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RESEARCH PAPER

Price forecasting of onion in Bijapur market of northern Karnataka using ARIMA technique

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ABSTRACT

The present study is an attempt to forecast the prices of onion at Bijapur district of Northern Karnataka. The study was carried out in Bijapur market where arrivals of onion were found to be more in Northern Karnataka. The time series data on monthly price of onion required for the study was collected from the registers maintained in the Bijapur APMC Market from year 1996-97 to 2010-11. The ARIMA model forecasted prices revealed there was sudden increase in the prices during 1998, 1999, 2010 and 2011.The year-wise alternate decrease in production and adequate storage facilities might be the reasons for such sudden increase in the price. The forecasted price values showed an increasing trend in the next coming years. Hence, farmers' needs to plan the production process in such a way that a good price for the produce can be expected. ARIMA model is an extrapolation method that requires only historical time series data on the variable under study. The Box-Jenkins approach primarily makes use of three types of filters, namely, the autoregressive, the integration and the moving average. The Box-Jenkins model provides a verified approach for identifying and filtering most appropriate variations for the series being analyzed, for diagnosing the accuracy and the reliability of the models that have been estimated and lastly, for forecasting the policy.

KEY WORDS : ARIMA, Auto-correlation function, Akike information co-efficient, Swarz information co-efficient

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ARIMA models are extensively used to study market fluctuations particularly of agricultural commodities. The main advantage of this class of models lies in its ability to quantify random variations present in many economic time series. Hence, the data on prices of onion in the selected market was subjected to ARIMA analysis to quantify the variation and also to predict the future prices of onion.

Since ARIMA model used only stationary series, there was also a need to change the non-stationary series into stationary series by applying appropriate order of differencing to the series. Thereafter, the autocorrelation and partial autocorrelation co-efficient of the working series were computed and confirmed the absence of trend component in the series. An examination of such tables revealed that this is justified by the autocorrelation function of the series dropping to zero after second or third lag.

METHODOLOGY

The study has utilized secondary source of data. The time series data on monthly price of onion required for the

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study was collected from the registers maintained in the APMC of Bijapur market from year 1996-97 to 2010-11. This market maintains data on daily, monthly and yearly prices of agricultural commodities. The data on prices refers to modal prices in a month. Modal price was considered superior to the monthly average price as it represented the major proportion of the commodity marketed during the month in a market.

Auto regressive iontegrated moving average (ARIMA) model (Box-Jenkins models):

The Box-Jenkins procedure is concerned with fitting a mixed Auto Regressive Integrated Moving Average (ARIMA) model. The main objective in fitting ARIMA model is to identify the stochastic process of the time series and predict the future values accurately. These methods have also been useful in many types of situation which involve the building of models for discrete time series and dynamic systems. But, this method was not good for lead times or for seasonal series with a large random component (Granger and Newbold, 1970).

Originally ARIMA models have been studied extensively by George Box and Gwilym Jenkins (1968) and their names have frequently been used synonymously with general ARIMA process applied to time series analysis, forecasting and control. However, the optimal forecast of future values of a time-series are determined by the stochastic model for that series. A stochastic process is either stationary or non-stationary. The first thing to note is that most time series are non-stationary and the ARIMA model refer only to a stationary time series. Therefore, it is necessary to have a distinction between the original non-stationarity time series and its stationarity counterpart.

Stationarity and non-stationarity:

The term stationarity meaning that the process generating the data is in equilibrium around a constant value and that the variance around the mean remains constant over time. The data must be roughly horizontal along time axis.

If mean changes over time (with some trend cycle pattern) and variance is not reasonably constant then series is non-stationary in both mean and variance.

If a time series is not stationary, then it can be made more nearly stationary by taking the first difference of the series. Conversely, a stationary process may be summed or integrated to give a non-stationary process.

Let Xt be a random variable and xt (where t=1, 2, . . . n) be the observations on Xt with density function f (xt). If the observations are independent, then

$$f(X_1, X_2 \ldots . . Xn) = f_1(x_1), f_2(x_2), \ldots, fn(xn)$$

This implies that joint distribution is independent of historical time. The assumption of stationarity reduces the number of parameters in the joint probability density function of a random variable Xt in the series.

Since the ARIMA model refers only to a stationary time series, the first stage of Box-Jenkins model is reducing non-stationary series Xt to a stationary series Yt by taking first differences as follows.

$$\begin{aligned} Y_t &= a{:}X_t \\ &= X_t - X_{t-1} \\ &= X_t - BX_t \\ &= (1-B)\, X_t \end{aligned} \qquad \ldots\ldots. (1)$$

where,

B = Backward shift operator.

