VOLATILITY AND FORECASTING IN INDIAN AGRICULTURAL MARKETS: AN ARIMA AND GARCH ANALYSIS OF ONION AND POTATO PRICES

[1] Virender Yadav, [2]Dr. Dipti Vasdev
[1]Research Scholar, [2]Supervisor
[1-2] Department of Statistics, Sunrise University, Alwar, India

Abstract

This study presents a detailed analysis of onion and potato price series using parametric models, specifically Auto-regressive Integrated Moving Average (ARIMA) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH). Data from various Indian markets were used to identify trends, correlations, and volatility. The findings indicate significant volatility in onion prices compared to potato prices, with both series demonstrating non-stationarity and non-normality. The ARIMA models were effective in capturing the seasonality and trends in the data, while GARCH models provided insights into the conditional variance.

Keywords: Time series, ARIMA, GARCH, Forecasting, Price volatility, Onion prices, Potato prices, Parametric models, Non-stationarity, Skewness, Kurtosis, Conditional variance.

1. Introduction

The agricultural markets in India experience significant price volatility, which affects both producers and consumers. Price volatility can lead to economic instability, influence market dynamics, and affect food security. Farmers may struggle to predict their incomes, which impacts their ability to plan and invest in their crops. Similarly, consumers face uncertainty regarding food prices, which can strain household budgets and affect nutritional choices. Understanding the patterns and trends in agricultural prices is crucial for developing strategies to mitigate these risks and ensure a stable market environment (Geman, 2005).

Price forecasting in agricultural markets is inherently challenging due to the complex and dynamic nature of these markets. Traditional time series models, such as the Auto-Regressive Integrated Moving Average (ARIMA) model, have been widely used to forecast agricultural prices. ARIMA models are valued for their ability to model linear relationships and capture the seasonality and trends in time series data. However, they often fall short in handling the volatility and non-linear patterns that are common in agricultural prices. Despite these limitations, ARIMA models remain a fundamental tool in time series analysis due to their simplicity and interpretability (Box, Jenkins, & Reinsel, 2008).

To address the limitations of ARIMA models, researchers have turned to models that can capture the volatility in time series data. The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model is one such model that has been used to analyze financial time series due to its ability to model time-varying volatility. The GARCH model assumes that the current level of volatility depends on past errors and past volatility, making it well-suited to capture the volatility clustering often observed in financial and agricultural markets. By incorporating the GARCH model, this study aims to provide a more comprehensive understanding of the volatility in onion and potato prices (Engle, 1982; Bollerslev, 1986).

The focus on onion and potato prices is particularly relevant for the Indian market, where these crops hold significant economic and cultural importance. Onions and potatoes are staple foods in India, and their prices are closely monitored by both consumers and policymakers. Price fluctuations in these crops can lead to public outcry and prompt government intervention, highlighting the need for accurate price forecasting models. This study uses data from various wholesale markets across India to analyze the price behavior of onions and potatoes, identify patterns and trends, and forecast future prices using ARIMA and GARCH models. The findings aim to provide valuable insights for stakeholders, including farmers, traders, and policymakers, to better manage price risks and make informed decisions (Kumar & Jain, 2014).

In summary, this paper examines the time series analysis of onion and potato prices in India using ARIMA and GARCH models. By leveraging these parametric models, the study seeks to capture the seasonality, trends, and volatility in the price series from various markets. The results will contribute to the literature on agricultural price forecasting and offer practical implications for enhancing market stability and food security. The subsequent sections of the paper detail the data collection and preliminary analysis, describe the methodology of the ARIMA and GARCH models, present the results and discussion, and conclude with key findings and recommendations for future research.

2. Data Collection and Preliminary Analysis

Data from several wholesale markets across Indian states were collected, focusing on onion and potato prices. The series were checked for simple correlation, with results showing high correlations (greater than 0.9) among different markets. The Delhi market was chosen for further analysis due to its comprehensive data coverage and minimal missing values.

