# A COMPARISON OF PRICE FLUCTUATIONS FOR THE GREEN CHILLI AND TOMATO IN DAMBULLA DEDICATED ECONOMIC CENTER IN SRILANKA

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## Abstract

*The cultivation of green-chili and tomato has become a prominent income among the farmers in Sri Lanka. Therefore, establishing a statistically equipped market information system and a comparative study is important to identifying the price fluctuations of green-chili and tomato as well as managing the price risk. For this study, 10 years (2004-2013) monthly wholesale prices of green-chili and tomato were obtained from Dambulla Dedicated Economic Centre. The time series analysis was used to analyze the fluctuations of prices and estimate forecasting models for wholesale prices of both selected vegetables. Based on the trend analysis, the quadratic trend models were selected as the best trend models for both green-chili and tomato. Furthermore,* $SARIMA(1,1,1)(2,1,2)_{12}$ *and* $ARIMA(2,1,2)$ *models were selected as the most suitable model to forecast the wholesale prices of green-chili and tomato respectively. Moreover, the Granger-causality test and VAR method were revealed that there is an unidirectional causality between wholesale prices of green-chili and tomato.*

**Key words:** ARIMA, Causality, Price fluctuation, SARIMA, Seasonality, Trend analysis.

## Introduction

The vegetable crops cultivation in Sri Lanka is playing a major role in agriculture industry like paddy cultivation. It requires more labors throughout the year compared to paddy cultivation which holds only a seasonal demand. Therefore, cultivation of vegetable crops would generate more employment opportunities. In Sri Lanka, chili cultivation sector contributes on an average Rs.750 million to GDP and creates employment of 14 million work days annually. The average extent under chili at present is around 14,083 ha, of which 2/3 is cultivated in maha season. North province considered as the major production area but the expansion of the crop in non-traditional areas such as Mahaweli System H, Matale, Polonnaruwa and Kurunegala has grown tremendously (Department of Agriculture, 2015).

Tomato is also one of the most essential vegetable crop in Sri Lanka, is preferred by farmers due to high economic returns, export potential and nutritional value. Tomato is cultivated in more than 7137 ha, producing nearly 73917 Mt/year with the average productivity of 10.36 Mt/ha (Department of Agriculture, 2015). Production of these two vegetables in Sri Lanka is highly seasonal and mostly weather dependent. The available extents have also been fully exploited due to adverse environmental conditions that prevail during the rainy season. It reduces the production stability and quality of vegetables with negative impacts on prospective markets (Wahundeniya et al.). As a result, unrealistic high prices of these vegetable had been observed in unfavorable season. Thus it is necessary to discuss such uncertainty of price behaviors through a statistical point of view.

The higher price fluctuation of the vegetables is a major issue in Sri Lanka which distresses the farmers tremendously and create political issues. This problem is due to lack of knowledge about the adverse fluctuations of prices and that lead to economic bankrupt on farmers, retailers and wholesalers. This information should be with agricultural policy and decision makers to instruct the farmers. In this study, the price fluctuations of two essential vegetables green chili and tomato which are holding high market demand, are focused. The main purpose of this research is to establish a properly detailed market information system for green-chili and tomato in a statistical point of view by identifying the trend of price fluctuations for green-chili and tomato. This also aims to fit appropriate time series forecasting models for identifying the seasonal and non-seasonal variations of wholesale prices for both crops. Finally to compare the two time series variables to identifying the causality effect between green-chili and tomato.

Pradeep and Wickramasinghe, (2015), conducted a research on price behavior of selected up-country vegetables and pointed the uncontrollable price fluctuations due to high number of middlemen, seasonality, increasing population, highly perishable nature, consumer preference and low level of farmers' knowledge about price behavior. In this study, wholesale and retail price data of 27 years of selected five up-country vegetables (Beet, Cabbage, Carrot, Leeks and Tomato) had been analyzed and it was found the prices were non-stationary. Therefore difference of prices were used to make the data stationary. Monthly prices of vegetables were forecasted using the ARIMA approach. According to the graphical analysis both yearly and monthly real prices of selected vegetables were comparatively high during 1994 to 1996 and it has dropped during 2008 to 2009. Higher prices of five vegetables have been reported from November to January and from May to July, while peak price of tomato was reported in February. Moreover, they have found that Annual rainfall has not much directly influenced on vegetable while its previous price values have been significantly influencing on it.

Bogahawatta, (1987), has explored the possibilities of developing forecasting equations for vegetable prices and other agriculture commodities based on the past data of year 1976 to 1984. He had determined the seasonal pricing patterns of rice, dried chilly, red onion, cowpea, green gram, vegetables, fish and egg in the retail and whole sale markets using seasonal indices. He developed some econometric methods to identify the relationship between retail prices and wholesale prices of the commodities. Furthermore, the identification of seasonal variation and modelling of price fluctuations of each commodity have been carried out by using suitable ARIMA approaches (Seasonal or non-seasonal).