The backward shift operator is convenient for describing the process of differencing. To define B, such that,

BBixt = xt-1 i= 1, 2, . . .

Suppose the first difference of the series doesn't become stationary then second order differencing is done as follows.

$$\begin{aligned} Y_t &= a\,(aX_t) \qquad \ldots\ldots (2) \\ &= a\,(X_t - X_{t-1}) \\ &= (X_t - X_{t-1}) - (X_{t-1} - X_{t-2}) \\ &= X_t - 2X_{t-1} + X_{t-2} \\ &= X_t - 2BX_t + B^2X_t \\ &= (1 - 2B + B^2)\, X_t \\ &= (1 - B)^2\, X_t \end{aligned}$$

In general, if it takes a d^{th} order difference to achieve stationarity, it is written as:

$$d^{th} \text{ order difference} = (1\text{-}B)d\, X_t \qquad \ldots\ldots. (3)$$

The general ARIMA (o, d, o) model will be:

$$(1 - B)^2\, X_t = et \qquad \ldots\ldots. (4)$$

where, et is error term distributed normally with:

$E(et) = 0$, $V(et) = et^2$ and

$Cov(ei, ej) = {}^{-}$ for all t $(i \neq j)$

In order to test the stationarity, auto-correlation functions (ACF) of difference series (Yt) upto 36 lags should be computed. If the ACF for first and higher differences (after 2-3 lags) drop abruptly to zero then it indicates the series is stationary.

Stationary time series model:

Auto regressive process (p, o, o):

If the observation Yt depends on previous observation and error term et is called auto regressive process (AR process):

Yt = « + ĄtYt-1 +:Ą 0Yt-2 + ĄpYt-p + e= Ąp (B) (Yt-«) + et ....(5)

Note the term μ in equation (3.5) is not quite the same as the "Mean" of the Y series. Rather, the development is as follows:

(Yt-«) = ¨ p (Yt - «) + et
= ¨ 1 (Yt-1 - «) + ¨ 2 (Yt-2 - «) + ... ¨ p (Yt-p - «) + et ...... (6)
= ¨ 1 (Yt-1 - ¨ 1«) + ¨ 2 (Yt-2 - ¨ 2«) + ... ¨ p (Yt-p - ¨ «) + et
Yt = («- ¨ 1« - . . . . . ¨ «) + ¨ 1 Yt-1 + ... + ¨ p Yt-p + et
= «1 + ¨ 1Yt-1 + ... + ¨ pYt-p + et

and the values of auto regressive co-efficient restricted to lie between -1 and +1.

Moving average process (o, o, q):

If the observation Yt depends on the error term et and also on one or more previous error terms (et 's) then we have moving average (MA) process:

Yt = «÷+ et - ¯1e(t-1) - ¯2e(t-2) - . . . . qqe(t-q) ....(7)

where,

Θi = i^{th} moving average parameter

i = 1, 2, ... q

q = Order moving average.

The values of the co-efficient are restricted to lie between -1 to +1.

Mixtures: ARIMA process:

If the non-stationarity is added to a mixed ARIMA process, then the general ARIMA (p, d, q) is implied. Here the word integrated is confusing to many and refers to the differencing of the data series:

(1-B)d (1-¨ pBp) Yt = u = (1-¨ pBq) et ....(8)

Seasonality and ARIMA models:

Some time series exhibit perceptible periodic pattern for instance price and arrivals of Agricultural commodities usually have a seasonal pattern process then the general.

The ARIMA notation can be extended readily to handle seasonal aspects and the general shorthand rotation is ARIMA:

(p.d.q.) (P.D.Q.)

(non-seasonal part of the model) (Seasonal part of the model)

s = number of periods per season

The mixture of AR and MA seasonal model is:

Ąp (B) ad Ąp(Bs) aD xt = ¯q (B) . (H)Q (Bs) et ....(9)

If Yt = Δd Δd xt – the model becomes an integrated model.

The main stages in setting up a Box-Jenkins forecasting model are as follows:

– Identification
– Estimating the parameters
– Diagnostic checking and
– Forecasting.

Identification of models:

A good starting point for time series analysis is a graphical plot of the data. It helps to identify the presence of trends.

Before estimating the parameter p and q of the model, the data are not examined to decide about the model which best explains the data. This is done by examining the sample ACF (Autocorrelation function) and PACF (Partial Autocorrelation function) of differenced series Yt.

The sample auto correlations for k time lags can be found and denoted by rk as follows.