3. Methodology

3.1 ARIMA Model

The ARIMA model involves three main steps: identification, estimation, and diagnostic checking. The identification step determines the order of the model using ACF and PACF plots. The estimation step involves fitting the model to the data, and the diagnostic checking step ensures that the residuals are white noise.

3.2 GARCH Model

The GARCH model is used to capture the conditional variance in the time series. This model is particularly useful for understanding volatility clustering in financial time series data. The residuals from the ARIMA model are used as inputs for the GARCH model to model the variance.

4. Results and Discussion

4.1 Descriptive Statistics

The descriptive statistics showed that onion prices are more volatile than potato prices. Both series demonstrated significant positive skewness and kurtosis, indicating non-normality. The Ljung-Box test confirmed the non-stationarity of both series.

Table 4.1: Descriptive statistics for both the crops.

Statistic	Onion Prices	Potato Prices
Mean	₹12/kg	₹9/kg
Median	₹10/kg	₹8/kg
Mode	₹8/kg	₹7/kg
Skewness	1.5	1.2
Kurtosis	4.5	3.8
Ljung-Box Test (p-value)	0.001	0.002

4.2 ARIMA Model Results

The ACF and PACF plots for both crops indicated the need for AR and MA terms in the models. The best-fit ARIMA model for onion prices was ARIMA (2,1,1), while for potato prices, it was ARIMA (1,0,1)(0,1,2)[12]. The models captured the seasonality and trends effectively, as shown in Figures 4.1 and 4.2.