Gathondu, (2012), has modelled the wholesale prices of selected vegetables in Kenya using time series models which was utilized to improve domestic market potential for small hold producers, who are the biggest suppliers in the market. He used the prices of tomato, potato, cabbages, kales and onions from the wholesale markets in Nairobi, Mombasa, Kisumu, Eldoret and Nakuru. In his analysis, the patterns and variations of prices due to trends have been explored according to different types of regression models. For the seasonal variation, has used three autoregressive models. Those were ARMA, VAR, GARCH and the mixed model of ARMA and GARCH. Based on the three model selection criterion (AIC, RMSE, MAE and MAPE), the best fit models are potato ARIMA (1,1,0), cabbages ARIMA (2,1,2), tomato ARIMA (3,0,1), onions ARIMA (1,0,0) and kales ARIMA (1,1,0) and the best GARCH model was GARCH(1,1).

## Materials and Methods

The farmers cultivating these two crops, are tending to supply their products to the wholesale markets because it is less time consuming and easy way. Dambulla Dedicated Economic Center (DDEC) is the first and the oldest vegetable wholesale center which has the highest number of operations, highest number of stalls (144 stalls) and facilities, as well as situated in the central part of Sri Lanka compare with other 12 dedicated economic centers in Sri Lanka. Therefore in this study, the prices of green-chili and tomato determined at DDEC is used. These data were obtained from Socio Economic and Planning Centre in the Department of Agriculture. For the analysis 10 years (2004 to 2013) monthly average prices of green-chili and tomato were used. Usually in DDEC, the data are being recorded at two or three times per a day and the final monthly data is an average of prevailed prices all over the month.

In the preliminary analysis, descriptive statistics and normality tests for raw data were obtained. The prices fluctuate over seasons due to the variations in production and market arrivals. Henceforth, the trend analysis, ARIMA and SARIMA approaches are also to be yield to explore the monthly price behavior and forecasts. In ARIMA modelling process, suitable data transformations (log and first difference) have to be drawn to utilize the raw data because the residual diagnostic were not satisfied for ARIMA models with original raw data. The comparison of price fluctuation between green chili-and tomato will help to reveal the causality effects. Therefore the Granger causality test and VAR models were also used. All the analysis in this study were carried out by using EViews 8.0 and MINITAB 16 statistical software packages.

Different time series models in the family of linear, exponential and quadratic were fitted and the model which hold the minimum values of accuracy measures (MAPE, MAD, MSD) is selected the best trend model. Seasonality is a component of variation in a time series which is dependent on the time of the year. The Kruskal-Wallis Statistics test mainly was used to detect the seasonality.The equation form of the ARIMA(p, d, q) model was

$$\varphi_p(B)(1-B)^d X_t = \alpha + \theta_q(B)e_t \quad (1)$$

The equation form of the SARIMA$(\mathrm{p, d, q})(\mathrm{P, D, Q})_{\mathrm{s}}$model as

$$\varphi_p(B)\Phi_{\mathrm{P}}(B^s)(1-B)^d(1-B^s)^D X_t = c + \theta_q(B)\Theta_Q(B^s)\varepsilon_t \quad (2)$$

Where; ∇= Differencing operator, $B$= Backward shift operator,d = differencing term , s = length of seasonality (for monthly data it would be 12) , $\varphi_p(B)$ =AR operator, $\Phi_{\mathrm{P}}(B^s)$ = Seasonal AR operator, $\theta_q(B)$ =MA operator and $\Theta_Q(B^s)$ = Seasonal MA operator.

AIC, SIC, maximum log-likelihood and DW statistic values have been used as model selection criterions in the analysis to detect the best model.

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another and those time series should also be stationary. The VAR model usually used when set of time series are not co-integrated each other.

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t \quad (3)$$

Where, each $y_t$ is a vector of length k and each $A_i$ is a k × k matrix.

# Results and Discussion

**Descriptive statistics**

The descriptive results for the price values (Rupees per kg) of green-chili and tomato are given in the following table. This statistics are not much meaningful under the heavy inflation in Sri Lanka in the past.

**Table 1: Descriptive statistics for green-chili & tomato**

| Vegetable | Mean | Maximum | Minimum | Standard Deviation | 95% C.I for Mean |
|---|---|---|---|---|---|
| Green-chili | 86.69 | 327.30 | 19.90 | 58.78 | ( 76.06 , 97.31 ) |
| Tomato | 41.00 | 139.20 | 10.80 | 22.54 | ( 36.93, 45.08 ) |

**Stationary test for the original data**

Time series plots and unit root test were used to check the stationary of the prices of the vegetables. From Figure 1 and Figure 2 it was observed that variation of original series are not stable and have a small upward trend. According to the unit root test given in Table 2, the p-values are less than in each significance levels of $\alpha = 0.01, 0.05$ and 0.1 then null hypothesis could be rejected and concluded that our original data series for the wholesale prices of both vegetables (green chili and tomato) are stationary.

