Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7749

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2019) *7*(5), 531-541

Indian Journal of Pure & Applied Biosciences

Research Article

Modeling and Forecasting of Mulberry Cocoon Prices in Ramanagaram and Siddlaghatta Markets of Karnataka

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Received: 17.09.2019 | Revised: 23.10.2019 | Accepted: 28.10.2019

ABSTRACT

Accurate forecasting of prices of mulberry cocoons (CB)is essentialfor planning and policy purposes. A study had been taken up to forecast the prices of mulberry cocoons (CB) in Government Cocoon Market (GCM), Ramanagaram and Siddlaghatta of Karnataka by employing Auto Regressive Integrated Moving Average (ARIMA) method. A suitable model was identified based on the autocorrelation function and partial autocorrelation function and the adequacy of the model was judged based on the values of Ljung-Box Q statistics and Normalized BIC. The forecasted values of price showed decreased trend in both the markets across the periods. The forecasting performance of the model was assessed for both the markets using coefficient of determination, Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE) and Bayesian Information Criteria (BIC) and found thatthe fitted ARIMA model was found to be better model in forecasting the prices of mulberry cocoons in both themarkets.

Keywords: *Mulberry Cocoons, ARIMA, RMSE, Forecasting of Prices, Ljung-Box Q statistics.*

INTRODUCTION

Silk is the most elegant and the most loved fibre among textiles in the world. It is literally just a continuous protein filament secreted by specific types of caterpillars commonly known as silkworms. The endearing qualities of silk are natural sheen, inherent affinity for rich colors, high absorbance and light weight with high durability. Hence, it is acclaimed as the "Queen of Textiles" and also an Aristocrat product.

Sericulture being a small enterprise provides ample opportunity to reach target groups especially small and marginal farmers. It has the advantage of addressing simultaneously and rapidly towards several development priorities such as employment and income generation in rural and semi-urban areas. India is the second largest producer of raw silk in the world with the annual production of 35,468 MT during 2018-19 and has the unique distinction of producing all the four types of silk *viz.*, mulberry, tasar, muga and eri. Among them, mulberry silk is predominant and accounts for 71.46 % of thetotal natural silk produced in India.

Cite this article: Halagundegowda, G.R., Kantharaju, B.M., & Kumaresan, P. (2019). Modeling and Forecasting of Mulberry Cocoon Prices in Ramanagaram and Siddlaghatta Markets of Karnataka, *Ind. J. Pure App. Biosci. 7*(5), 531-541. doi: http://dx.doi.org/10.18782/2320-7051.7749

In 25,344 MT of mulberry silk produced during 2018-19, the cross breed (multivoltine) silk production amounted to 18,357 MT and the rest was bivoltinesilk. Karnataka is the largest silk producer in the country with the annual production of 9,525 MT of cross breed silk and 2,067 MT of bivoltine silk totaling to 11,592 MT of mulberry silk in 2018-19,

Cocoon is the raw material for the production of raw silk. Cocoon is produced by the farmers by rearing silkworm, which is reared inside a house by feeding mulberry leaves cultivated in the fields. Our problem in the world silk economy is the prevailing price instability in the cocoon and raw silk markets. Cocoon being an agricultural commodity, its prices is influenced by many exogenous factors such as agro-climatic conditions, demand for silk in the domestic and international markets, prices of international silk, Government policies on import of silk and other related factors.

As the prices of cocoon keep on changing from time to time, it creates risks to producers, reelers, twisters, processors, weavers and other parties involved different activities across the value chain. Thus, it is important to develop a reliable model to forecast the cocoon prices more accurately. In this context, this paper applies Autoregressive Integrated Moving Average (ARIMA) forecasting model, the most popular and widely used forecasting models for uni-variate time series data. The time series approachto forecasting is one such approach which relies onthe past pattern in a time series to forecast prices inthe future. Burark and Sharma (2012) confirmed the suitability of ARIMA models in agricultural price forecasting.

MATERIALS AND METHODS

The weekly price data of cross breed reeling mulberry cocoons were collected for the period from first week of April 2011 to last week of July 2019 for Ramanagaram and Siddlaghatta cocoon markets. The statistical softwares namely R (v.3.3) and SPSS (Expert Modeler) were used for modeling and forecasting.

Autoregressive Integrated Moving Average Model (ARIMA) Model

The Box-Jenkins procedure is concerned with fitting a mixed Auto Regressive Integrated Moving Average (ARIMA) model to a given set of data. The main objective in fitting this ARIMA model is to identify the stochastic process of the time series and predict the future values accurately. These methods have been useful in many types of situation which involve the building of models for discrete time series and dynamic systems. Auto Regressive (AR) models were first introduced by Yule in 1926. These were consequently supplemented by Slutsky who in 1937 presented Moving Average (MA) schemes. Wold (1938), combined both AR and MA schemes and showed that ARMA processes can be used to model all stationary time series as long as the appropriate order of p, the number of AR terms, and q, the number of MA terms stands.

