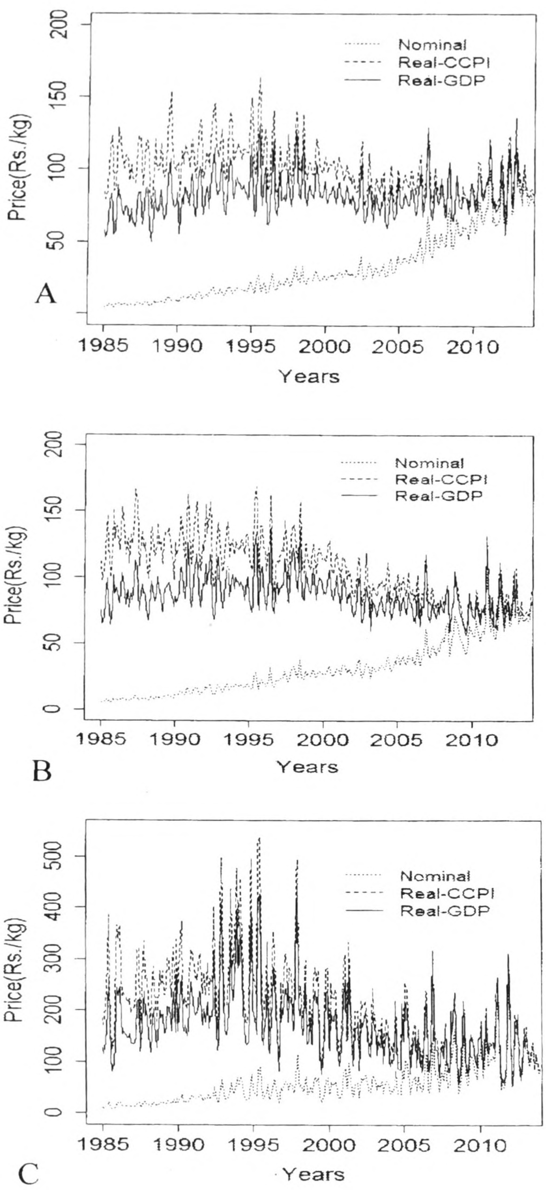

Figure 1. Time series plots of raddish, cucumber and tomato. ***A.*** *Raddish,* ***B.*** *Cucumber,* ***C.*** *Tomato*

The trend analysis further revealed that all vegetable nominal prices showed a statistically significant increasing trend over the time, while real prices showed a decreasing trend or stable over the time. Figure 2 depicts time series plots of CCPI and GDP deflator which apparently show an increasing trend over the time. Results of ARCH LM test, McLeod test and BDS tests applied on both nominal and real prices are given in Table 1. Significant results from the three tests applied on both real and nominal prices evident that volatility clustering is apparent in respective time series of all vegetables which was confirmed by respective time series plots, ACFs and PACFs. The best fitted ARMA-GARCH models for the nominal and real prices of vegetable under investigation are illustrated in Table 2. And Table 3 confirm the goodness of fit of the models further.

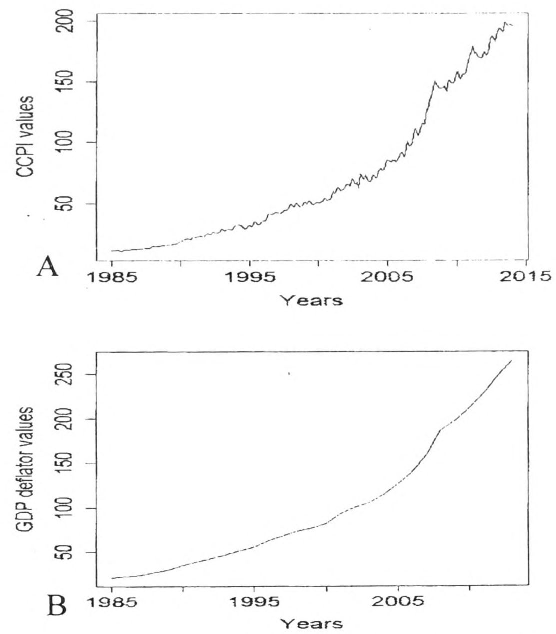

Figure 2. Time series plots of CCPI and GDP deflator. ***A.*** *CCPI vs. Time,* ***B.*** *GDP deflator vs. Time*