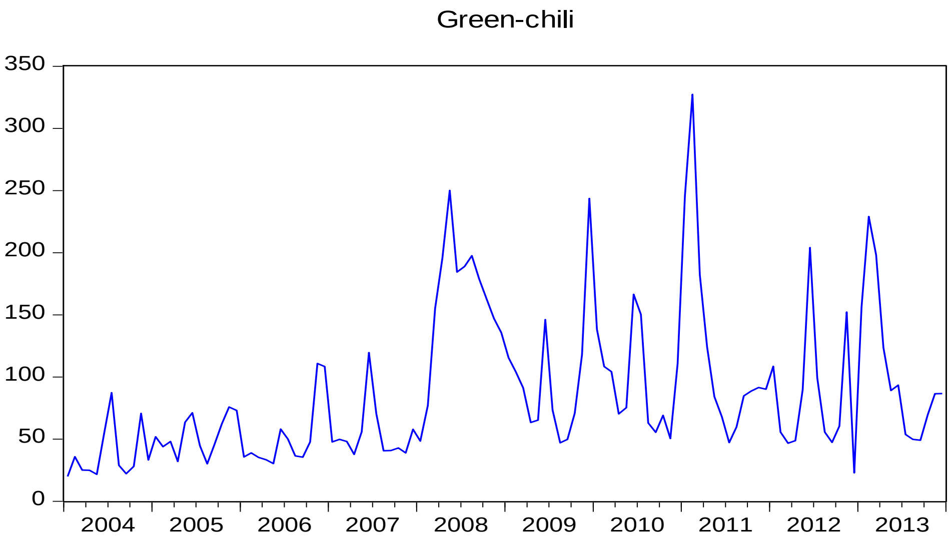



**Figure 1: Time series plot for original data series of green chili**

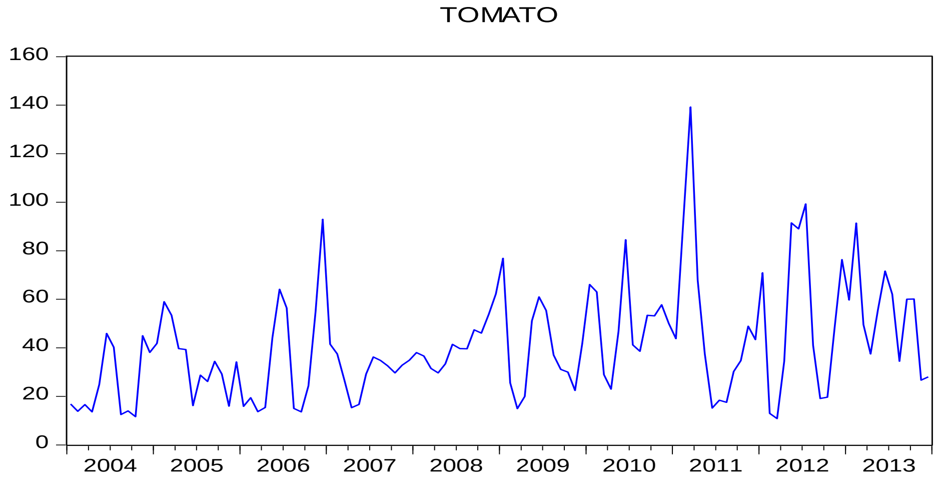



**Figure 2: Time series plot for original data series of tomato**

**Table 2: Unit root test results for wholesale prices of green chili.**

| | P - Value | t – Statistics | | | |
|---|---|---|---|---|---|
| | | Augmented Dickey-Fuller statistic | Test critical Value | | |
| | | | 1% level | 5% level | 10% level |
| Green-chili | 0.0001 | -4.7392 | -3.4860 | -2.8858 | -2.5798 |
| Tomato | 0.0000 | -7.2347 | -3.4865 | -2.8860 | -2.5799 |

**Trend analysis**

The regression form of trends for the prices of green-chili and tomato were obtained and it would explain how the prices of two items fluctuate within the 10 years of period. Accuracy measures were used to select the best trend model. According to the

Table 3 and 4, the results indicate that quadratic model is the best trend model for both green-chili and tomato which holds the lowest MAPE, MAD and MSD values compared with other two models. From the above trend analysis we could get a bulky idea about how the prices of green-chili and tomato fluctuate over the time. But it will not adequate at all to explain the fluctuation of prices. Still there are so many techniques to detect the variations of time series process.