ARIMA is one of the most traditional methods of non-stationary time series analysis. In contrast to the regression models, the ARIMA model allows r_t to be explained by its past, or lagged values and stochastic error terms. These models are often referred to as "mixed models". Although this makes forecasting method, more complicated, but the structure may indeed simulate the series better and produce a more accurate forecast. Pure models imply that the structure consists only of AR or MA parameters - not both. The models developed by this approach are usually called ARIMA models because they use a combination of autoregressive (AR), integration (I) - referring to the reverse process of differencing to produce the forecast, and moving average (MA) operations. An ARIMA model is usually stated as ARIMA (p, d, q). An autoregressive integrated moving average is expressed in the form (Andersen & Weiss, 1984):

$$\text{If } w_t = \nabla^d r_t = (1-B)^d r_t \text{ then}$$

$$w_t = \phi_1 w_{t-1} + \phi_2 w_{t-2} + ... + \phi_p w_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - ..... - \theta_q \varepsilon_{t-q}$$

If $\{W_t\}$ follows the ARMA (p, q) model, and $\{r_t\}$ is an ARIMA (p, d, q) process. For practical purposes, we can take is usually d = 1 or 2 at most. Above equation is also written as:

$$\phi(B)w^t = \theta_0 + \theta(B)\varepsilon_t$$

Where $\phi(B)$ is a stationary autoregressive operator, $\theta(B)$ is a stationary moving average operator, and ε_t is white noise and θ_0 is a constant.

The main stages in setting up a Box-Jenkins forecasting model are Identification, Estimation, Diagnostic Check and Forecasting.

RESULT AND DISCUSSION

I.Forecasting of Weekly Prices of Mulberry Reeling Cocoons (Cross Breed) in Ramanagaram Market

An ARIMA model was attempted using the R (v.3.3) and SPSS expert modeler statistical package. The model was then used to forecast for 20 out-of-sample set. The first step in time series analysis is to plot the data in order to assess the variation and volatility of the series across the time component. Fig. 1 shows the time series plot of average weekly price of cross breed mulberry cocoons in Ramanagaram marketfrom first week of April 2011 to last week of July 2019 (436 weeks). A perusal of Fig.1 reveals a positive trend over time which indicates the non-stationary nature of series. It is confirmed through plotting the auto correlation function (ACF) and partial autocorrelation function (PACF) in two dimension chart. ACF of the time series in Fig.2 shows a slow linear decay of the autocorrelation coefficients (Sahu & Mishra, 2013).

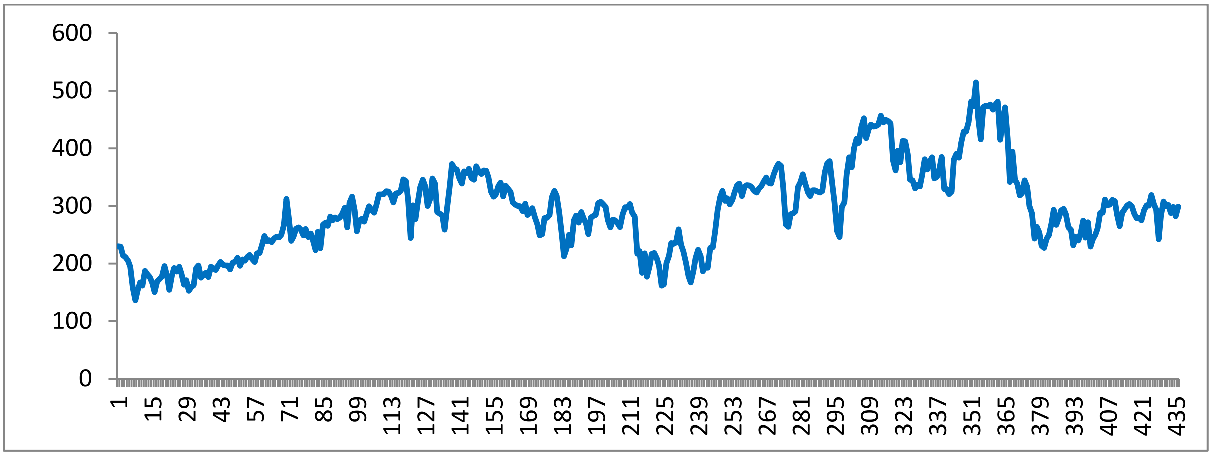

Fig. 1 : Weekly prices of cross breed mulberry cocoons in Ramanagaram market

The PACF of the time series show that the series was not stationary as auto correlation coefficient did not cut off to statistical insignificance fairly quickly (Fig. 3). All the initial autocorrelations spikes were significantly different from zero at 5% level of significance; most of the initial spikesin the ACF extended beyond the limit of significance line (Confidence Band). In same way, the first spike of the PACF plot was extended out of significance line; Both ACF and PACF of the series have shown a strong and consistent pattern. To make the non-stationary series in to stationary series, the series was first differenced (Burark & Sharma, 2012).