Table1. Outcome of Volatility Tests

Commodity	Nominal prices			Real prices		
	ARCH LM	Mcleod Li test	BDS test	ARCH LM	Mcleod Li test	BDS test
Green bean	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carrot	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Leeks	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Beetroot	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Knolkhol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Raddish	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cabbage	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tomato	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ladies fingers	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Brinjal	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pumpkin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cucumber	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bitter gourd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Snake gourd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Luffa	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Long bean	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ash Plantain	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: $P \leq 0.05$

Table 2. Best Fitted ARMA-ARCH/GARCH Models fitted on nominal and real prices of different vegetables

Vegetable	Nominal Prices			Real Prices		
	Model	AIC	BIC	Model	AIC	BIC
Green Bean	ARMA(1,0)GARCH(1,1)	7.401	7.456	ARMA(1,1)GARCH(1,1)	9.719	9.785
Carrot	ARMA(1,1)GARCH(1,1)	7.226	7.292	ARMA(1,1)GARCH(1,0)	9.599	9.654
Leeks	ARMA(1,1)GARCH(1,1)	6.239	6.305	ARMA(1,1)GARCH(1,1)	8.771	8.837
Beetroot	ARMA(1,1)GARCH(1,1)	6.965	7.032	ARMA(1,1)GARCH(1,0)	9.325	9.38
Knolkhol	ARMA(1,1)GARCH(1,1)	6.141	6.207	ARMA(1,1)GARCH(1,1)	8.421	8.487
Raddish	ARMA(1,1)GARCH(1,1)	5.312	5.378	ARMA(1,1)GARCH(1,1)	7.594	7.660
Cabbage	ARMA(1,1)GARCH(1,1)	6.207	6.273	ARMA(1,1)GARCH(1,0)	8.639	8.694
Tomato	ARMA(1,1)GARCH(1,1)	8.468	8.531	ARMA(1,1)GARCH(1,1)	10.965	11.032
Ladies Fingers	ARMA(1,1)GARCH(1,1)	6.029	6.095	ARMA(1,1)GARCH(1,1)	8.551	8.618
Brinjal	ARMA(1,0)GARCH(1,1)	6.532	6.587	ARMA(0,1)GARCH(1,1)	8.966	9.021
Pumpkin	ARMA(1,0)GARCH(1,1)	5.125	5.180	ARMA(1,1)GARCH(1,0)	7.522	7.577
Cucumber	ARMA(1,1)GARCH(1,1)	5.440	5.506	ARMA(1,1)GARCH(1,1)	7.899	7.965
Bitter Gourd	ARMA(1,1)GARCH(1,1)	6.049	6.115	ARMA(1,1)GARCH(1,1)	8.433	8.499
Snake Gourd	ARMA(1,1)GARCH(1,1)	5.772	5.838	ARMA(1,1)GARCH(1,1)	8.090	8.156
Luffa	ARMA(1,0)GARCH(1,1)	5.921	5.986	ARMA(1,1)GARCH(1,1)	8.393	8.459
Long Bean	ARMA(1,1)GARCH(1,1)	6.244	6.309	ARMA(1,1)GARCH(1,1)	8.625	8.691
Ash Plantain	ARMA(1,1)GARCH(1,1)	4.991	5.057	ARMA(1,1)GARCH(1,1)	7.475	7.542

Note: AIC – Akaike Information Criteria, BIC – Bayesian Information Criteria

Table 3. Results of volatility tests applied on residuals of beast fit ARMA-GARCH models for seventeen vegetables

Commodity	ARMA-GARCH Residuals (Nominal)			ARMA-GARCH Residuals(Real)		
	ARCH LM Test	Mcleod Li Test	BDS Test	ARCH LM Test	McLeod Li Test	BDS Test
Green bean	0.954	0.949	0.197	0.569	0.568	0.415
Carrot	0.229	0.112	0.017*	0.535	0.526	0.008*
Leeks	0.994	0.992	0.571	0.981	0.723	0.001*
Beetroot	0.617	0.556	0.837	0.075	0.070	0.727
Knolkhol	0.999	0.999	0.746	0.066	0.129	0.396
Raddish	0.964	0.951	0.944	0.896	0.882	0.025*
Cabbage	1.000	0.999	0.001*	0.217	0.462	0.251
Tomato	0.999	0.999	0.129	0.915	0.773	0.019*
Ladies Fingers	0.392	0.309	0.973	0.667	0.751	0.840
Brinjal	0.326	0.316	0.003*	0.066	0.051	<0.001*
Pumpkin	0.999	0.999	<0.001*	0.859	0.856	0.769
Cucumber	0.752	0.773	0.317	0.889	0.871	0.683
Bitter Gourd	0.514	0.455	0.859	0.577	0.500	0.507
Snake Gourd	0.755	0.748	0.968	0.466	0.623	0.008*
Luffa	0.058	0.013*	0.950	0.256	0.462	0.655
Long Bean	0.080	0.021*	0.204	0.650	0.588	0.415
Ash Plantain	0.711	0.584	0.072	0.905	0.828	0.413