**Table 3: Results of trend analysis for green-chili**

| Model | Equation | Accuracy measures | | |
|---|---|---|---|---|
| | | MAPE | MAD | MSD |
| Linear trend | Yt = 49.6 + 0.613*t | 58.44 | 41.25 | 2974.58 |
| Growth curve | Yt = 43.04 * (1.00835**t) | 47.02 | 38.98 | 3235.17 |
| Quadratic trend | Yt = 9.2 + 2.597*t - 0.0164*t**2 | 53.33 | 38.79 | 2664.96 |

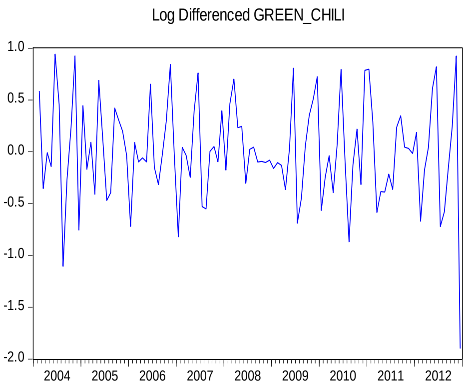
**Table 4: Results of trend analysis for tomato**

| Model | Equation | Accuracy measures | | |
|---|---|---|---|---|
| | | MAPE | MAD | MSD |
| Linear trend | Yt = 26.17 + 0.245*t | 52.71 | 15.69 | 431.98 |
| Growth curve | Yt = 24.454 * (1.00613**t) | 46.66 | 15.69 | 458.43 |
| Quadratic trend | Yt = 23.4+ 0.382*t - 0.00113*t**2 | 52.45 | 15.74 | 430.51 |

**Transformations of the original data**

When a rough sketch of ARIMA forecasting model was fitted, for original data, most of its model diagnostics not satisfied the necessary requirements. Considering this, it was decided to transform the original data by using a suitable log transformation method and first order lag difference transformation, even if the original data were stationary.

The main purpose of this transformation is to utilize the data since it was intended to fit the ARIMA models for both items so that the model diagnostics are satisfied. 108 (nine years) observations were used out of 120 (ten years) observations from both items on account of forecasting and validating the models that obtain. The first lag-order difference transformed data for green-chili and tomato were stationary and therefore those transformed series were used to fit the ARIMA and SARIMA forecasting models.



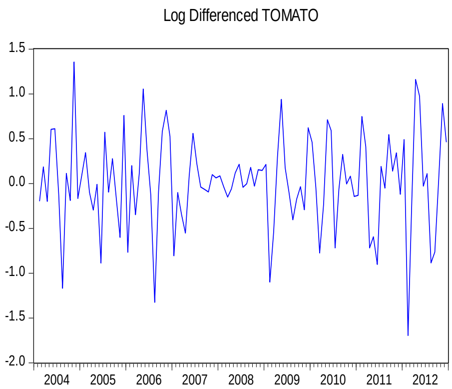




**Figure 3: Time series plots for logand first lag differencetransformations of green-chili and tomato**

**Seasonal variation of the prices of green-chili and tomato**

From the seasonal graph in Figures 4 and 5, green-chili production shows a significant seasonality than the tomato. The seasonal variations of above graphs was further confirmed through Kruskal-Wallis statistics.

Identifiable seasonality was present for wholesale prices of green-chili (KW statistic 31.89, p level 0080%). Then SARIMA model can be appropriate and it had to be separated into two factors as seasonal adjusted factor and seasonal factor. Identifiable seasonality was no present for wholesale prices of tomato (KW statistic 21.16, p level 3.171%). Then ARIMA model can be adequate to fitted for forecasting purposes.

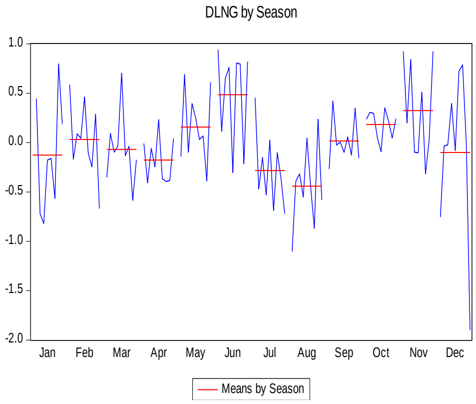



**Figure 4: Seasonal graph for green-chili**

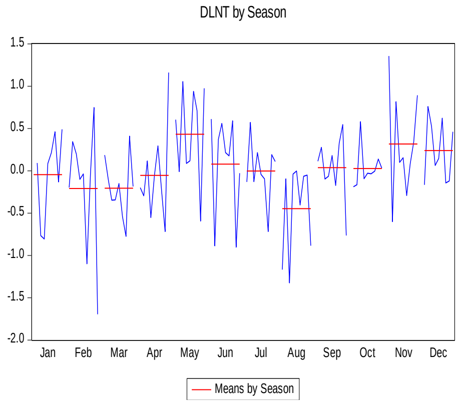



**Figure 5: Seasonal graph for tomato**

**Fitting the SARIMA model for wholesale prices of green-chili**

After separating the seasonal adjusted factor and seasonal factor for wholesale prices of green chili, the stationarity were tested individually and it certified that two isolated time series processes are stationary.