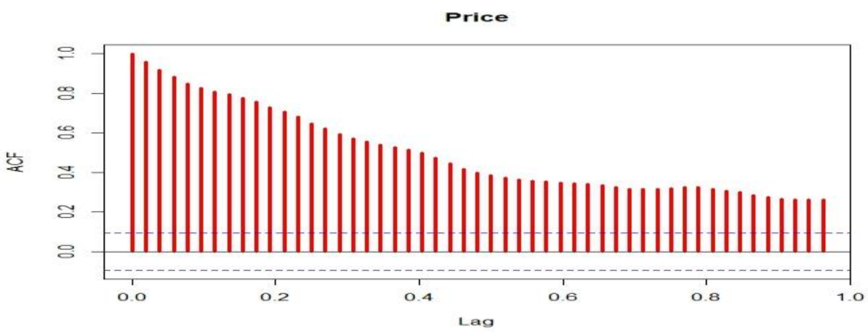

Fig. 2: Autocorrelations at different lags of weekly prices of cross breed mulberry cocoons in Ramanagaram market

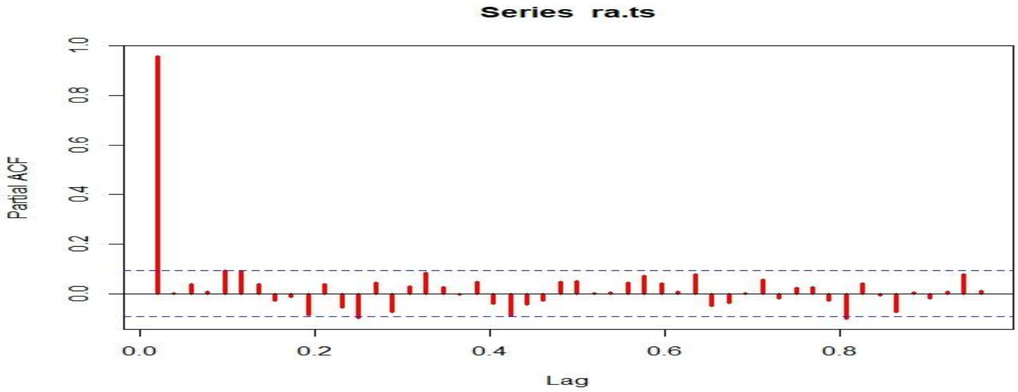

Fig. 3: Partial Autocorrelations at different lags of weekly prices of cross breed mulberry cocoons in Ramanagaram market

Theauto correlation function (ACF) and the partial auto correlation functions (PACF) of the differenced time series are represented in Fig. 4 and Fig.5, respectively (Naveen et al., 2017). The autocorrelations decayed, statistical insignificantly rather quickly. It was concluded that the mean of the series was stationary. The ACF and PACF of different series did not show a strong and consistent pattern. The first spike in ACF plot extended beyond the significance line (positive side) followed by non-significant spikes throughout the series, which indicates that the length of the MA process was fixed to one lag and the initial spikes of the PACF were not crossed the significance line but crossed later stage and most of the spikes were directed towards downward trend, that specifies the zero lagged AR process.

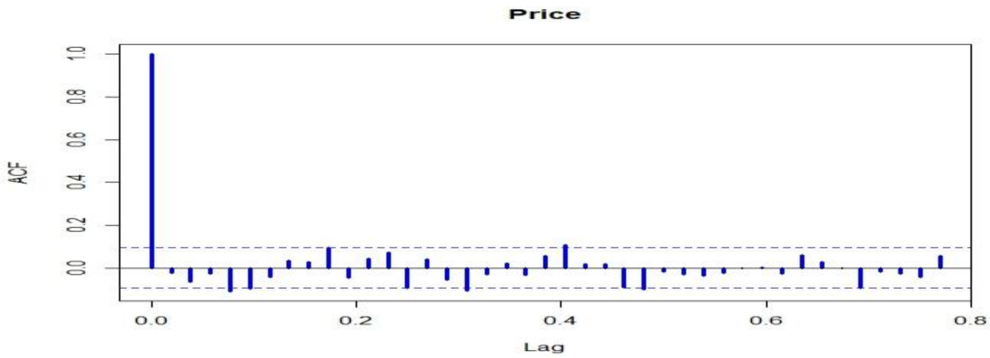

Fig. 4: Autocorrelations at different lags of 1st differenced time series for weekly prices of cross breed mulberry cocoons in Ramanagaram market