Note: $^{*}P \leq 0.05$

This indicates the variability of vegetable prices changes over the time creating a price risk in the vegetable market apart from the significant increasing trend in nominal prices. Thus there is an implication of modeling stochastic volatility. For nominal prices, it can be seen that the mean model is an ARMA (1, 1) for all vegetables except Green bean, brinjal, pumpkin and luffa. However the volatility of nominal prices of all vegetables showed a GARCH (1, 1) process which apparently indicate that present volatility depends on that of the last month and short term random shocks develop in the market. For real prices of all vegetables, except for brinjal, the mean model was reported as a ARMA (1, 1). The volatility in real prices of carrot, beat, cabbage, pumpkin is an ARCH (1) process while rest of the vegetables hold a GARCH (1,1) process for volatility. This indicates that for some vegetables, previous month's volatility is more influential on the present volatility than market random shocks if the impact of inflation on the price is ignored Results of three volatility tests applied on the residuals of best fit models appeared in Table 2 are presented in Table 3.

It can be seen that ARCH-LM test and Mcleod Li test have failed to reject the null hypothesis of volatility clustering in the residuals of fitted models. In very few cases BDS test bring some evidence for significant ARCH effects even after fitting the most promising model. However, by considering the results of all three tests it can be seen that the goodness of fit of the models reported in Table 2 is adequate. The significant ARCH/GARCH models found on vegetable prices further suggest the price volatility is symmetric which doesn't imply news on volatility is variable between both positive and negative news on volatility.

Further to explain, variability of prices of vegetable in the market does not tend to be variable at price hicks and depressions which is more important in setting up price policy. However, this study brings clear evidence that the vegetable prices in the local market are highly volatile bringing more risk on market decisions taken by various stakeholders which should be seriously taken up. During the model fitting it was observed that models parameters of the best fit models (Table 2) were statistically significant at 5%.

The results in Table 3, it is not trivial to use the models in Table 2 for forecasting future volatility in different vegetables in support of making better market decisions by various stakeholders.

CONCLUSIONS

The nominal price of each vegetable has shown an increasing trend over the time period of 1985 to 2014, while real prices show an overall decreasing trend. Considering the two price deflators, it conclude that prices changes can be mainly a consequence of rising inflation. All vegetables show stochastic volatility nature with both their real and nominal prices. It leads to a conclusion of that the price risk associated with the vegetables are high in Sri Lankan market. The GARCH models fitted in this study are usable and adequate to forecast and decision making of price volatility nature of the vegetables.

ACKNOWLEDGEMENTS

The authors would like to extend their profound gratitude to Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI) for providing data for the study.

REFERENCES

Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroscedasticity. *Journal of Econometrics*, **31**, 307-327.

Bowbrick, P. (1976). Market margin investigations and price control of fruit and vegetables. *Irish Journal of Agricultural Economics*, **6**, 9-20.

Engle, R.F. (1982). Autoregressive Conditional Heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, **50**, 987-1008.

Li, W. and McLeod A. (1981). Distribution of the residual autocorrelations in multivariate ARMA Time Series Models. *Journal Royal Statistic Society* B, **43**, 231-239.

Mahaliyanaarachchi, R.P. (2004). Assessing information and communication needs of vegetable growers in Sri Lanka. *Sabaragamuwa University Journal*, **4**, 34-44.

Perera, K.B.P. and Herath, H.M.L.K. (2014).Forecasting fish prices in Colombo with SARIMA model. In proceedings of 13th Agricultural Research Symposium, 7 -8 August, 2014, Wayamba University of Sri Lanka. 81-85.

Ranathilaka, M.B. and Andri, K.B. (2014). Market efficiency on vegetable commodities in developing country: case study from Dambulla wholesale market in Sri Lanka. *International Journal of Agricultural Research,* **9**, 99-101.Available from: http://www.scialert.net/abstract/?doi=ijar.2014.99.109 (Accessed 12th March 2016).

Sandika, A.L., (2011). Impact of middleman on vegetable marketing channels in Sri Lanka. *Tropical Agricultural Research and Extension*, **14** (3), 58-62.

Verma, A., Kumar, S. and Singh, P.M. (2002). Marketing and export of fresh vegetables. Agricultural marketing, India, 18-21.