Then both factors can be recommended to SARIMA approach. Here, two ARIMA models have to be fitted for each two factor. Eventually the best fitted ARIMA models for two factors will be combined to yield our SARIMA model. Seasonal length would be 12. Correlograms are individually drawn for each factor to identify the suitable AR and MA compositions of forecasting models.

**ARIMA structure for seasonal adjusted factor**

The correlograms obtained for seasonal adjusted factor of the green-chili is given in Figure 6. Using the hints provided by correlogram, all the appropriate ARIMA models could be expanded as given in Table 5. According to the results of Table 5, all the AR and MA components of ARIMA models were tested at 5% significance level, then it was observed that only ARIMA(1,1,1) was significant out of four models. And also in the above models, some of the constants and AR components were not significant to their model while rest of the constants and components were significant.

Using an appropriate model selection criteria it was concluded that ARIMA(1,1,1) is the best model (seasonal adjusted ) which hold the minimum values of AIC ,SBC; maximum of Log likelihood value and Durbin-Watson statistics ≈ 2. The estimated parameters for this model is given in Table 6. The constant term is not significant to the model. But all the AR and MA terms are significant to their model.

**Table 5: Expanded results of ARIMA model for seasonal adjusted factor.**

| Model | P-value | AIC | SBC | Log likelihood | DW |
|---|---|---|---|---|---|
| ARIMA(0,1,0) | - | 1.1776 | 1.2025 | -62.0025 | 1.9841 |
| ARIMA(0,1,1) | 0.0718 | 1.1652 | 1.2152 | -60.3433 | 1.6941 |
| ARIMA(1,1,0) | 0.1568 | 1.1769 | 1.2272 | -60.3799 | 1.8028 |
| ARIMA(1,1,1) | 0.0008 | 1.0773 | 1.1527 | -54.1005 | 1.7115 |

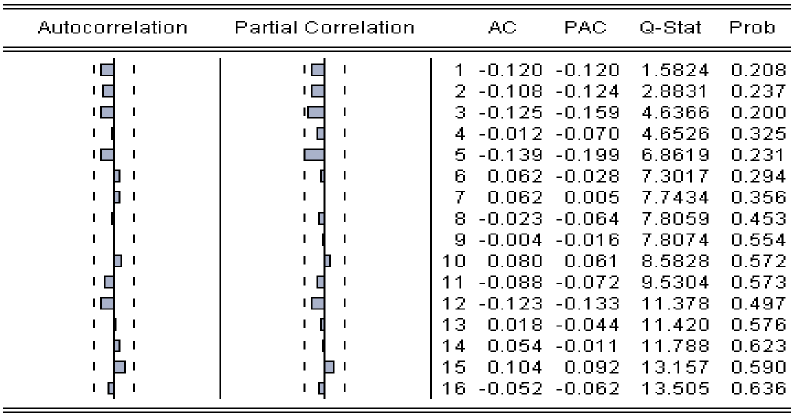



**Figure 6: Correlogram of seasonal adjusted factor for green-chli**

**Table 6: Estimated Parameters for the seasonal adjusted factor ARIMA (1, 1, 1) model**

| | Constant | AR(1) | MA(1) |
|---|---|---|---|
| Coefficient | 0.0064 | 0.6307 | - 0.9592 |
| Sig. P- value | 0.3783 | 0.0000 | 0.0000 |

**ARIMA structure for seasonal factor**

The correlograms obtained forseasonal factor of the green-chili is given in Figure 7. According to the hints provided by correlograms, the appropriate combinations of ARIMA models were arranged as given in Table 7. All the SAR and SMA components of seasonal factor ARIMA models were tested at 5% significance level, According to the results of Table 7, it could be observed that some of the constants and SAR, SMA components were not significant to their model while rest of the constants and components were significant. However all the seasonal factor ARIMA models were significant except ARIMA(1,1,0). Using the model selection criteria it was concluded that seasonal factor ARIMA(2,1,2) is the best model which hold the minimum values of AIC, SBC; maximum of Log likelihood value and Durbin-Watson statistics ≈ 2. The estimated parameters for this model given in Table 8.Constant term is not significant in this model but all the SAR and SMA terms are significant.