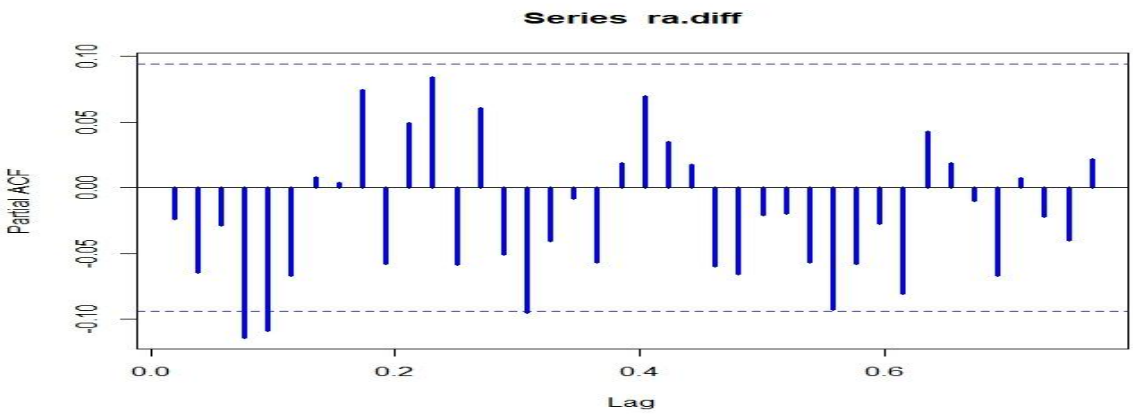

Fig. 5: Partial Autocorrelations at different lags of 1st differenced time series for weekly prices of cross breed mulberry cocoons in Ramanagaram market

Augmented Dickey Fuller (ADF) test was also applied for raw series to test for the unit root (Stationarity) and the results are presented in Table 1. The test was conducted to know the stationarity of the series and the results were recorded for both before differencing and after differencing of the series, the series was tested by considering model with constant and model with constant having linear trend, The value of test statistic (-0.897& -2.623) was observed non-significant (p>0.05) for first case, thus indicating the non-stationarity of level series. After first differencing of the series, the value of test statistic (-7.211& -8.926) was observed significant (p<0.05) for second case pointing the stationarity of series and ruled out for further differencing (Yegnanew, 2012).

Table 1: Augmented Dickey-Fuller Stationary Test for weekly prices of cross breed mulberry cocoons in Ramanagaram market

Parameters	Level Series		1st differenced series	
	Test statistic	Prob.	Test statistic	Prob.
Constant	-0.897	0.801	-7.211	0.006*
Constant with Linear trend	-2.623	0.382	-8.926	0.015*

Note: * Significant at 5% level of Significance (*P<0.05*).

Once the time series has become stationary, the ARIMA model was built and the parameters of the model were estimated. After conducting several iterations, ARIMA (0, 1, 1) (0, 0, 0) model was found to be the best among the family of ARIMA models. The Model parameters are given in Table 2 and it satisfies the invertibility condition$|\theta_1| \leq 1$ and the moving average (MA) of Lag 1 was found to be statistically significant at 5% level of significance (P<0.05).

Table 2: Estimate of the ARIMA Model parameterfor weekly prices of cross breed mulberry cocoons in Ramanagaram market

	Estimate	SE	Test stat.	Sig.
Difference	1			
MA Lag1	0.426	0.053	3. 17	0.004*

Note: * Significant at 5% level of Significance (*P<0.05*).

A high R^2 value of 0.919 indicates goodness of the fit. RMSE, MAPE, MAE, BIC were 10.961, 5.577, 5.556 and 6.113, respectively and these values were not far away from zero. These also specify that the constructed model was good fit and statistically potential enough to forecast the future price events, the model fitting statistics are represented in Table 3.

Table 3: Model fit statistics and Ljung-Box Q statistics for weekly prices of cross breed mulberry cocoons in Ramanagaram market

Model Fit statistics						Ljung-Box Q(18)		
Stationary R^2	R^2	RMSE	MAPE	MAE	Normalized BIC	Statistics	DF	Sig.
0.017	0.919	10.961	5.577	5.506	6.113	26.631	17	0.446

The adequacy of the model was also adjudicated based on the test values of Ljung-Box Q statistics (Q=26.631), which was found to be non-significant (*P>0.05*). Further, we can conclude that ARIMA (0,1,1)(0,0,0) model shown satisfactory result and good fit, among different ARIMA models (Jalikatti & Patil, 2015). The model with its parameter is indicated below:

$Y_t=0.426 * e_{t-1} + e_t$

Residual analysis was carried out to check the adequacy of the several iterative models. The residuals of ACF and PACF were obtained from the tentatively identified model, most of lags were found to be non-significant (Fig 6), which indicates the built model is adequate for forecasting of weekly prices.

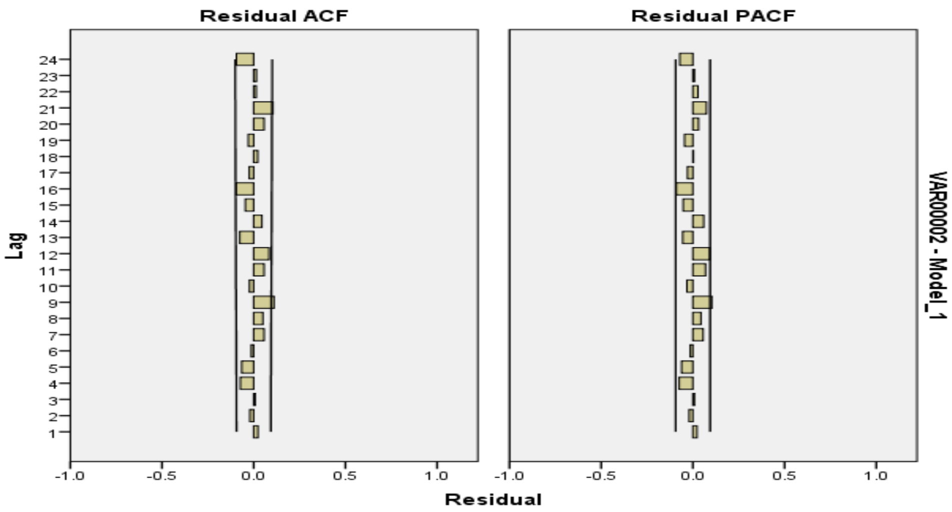

Fig. 6: Residual auto and partial autocorrelations for weekly prices of cross breed mulberry cocoons in Ramanagaram market