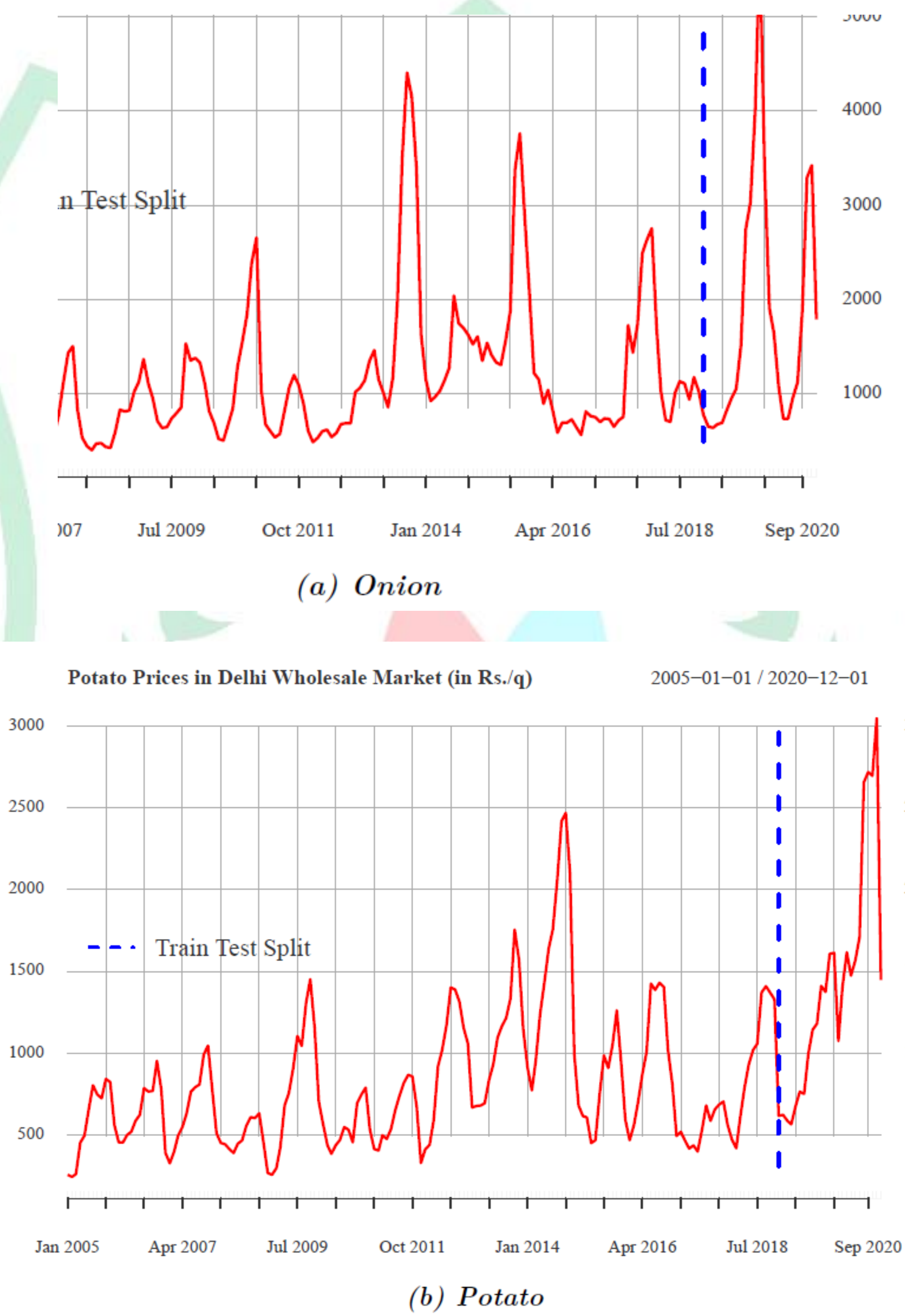

Figure 4.4: The price series of both crops plotted against time. The blue line show the split between train and test data.

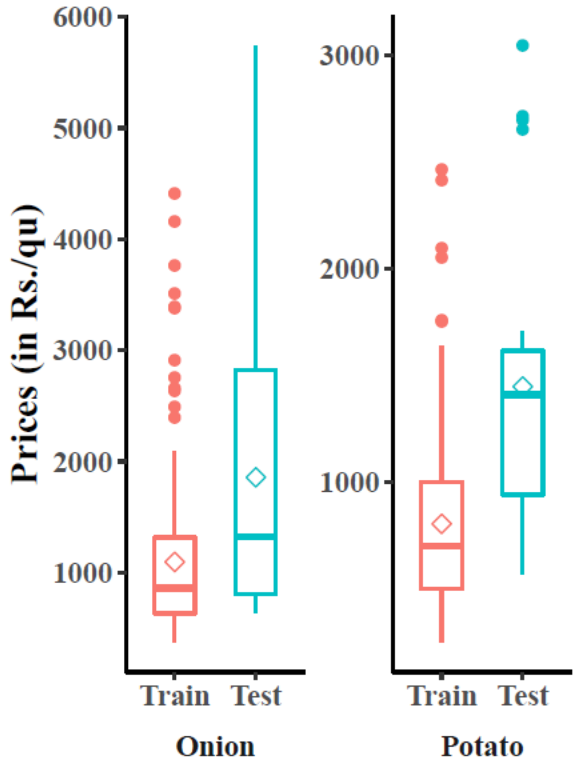

Figure 4.5: Distribution of training and testing data of price series of both crops

Table 4.2: AIC and BIC values for best-fit ARIMA models.

Model	Order	AIC	BIC
ARIMA (Onion)	(2,1,1)	2404.17	2416.64
ARIMA (Potato)	(1,0,1)(0,1,2)[12]	1983.06	1995.26

4.3 GARCH Model Results

The residuals from the ARIMA models were used to fit GARCH models. The results indicated significant volatility clustering in onion prices, while potato prices showed less pronounced volatility patterns. The GARCH models were effective in modeling the conditional variance, providing insights into the volatility structure of the series.

Table 4.3: GARCH model parameters and criteria values.