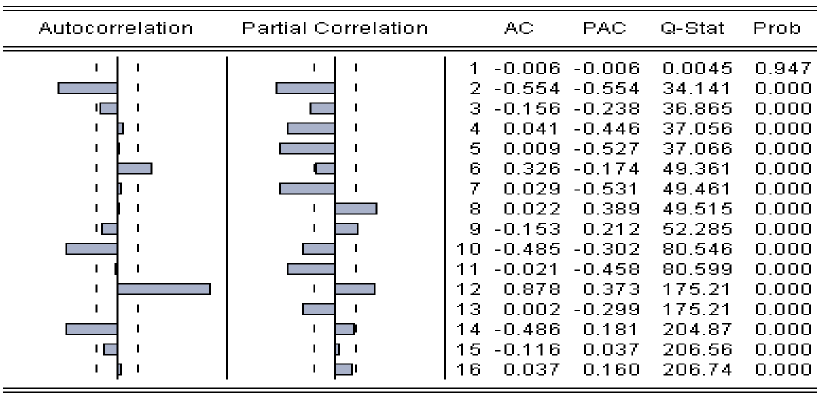



**Figure 7: Correlograms of seasonal factor for green-chili**

**Table 7: Expanded results of ARIMA model for seasonal factor**

| Model | Sig: P-values | AIC | SBC | Log likelihood | DW |
|---|---|---|---|---|---|
| ARIMA(0,1,0) | - | 0.6139 | 0.6389 | -31.8467 | 2.0020 |
| ARIMA(0,1,1) | 0.0000 | 0.1974 | 0.2474 | -8.5653 | 1.5696 |
| ARIMA(0,1,2) | 0.0000 | -0.0051 | 0.0697 | 3.2751 | 2.1270 |
| ARIMA(0,1,3) | 0.0000 | -0.4336 | -0.3337 | 27.2021 | 1.7628 |
| ARIMA(1,1,0) | 0.9475 | 0.6403 | 0.6906 | -31.9402 | 1.9962 |
| ARIMA(1,1,1) | 0.0000 | 0.1833 | 0.2587 | -6.7165 | 1.7146 |
| ARIMA(1,1,2) | 0.0000 | 0.0137 | 0.1142 | 3.2711 | 2.0552 |
| ARIMA(1,1,3) | 0.0000 | -0.4042 | -0.2786 | 26.4267 | 1.9482 |
| ARIMA(2,1,0) | 0.0000 | 0.2965 | 0.3723 | -12.5687 | 2.2445 |
| ARIMA(2,1,1) | 0.0000 | -0.3137 | -0.2126 | 20.4724 | 2.2818 |
| ARIMA(2,1,2) | 0.0000 | -0.8676 | -0.7413 | 50.5542 | 2.1951 |
| ARIMA(2,1,3) | 0.0000 | -0.1804 | -0.0287 | 15.4722 | 2.0578 |
| ARIMA(3,1,0) | 0.0000 | 0.2640 | 0.3657 | -9.7325 | 2.1995 |
| ARIMA(3,1,1) | 0.0000 | -0.3576 | -0.2305 | 23.5998 | 2.2593 |
| ARIMA(3,1,2) | 0.0000 | -0.4309 | -0.2783 | 28.4068 | 2.2302 |
| ARIMA(3,1,3) | 0.0000 | -0.4627 | -0.2847 | 31.0630 | 2.2250 |

**Table 8: Estimated parameters for the seasonal factor ARIMA(2,1,2) model of green-chili**

| | Constant | SAR(12) | SAR(24) | SMA(12) | SMA(24) |
|---|---|---|---|---|---|
| Coefficient | -9.24E | 0.6755 | -0.7580 | -1.9272 | 0.9291 |
| Sig P-value | 0.8513 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

**Fitting the ARIMA model for wholesale prices of tomato**

As the transformed data for wholesale price of tomato hadn't contained any seasonal variation, the ARIMA model can be fitted directly. The correlograms for this data is given in Figure 8. According to the hints provided by correlograms, the appropriate ARIMA models were arranged as given in Table 9. All the AR and MA components of above ARIMA Models were tested at 5% significance level andmost of ARIMA models are significant except ARIMA(0,1,1), ARIMA(1,1,1) and ARIMA(1,0,0). According to the model selection criteria ARIMA(3,1,1) was the best model which hold the minimum values of AIC ,SBC; maximum of Log likelihood value and Durbing-Watson statistics ≈ 2.

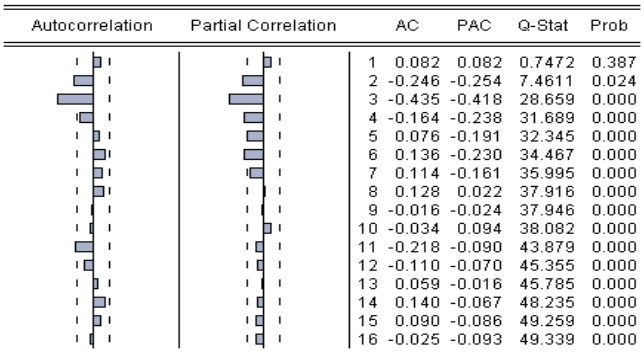



**Figure 8: Correlograms for tomato**

But it was observed that the above fitted model is not satisfied most of diagnostics tests. But it was observed that the above fitted model is not satisfied most of diagnostics tests. Therefore it was compelled to select the next appropriate model, ARIMA(2,1,2) as the best model for seasonal factor by using the same model selection criteria.The estimated parameters for this model is given in Table 10. All the parameter estimates are significant to their model except MA(2) term.