^° k (Yt) = rk (Yt) .... (10)
= C_k(Yt)/ C_0 (Yt)
where, n-k
t-1

C_k (Yt) = 1/n Σ (Yt – Y) (Yt+k – Y)

K = 0, 1, 2, ... n

t = 1, 2, . . . n-k

Y_t = 1/n ΣY_t

n = Length of time period.

Both ACF and PACF are used as the aid in the identification of appropriate models. There are several ways of determining the order type of process, but still there was no exact procedure for identifying the model.

Estimation of parameters:

After tentatively identifying the suitable model, next step is to obtain Least Square Estimates of the parameters such that the error sum of squares is minimum.

S (¯⊩Ą) = p et² (¯⊩Ą) ....(11)

where,

t = 1, 2, 3, . . . n.

There are fundamentally two ways of getting estimates for such parameters.

Trial and error:

Examine many different values and choose set of values that minimizes the sum of squares residual.

Interactive method:

Choose a preliminary estimate and let a computer programme refine the estimate interactively.

The latter method is used in our analysis for estimating the parameters.

Diagnostic checking:

After having estimated the parameters of a tentatively identified ARIMA model, it is necessary to do diagnostic checking to verify that the model is adequate.

Examining ACF and PACF of residuals may show an adequacy or inadequacy of the model. If it shows random residuals, then it indicates that the tentatively identified model is adequate. When an inadequacy is detected, the checks should give an indication of how the model need be modified, after which further fitting and checking takes place.

One of the procedures for diagnostic checking mentioned by Box-Jenkins is called over fitting *i.e.* using more parameters than necessary. But the main difficulty in the correct identification is not getting enough clues from the ACF because of inappropriate level of differencing. The residuals of ACF and PACF considered random when all their ACF were within the limits:

± 1.96 Ĕ 1/(n-12) ....(12)

We also used Box and Pierce (1970) 'Q' statistic for whether the auto correlations for these residuals are significantly different from zero. It can be computed as follows:

$$Q = n \sum_{k=1}^{m} r_k^2 \qquad ....(13)$$

where,

m = Maximum lag considered

n = N – D

N = Total number of observations

rk = ACF for lag k

D = Differencing.

And Q is distributed approximately as a Chi-square statistic with (m-p-q) degree of freedom.

The minimum Akike Information co-efficient (AIC) criteria is used to determine both the differencing order (d, D) required to attain stationarity and the appropriate number of AR and MA parameters, it can be computed as follows:

AIC (p+q) = N ln ±² + 2 (p + q) ....(14)

where,

σ^2 = Estimated MSE

N = Number of observations

(p+q) = Number of parameters to be estimated.

This diagnostic checking helps us to identify the differences in the model, so that the model could be subjected to modification, if need be.

Forecasting:

After satisfying about the adequacy of the fitted model, it can be used for forecasting. Forecasts based on the model.

(1-ĄB) (1-¨B)s Yt = (1-¯B) (1-(H)sB) et ....(15)

were computed for upto 36 months (m) ahead. The above model (3.15) gives the forecasting equation is:

Yt = ĄYt-1+¨Yt-12 - Ą¨Yt-13 + et-¯et-1
–(H) et-12 +¯(H) et-13 ...(16)

Given data upto time 't' the optional forecast of Y (also called Ex-Ante forecast) model at the t is the conditional expectation of Y_{t+1}.

It follows, in particular, that:

$$et = Y_t - Y_{t-1} \qquad ......(17)$$

The errors et in model (3.17) are in fact that forecast errors for unit lead time. That for an optimal forecast these 'one step ahead' forecast errors ought to form an uncorrelated series is otherwise obvious. Suppose, if these forecast errors were autocorrelated, then it could be possible to forecast the next forecast error in which case it could not be optimal.

The required expectations are easily found because:

$$E(Y_{t+m}) = Y_t(m),\ E(e_{t+m}) = 0 \qquad ....(18)$$

where,

m = 1, 2, 3 . . . . . n

$E(Y_{t-m}) = Y_{t-m}\ E(e_{t-m}) = a_{t-m} = Y_{t-m} - Y_{t-m-1}$

Where, m = 0, 1, 2, ... n ....(19)

For instance, to determine the three month ahead (1-3) forecast for series Yt.

$Y_{t+1} = Y_{t+3}$

= ĄYt+2 + ¨Yt-9 - Ą¨Yt-10 + et+13 - ¯et-2 – (H) et-9 + ¯ (H) et-10

taking conditional expectations at time t,

$Y_t(1) = Y_t(3)$

= ĄYt(2) + ¨yt-9 - Ą¨Yt-10 + 0-¯ (0)-

(H) (Yt-9-Yt-10) + ¯(H) (Yt-10–Yt-11)

Because, $E(e_{t+1}) = 0$, $E(e_{t-1}) = Y_{t-1} - Y^{\wedge}{}_{t-1} = e_{t-1}$

i.e. $Y_t(3) = 0\ Y_t(2)$.