Table 4 shows the forecasted value of average price for future periods of 22 weeks along with the confidence interval. The results indicate that the average prices were varying between Rs 294 to 298 per kg of reeling cocoons in Ramanagaram market. The forecasted values of price showed a decreasing trend across the periods in Ramanagaram market (Seyed et al., 2015).

Table 4: Forecasted values for weekly prices of cross breed mulberry cocoons in Ramanagaram market

Weeks	Forecast	Lo 95	Hi 95
1 Week Aug 2019	298.15	257.06	339.25
2 Week Aug 2019	297.70	241.43	353.97
3 Week Aug 2019	297.30	230.43	364.16
4 Week Aug 2019	296.95	221.90	372.00
1 Week Sept 2019	296.65	214.94	378.35
2 Week Sept 2019	296.38	209.08	383.68
3 Week Sept 2019	296.15	204.03	388.26
4 Week Sept 2019	295.94	199.61	392.28
5 Week Sept 2019	295.77	195.67	395.86
1 Week Oct 2019	295.61	192.13	399.08
2 Week Oct 2019	295.47	188.92	402.03
3 Week Oct 2019	295.35	185.96	404.75
4 Week Oct 2019	295.25	183.22	407.28
1 Week Nov 2019	295.16	180.67	409.65
2 Week Nov 2019	295.08	178.28	411.88
3 Week Nov 2019	295.01	176.01	414.00
4 Week Nov 2019	294.95	173.87	416.03
1 Week Dec 2019	294.89	171.82	417.97
2 Week Dec 2019	294.85	169.86	419.83
3 Week Dec 2019	294.81	167.98	421.64
4 Week Dec 2019	294.77	166.16	423.38
5 Week Dec 2019	294.74	164.40	425.08

II. Forecasting of Weekly Prices of Mulberry Reeling Cocoons (Cross Breed) in Siddlaghatta Market

The time series data of average weekly prices of cross breed mulberry cocoons in Siddlaghatta market from first week of April 2011to last week of July 2019 amounting to 436 weeks were plotted in a graph (Fig. 7) The graph revealed a positive trend over time which indicates the non-stationary nature of series. It was confirmed through plotting the auto correlation function (ACF) and partial autocorrelation function (PACF) in two dimension chart.

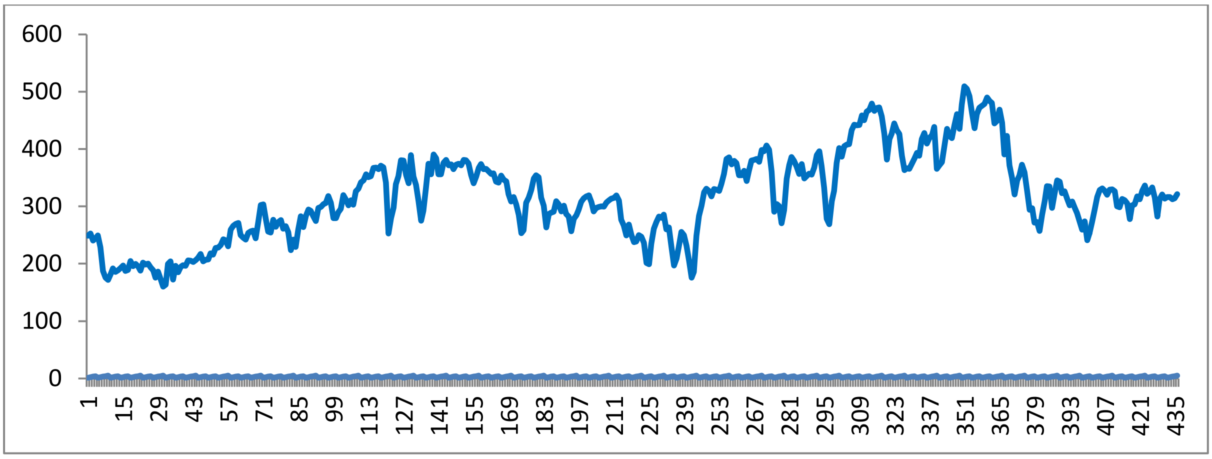

Fig. 7 : Weekly prices ofcross breed mulberry cocoons in Siddlaghatta market

The auto correlation function (ACF) and the partial auto correlation functions (PACF) of the time series are depicted in Fig. 8 and Fig 9 respectively. As the series was not stationary, to make the non-stationary series in to stationary series the series was first differenced.