**Table 9: Expanded results of ARIMA models for tomato**

| Model | Sig: P-value | AIC | SBC | Log likelihood | DW |
|---|---|---|---|---|---|
| ARIMA(0,1,0) | - | 1.5713 | 1.5963 | -83.0668 | 1.8269 |
| ARIMA(0,1,1) | 0.2747 | 1.5786 | 1.6285 | -82.4562 | 2.0324 |
| ARIMA(0,1,2) | 0.0000 | 1.2756 | 1.3505 | -65.2473 | 1.7650 |
| ARIMA(0,1,3) | 0.0000 | 1.1985 | 1.2984 | -60.1220 | 2.0362 |
| ARIMA(1,1,0) | 0.3988 | 1.5913 | 1.6416 | -82.3432 | 1.9493 |
| ARIMA(1,1,1) | 0.4253 | 1.6005 | 1.6759 | -81.8280 | 2.0318 |
| ARIMA(1,1,2) | 0.0000 | 1.2631 | 1.3636 | -62.9456 | 1.9218 |
| ARIMA(1,1,3) | 0.0000 | 1.2186 | 1.3442 | -59.5870 | 2.0132 |
| ARIMA(2,1,0) | 0.0208 | 1.5502 | 1.6261 | -78.3899 | 2.2098 |
| ARIMA(2,1,1) | 0.0000 | 1.1446 | 1.2457 | -56.0961 | 2.2675 |
| ARIMA(2,1,2) | 0.0000 | 1.1410 | 1.2674 | -54.9046 | 2.1606 |
| ARIMA(2,1,3) | 0.0000 | 1.1483 | 1.3000 | -54.2903 | 2.0862 |
| ARIMA(3,1,0) | 0.0000 | 1.3724 | 1.4741 | -67.3671 | 2.1900 |
| ARIMA(3,1,1) | 0.0000 | 1.0954 | 1.2225 | -51.9639 | 2.0274 |
| ARIMA(3,1,2) | 0.0000 | 1.1117 | 1.2643 | -51.8135 | 1.9734 |
| ARIMA(3,1,3) | 0.0000 | 1.1368 | 1.3148 | -52.1172 | 2.0427 |

**Table 10: Estimated parameters for ARIMA(2,1,2) model of tomato**

| | Constant | AR(1) | AR(2) | MA (1) | MA(2) |
|---|---|---|---|---|---|
| Coefficient | 0.0060 | 0.8177 | -0.5086 | -1.1091 | 0.1091 |
| Sig: P-value | 0.0005 | 0.0000 | 0.0000 | 0.0000 | 0.5692 |

## Model diagnostics checking

Diagnostic checks were carried out for the obtained SARIMA and ARIMA Models form randomness, normality, serial correlation and heteroscedasticity and given in Table 11. Most of Diagnostic tests were satisfied for green-chili and tomato.

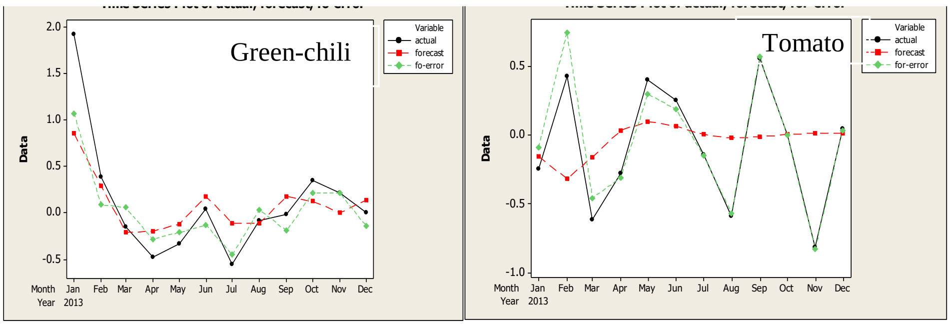
**Table 11: Results of Model Diagnostic checking for obtained SARIMA and ARIMA Models**

| Test | Green-chili | Tomato |
|---|---|---|
| Randomness | Exist | Exist |
| Normality | Slightly Normal | Normal |
| Serial Correlation | Does Not Exist | Does Not Exist |
| Heteroskedasticity | Exist | Does Not Exist |

## Forecasting and validating the models

The price values of both vegetables for all the above analysis have been taken from 2004 January to 2012 December, but the actual price values of green-chili and tomato from 2013 January to 2013 December (12 observations) have already been reserved for validating purposes and those actual values (transformed) were plotted with fitted forecast values for the same period. The obtained plots are given in following Figure 9.According to the two plots, it can be concluded that the prediction accuracy of the models has been secured.