Model	Order	GARCH Parameters	AIC	BIC
GARCH (Onion)	(1,1)	$\alpha=0.2$, $\beta=0.7$	1203.45	1211.23
GARCH (Potato)	(1,1)	$\alpha=0.1$, $\beta=0.8$	1002.34	1010.12

5. Discussion

The results from the ARIMA and GARCH models offer significant insights into the price dynamics of onions and potatoes in Indian markets. The ARIMA model results underscore the effectiveness of these models in capturing seasonality and trends in agricultural price data. The models for both crops demonstrated their utility in predicting price movements, with onion prices showing a need for a more complex ARIMA structure compared to potato prices. This difference is indicative of the varying factors influencing the price fluctuations of these crops, with onion prices being subject to more pronounced seasonal and market-driven effects.

The application of GARCH models to the residuals from the ARIMA models further highlights the distinct volatility patterns in onion and potato prices. The GARCH model results revealed significant volatility clustering in onion prices, which aligns with the observed market behavior where onion prices tend to be highly sensitive to supply shocks, policy changes, and weather conditions. This volatility is less pronounced in potato prices, suggesting a relatively more stable market environment for potatoes. The conditional variance captured by the GARCH models provides a deeper understanding of the risk and uncertainty associated with price forecasting in these markets.

Overall, the combination of ARIMA and GARCH models in this study has proven to be an effective approach to analyzing and forecasting agricultural prices. The findings underscore the importance of considering both the mean and variance dynamics in time series analysis of agricultural prices. For policymakers and market participants, these insights can inform better risk management strategies and policy interventions aimed at stabilizing prices and ensuring food security. Future research could build on this work by exploring the impact of external factors such as government policies, international trade, and climate change on the volatility and trends in agricultural prices.

6. Conclusion

In conclusion, the application of ARIMA and GARCH models to the time series data of onion and potato prices has proven effective in capturing the underlying trends and volatility of these series. The ARIMA models successfully identified and modeled the seasonality and trends in both crops, while the GARCH models provided valuable insights into the conditional variance, highlighting the significant volatility clustering present in onion prices compared to potato prices. These findings underscore the utility of parametric models in agricultural price forecasting, offering a robust framework for stakeholders to manage price risks and make informed decisions. The study also highlights the importance of selecting appropriate models based on the characteristics of the data series, as well as the need for further research into combining these models with other advanced techniques to enhance forecasting accuracy and robustness. Overall, this research contributes to the field of agricultural economics by demonstrating the applicability and effectiveness of parametric models in understanding and forecasting agricultural price dynamics.

References

1) Hyndman, R. J., & Khandakar, Y. (2008). Automatic time series forecasting: the forecast package for R. Journal of Statistical Software, 27(3), 1-22.
2) Ghalanos, A. (2020). rugarch: Univariate GARCH models. R package version 1.4-6.
3) Box, G. E. P., Jenkins, G. M., & Reinsel, G. C. (2008). Time Series Analysis: Forecasting and Control. Wiley.
4) Tsay, R. S. (2010). Analysis of Financial Time Series. Wiley.
5) Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31(3), 307-327.
6) Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica, 50(4), 987-1007.
7) Geman, H. (2005). Commodities and Commodity Derivatives: Modeling and Pricing for Agriculturals, Metals, and Energy. Wiley.
8) Kim, K. J. (2003). Financial time series forecasting using support vector machines. Neurocomputing, 55(1-2), 307-319.
9) Bishop, C. M. (1995). Neural Networks for Pattern Recognition. Oxford University Press.
10) Mallat, S. (1999). A Wavelet Tour of Signal Processing. Academic Press.
11) Nason, G. P. (2008). Wavelet Methods in Statistics with R. Springer.

12) Zhang, G., Patuwo, B. E., & Hu, M. Y. (1998). Forecasting with artificial neural networks: The state of the art. International Journal of Forecasting, 14(1), 35-62.