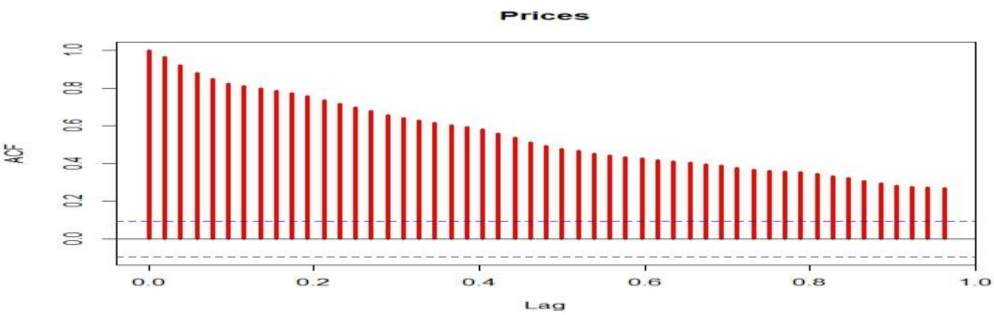

Fig. 8: Autocorrelations at different lags of weekly prices of cross breed mulberry cocoons in Siddlaghatta market

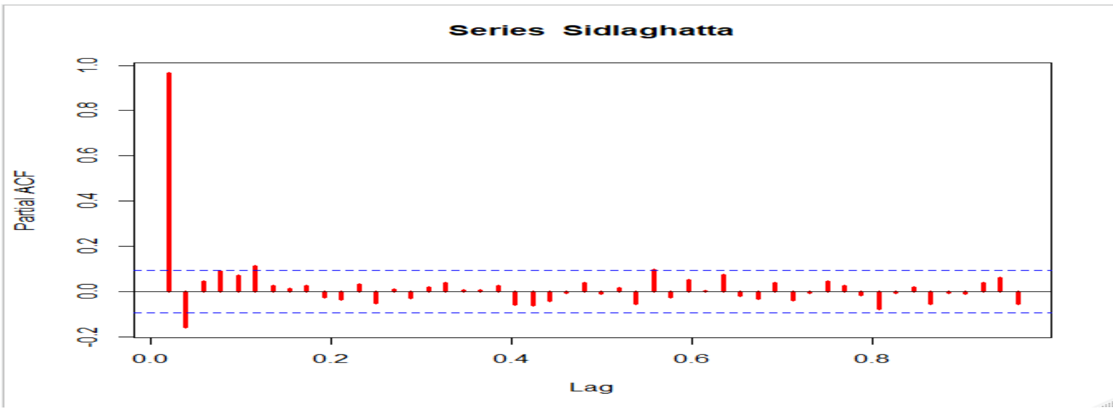

Fig. 9: Partial Autocorrelations at different lags of weekly prices of cross breed mulberry cocoons in Siddlaghatta market

The auto correlation function (ACF) and the partial auto correlation functions (PACF) of the differenced time series are shown in in Fig. 10 and Fig. 11, respectively. The autocorrelations decayed statistically insignificantly rather quickly (Naveen et al., 2017). It was concluded that the mean of the series was stationary. The ACF and PACF of different series did not show a strong and consistent pattern. The 1st and 2nd spikes in ACF plot extended beyond the positive significance line followed by 4th, 5th and 6th, which extended beyond the negative significance line, and non-significance spikes throughout the series, The length of the MA process was fixed based on the number of initial spikes which are projected out of significance line (either positive or negative or both). The current study has two spikes crossed positive significance line and the order of MA process is 2.

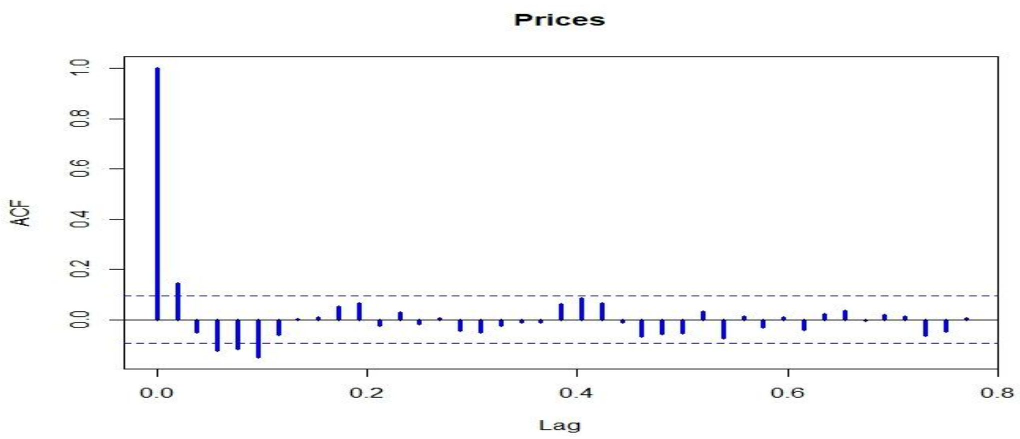

Fig. 10: Autocorrelations at different lags of 1st differenced time series for weekly prices of cross breed mulberry cocoons in Siddlaghatta market