**Figure 9: Time series plot for actual and prediction values of green-chili and tomato**




**Comparison of the price behavior between green-chili and tomato.**

So far it was explained the price fluctuation for both item in an individual point of view and in this section the behavior of prices for both were tested conjointly to identify the causality effect. Ten years raw data (January 2004 –December 2013) were used for Granger Causality and VAR approaches. The results obtained from Granger Causality test, given in Table 12. As it is known the data are stationary at level, it is useless for checking the co-integration test because co-integration can only be used for non-stationary series. Lag number 2 was from lag selection criteria.

**Table 12: Results of Pairwise Granger Causality Tests**

| Null Hypothesis: | Obs | F-Statistic | Prob. |
|---|---|---|---|
| Tomato does not Granger Cause Green-chili | 118 | 0.62650 | 0.5363 |
| Green-chili does not Granger Cause Tomato | | 9.31749 | 0.0002 |

According to the results of Table 12, the first null hypothesis could not be rejected since the p value is greater than critical values at 5 % significance level. Therefore the price fluctuation of tomato does not cause to the price fluctuation of green chili. In the second null hypothesis p values is less than critical value at 5% significance level, thenit can be rejected and concluded that the price fluctuation of green-chili may causes to the price fluctuation of tomato. The explorations of causality can be further explained by using VAR method.

VAR model usually describes the evolution of set variables (called endogenous variables) including their past values over the same sample period as a linear function. VAR was used for only to get an idea about causality of prices of green-chili (G) and tomato (T). The expanded VAR model for green-chili and tomato are given in equation (4) and (5) respectively. Moreover, the significance of each individual coefficients were also tested for both VAR models of green-chili and tomato,and the results are given in below Table 13 and Table 14.

$$G(green - chili) = 0.780(G-1) - 0.123(G-2) + 0.845(T-1) - 0.243(T-2) + 36.84 \quad (4)$$

$$T(tomato) = 0.16\mathrm{G}(-1) – 0.0682\mathrm{G}(-2) + 0.5675\mathrm{T}(-1) – 0.2815\mathrm{T}(-2) + 21.554 \quad (5)$$

**Table 13: Individual coefficient test for the VAR model of green-chili**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. | Significance |
|---|---|---|---|---|---|
| G(-1) | 0.780253 | 0.095537 | 8.167020 | 0.0000 | Significant |
| G(-2) | -0.123426 | 0.100247 | -1.231214 | 0.2208 | Not Significant |
| T(-1) | 0.084511 | 0.225020 | 0.375572 | 0.7079 | Not Significant |
| T(-2) | -0.243147 | 0.217956 | -1.115577 | 0.2670 | Not Significant |
| C | 36.84047 | 9.476609 | 3.887516 | 0.0002 | Significant |

**Table 14: Individual coefficient test for the VAR model of tomato**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. | Significance |
|---|---|---|---|---|---|
| G(-1) | 0.160076 | 0.038206 | 4.189769 | 0.0001 | Significant |
| G(-2) | -0.068288 | 0.040090 | -1.703357 | 0.0913 | Not Significant |
| T(-1) | 0.567529 | 0.089988 | 6.306706 | 0.0000 | Significant |
| T(-2) | -0.281522 | 0.087163 | -3.229829 | 0.0016 | Significant |
| C | 21.55441 | 3.789810 | 5.687463 | 0.0000 | Significant |

## Conclusion and Recommendations

The obtained trend models clearly explained the fluctuation of prices over the 10 years of period (2004-2013). The following quadratic trend models which showed the minimum accuracy measures for both green-chilli and tomato were obtained.

Quadratic trend model for green-chili - Yt = 9.2 + 2.597*t - 0.0164*t**2
Quadratic trend model for tomato - Yt = 23.4+ 0.382*t - 0.00113*t**2

In the exploration of seasonal variation, green-chili showed that seasonality was influencing to the fluctuation of its prices while it was not significantly effecting to the fluctuation of prices of tomato. Therefore, $\mathrm{SARIMA}(1,1,1)(2,1,2)_{12}$ and $\mathrm{ARIMA}(2,1,2)$ forecasting models were fitted as the best models for green-chili and tomato respectively, which showed the minimum values of AIC, SBC, maximum of Log likelihood value and DW values more close to the value 2 ($DW \approx 2$).

The granger causality test and VAR models could be deployed to compare the interaction causalities between green-chili and tomato and it was revealed that the price fluctuation of tomato does not cause to the price fluctuation of green-chili but the price fluctuation of green-chili may causes to the price fluctuation of tomato. It was an uni-directional causality.

The above findings can be used as a market information system for green-chili and tomato. On the basis of obtained models and other relative findings, it can predict the future fluctuation of prices for both two crops and then necessary decisions can also be made to manage the risk of uncertainty. The effect of inflation might have influenced on the past values of wholesale prices that were taken into the analysis. Then it is advisable to convert the past values of prices in to current real prices using suitable price index to reduce the effect of inflation.

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