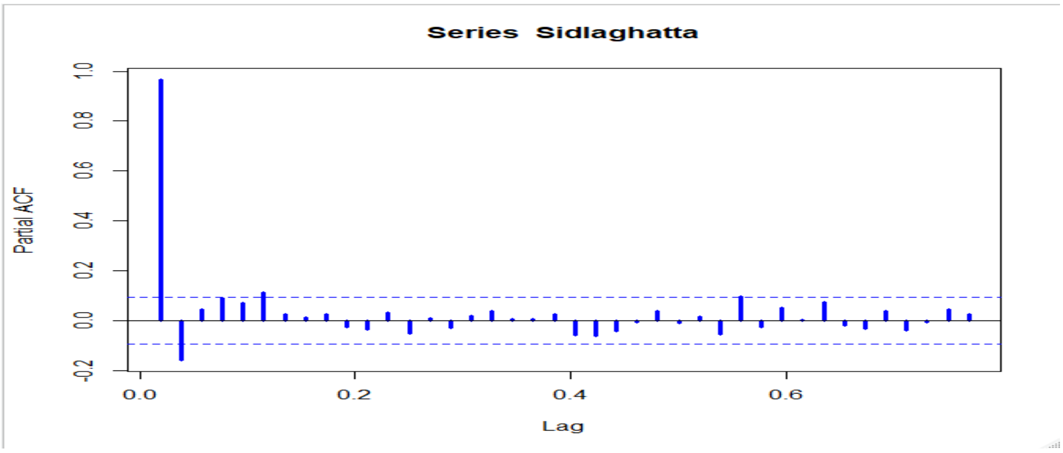

Fig. 11: Partial Autocorrelations at different lags of 1st differenced time series for weekly prices of cross breed mulberry cocoons in Siddlaghatta market

Augmented Dickey Fuller (ADF) test was applied for the raw series to test for the unit root (stationarity) for both before differencing and after differencing of the series (GanQiong, 2011).The series was tested by considering model with constant and model with constant having linear trend. The value of test statistic (-0.423& -4.467) was observed non-significant ($p>0.05$) for first case, thus indicating the non-stationarity of level series (Table 5). After first differencing of the series, the value of test statistic (-8.481& -9.712) was observed non-significant ($p<0.05$) for second casepointing the stationarity of series and ruled out for further differencing.

Table 5: Augmented Dickey-Fuller Stationary Test for weekly prices of cross breed mulberry cocoons in Siddlaghatta market

	Level Series		1st differenced series	
	t-statistic	**Prob.**	**t-statistic**	**Prob.**
Constant	-0.423	0.501	-8.481	0.025*
Constant with Linear trend	-4.467	0.482	-9.712	0.031*

Note: * Significant at 5% level (*P<0.05*).

Once the time series has become stationary, the ARIMA model was built and the parameters of the model were estimated. After going through several iterations, ARIMA (2, 1, 2) (0, 0, 0) model was found to be the best among the family of ARIMA models (Naveen et al., 2014). The model parameters given in Table 6 satisfy the invertibility condition $|\theta_1| \leq 1$ and the autoregressive process (AR Lags) of Lag 1, Lag 2 and moving average (MA) of Lag 1, Lag 2 were found to be statistically significant at 5% level of significance (P<0.05).

Table 6: ARIMA Model parameter estimatesfor weekly prices of cross breed mulberry cocoons in Siddlaghatta market

	Estimate	SE	Test stat.	Sig.
Constant	0.724	1.264	0.573	0.567
AR Lag 1	1.269	0.159	7.994	0.000*
AR Lag 2	-0.560	0.149	-3.761	0.000*
Difference	1			
MA Lag1	1.161	0.178	6.524	0.000*
MA Lag2	-0.363	0.172	-2.102	0.036*

Note: * Significant at 5% level (*P<0.05*).

R^2 value is 0.892 and RMSE, MAPE, MAE, BIC are 11.821, 7.705, 6.586 and 8.045 respectively, which are not far away from zero, specify that the constructed model was good fit and statistically potential enough to forecast the future price events (Table 7). The adequacy of the model, which was also adjudicated based on the test values of Ljung-Box Q statistics (Q=19.301), was found to be non-significant (*P>0.05)*. Further, we can say that ARIMA (2, 1, 2) (0, 0, 0) model has shown satisfactory result among different ARIMA models. The model with its parameter is indicated below:

$$Y_t=1.269*Y_{t-1}-0.560*Y_{t-2}+1.161*E_{t-1}-0.363*E_{t-2}+E_t$$

Table 7: Model fit statistics and Ljung-Box Q statistics for weekly prices of cross breed mulberry cocoons in Siddlaghatta market

Model Fit statistics						Ljung-Box Q(18)		
Stationary R^2	R^2	RMSE	MAPE	MAE	Normalized BIC	Statistics	DF	Sig.
0.065	0.892	11.821	7.705	6.586	8.045	19.301	17	0.635

Residual analysis was carried out to check the adequacy of the several iterative models. The residuals of ACF and PACF were obtained from the tentatively identified model. All lags were found to be non-significant (Fig. 12), which indicates the built model is adequate for forecasting of weekly price (Jalikatti & Patil, 2015).

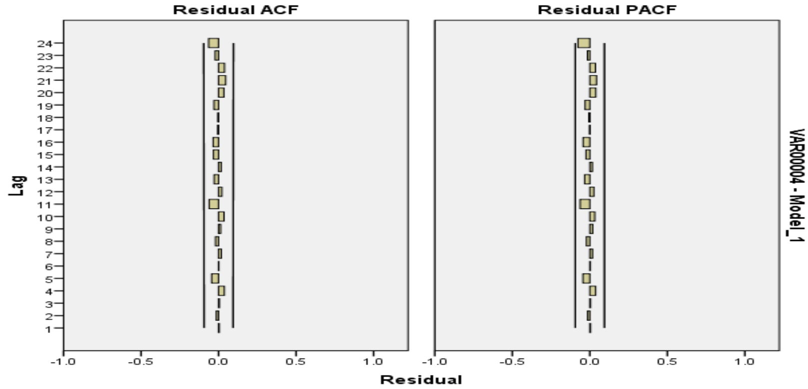

Fig. 12: Residual auto and partial autocorrelations for weekly prices of cross breed mulberry cocoons in Siddlaghatta market

The forecasted values of average prices for future period of 22 weeks along with the confidence interval are shown in Table 8. The fitted model suggests that the average price fluctuated between Rs 318 and Rs. 321 per kg of reeling cocoons in Siddlaghatta market. The forecasted values of price showed a decreasing trend across the periods in Siddlaghatta market.

Table 8: Forecasted Values for weekly prices of cross breed mulberry cocoons in Siddlaghatta market

Weeks	Forecast	Lo 95	Hi 95
1 Week Aug 2019	321.95	285.24	358.67
2 Week Aug 2019	321.27	265.94	376.60
3 Week Aug 2019	320.39	253.55	387.24
4 Week Aug 2019	319.71	245.30	394.11
1 Week Sept 2019	319.25	239.41	399.08
2 Week Sept 2019	318.96	234.86	403.06
3 Week Sept 2019	318.79	231.09	406.49
4 Week Sept 2019	318.69	227.77	409.61
5 Week Sept 2019	318.64	224.75	412.53
1 Week Oct 2019	318.61	221.91	415.30
2 Week Oct 2019	318.59	219.20	417.98
3 Week Oct 2019	318.58	216.59	420.56
4 Week Oct 2019	318.57	214.07	423.08
1 Week Nov 2019	318.13	211.61	425.54
2 Week Nov 2019	318.14	209.21	427.93
3 Week Nov 2019	318.27	206.86	430.28
4 Week Nov 2019	318.35	204.56	432.57
1 Week Dec 2019	318.51	202.31	434.83
2 Week Dec 2019	318.25	200.10	437.03
3 Week Dec 2019	318.75	197.94	439.20
4 Week Dec 2019	318.12	195.81	441.33
5 Week Dec 2019	318.42	193.72	443.42

The comparative performance of ARIMA models fitted for both Ramanagaram and Siddlaghatta cocoon markets is shown in Table 9. The coefficient of determination (R^2) measures the fitness of the model and it was found to be more for the Ramanagaram market (91.9%) compared to Siddlaghatta market (89.2%). The statistics such as RMSE, MAPE, MAE, BIC were constructed based on the model error, which are found to be less for the Ramanagaram market (10.961, 5.577, 5.556and 6.113, respectively) compared to Siddlaghatta market (11.821, 7.705, 6.586and 8.045, respectively). Its indicates that the fitted

ARIMA model was performing better for forecasting of average price of reeling cocoons in Ramanagaram market than Siddlaghatta market (Seyed et al., 2015).

Table 9: Comparative study of performance of ARIMA Model in two different markets

Model Fit statistics	Ramanagaram Market	Siddlaghatta Market
Model	ARIMA (0, 1, 1) (0, 0, 0)	ARIMA (2, 1, 2) (0, 0, 0)
R^2	0.919	0.892
RMSE	10.961	11.821
MAPE	5.577	7. 705
MAE	5.506	6.586
Normalized BIC	6.113	8.045

SUMMARY AND CONCLUSIONS

The forecasted prices of mulberry cocoons showed decreased trend for both the markets across the study period. The value of model statistics was found to be less for the Ramanagaram market compared to Siddlaghatta market and the fitted ARIMA model was performing better for forecasting of average prices of reeling cocoons in Ramanagaram market than Siddlaghatta market. The model can be extended to forecast the prices for other government regulated cocoon markets in Karnataka and other states to forecast the prices of mulberry and non-mulberry cocoons. The current study has been taken up with weekly data and the future studies can assess the volatility of the data and forecast the prices of the cocoons by considering daily, monthly and quarterly data with various time series and machine learning models.

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