The forecast Yt (2) can obtained in a similar way in terms of Yt(1) from E (Yt+2). Similarly Yt (1) can be obtained from E (Y_{t+1}). In practice it is very easy to compute the forecast Yt (1), Yt (2), Yt (3) *etc.* recursively using the forecast function.

$E(Y_{t+1}) = E(0Y_{t+1}\text{-}1 + Q_{t+1}\text{-}0\ e_{t+1}\text{-}1) - q\ e_{t+1}\text{-}1$

$-\ (H)\ e_{t+1}\text{-}12 + q(H)\ e_{t+1}\text{-}13$ **and using 3.18 and 3.19**

However, using these methods, Ex-post forecasts can also be calculated for comparing with the value actually realized.

ANALYSIS AND DISCUSSION

The detailed analysis of forecasting prices of onion in Bijapur market has been presented as under.

Identification of the model:

The computed values of ACF and PACF of Bijapur market are presented in Table 2, considering lags upto 36. An examination of ACF and PACF indicated the presence of seasonality in the data. However, the series was found to be stationary, since the co-efficient dropped to zero after the

Table 1 : Residual analysis of monthly prices of onion in Bijapur market

Market	Model	Akike information co-efficient	Swarz baysian criteria
Bijapur	(2,1,1) (2,1,1)	2301.809	2320.517

Table 2: ACF and PACF of onion prices in Bijapur market

Lags	Price			
	ACF	Standard error	PACF	Standard error
1	-0.017	0.077	-0.017	0.077
2	0.024	0.076	0.023	0.077
3	0.015	0.076	0.016	0.077
4	-0.064	0.076	-0.064	0.077
5	0.162	0.076	0.160	0.077
6	0.006	0.076	0.000	0.077
7	-0.046	0.075	-0.054	0.077
8	0.005	0.075	-0.003	0.077
9	-0.064	0.075	-0.042	0.077
10	0.080	0.075	0.056	0.077
11	-0.070	0.074	-0.074	0.077
12	-0.045	0.074	-0.034	0.077
13	0.020	0.074	0.017	0.077
14	-0.066	0.074	-0.042	0.077
15	0.043	0.073	0.014	0.077
16	-0.117	0.073	-0.108	0.077
17	-0.033	0.073	-0.013	0.077
18	-0.025	0.073	-0.042	0.077
19	-0.076	0.072	-0.055	0.077
20	-0.026	0.072	-0.058	0.077
21	-0.082	0.072	-0.054	0.077
22	0.023	0.072	-0.013	0.077
23	0.042	0.071	0.023	0.077
24	-0.027	0.071	-0.005	0.077
25	0.024	0.071	0.005	0.077
26	-0.078	0.071	0.060	0.077
27	0.048	0.07	0.044	0.077
28	-0.058	0.07	-0.099	0.077
29	-0.081	0.07	-0.084	0.077
30	-0.021	0.07	-0.057	0.077
31	0.068	0.069	0.101	0.077
32	-0.012	0.069	-0.052	0.077
33	0.049	0.069	0.030	0.077
34	-0.129	0.069	-0.121	0.077
35	-0.027	0.068	-0.042	0.077
36	0.148	0.068	0.126	0.077

second or third lag. Each individual co-efficient of ACF and PACF were tested for their significance using 't' test. Further, the absence of peak at first values clearly indicated suitability of the choice of non-seasonal difference d=1 to accomplish stationary series. Hence, based on ACF and PACF values, models were tested and finally the model (2,1,1) (2,1,1) was identified for prices of onion in Bijapur market as the best one.

Estimation of parameter:

The parameters of the tentatively identified model were estimated and presented in Table 3. Further, the residual of the model was estimated. The least square estimate of onion in Bijapur market was done to know the accuracy of the model selected. The standard error of MA 1.1, MA 2.1 and AR 2.1 was found to be statistically highly significant. It was used to know the difference between the actual and predicted prices.

Table 3: Conditional least square estimate of onion prices in Bijapur market

Parameter	Price			
	Estimate	Standard error	t value	Approximate Pr>ltl
MA1.1	0.547	0.166	3.288	0.001
AR1.1	0.050	0.176	0.284	0.777
AR1.2	-0.061	0.106	-0.578	0.564
MA2.1	0.820	0.084	9.726	0.000
AR2.1	-0.227	0.099	-2.298	0.022
AR2.2	-0.029	0.095	-0.307	0.759

MA – Moving average , AR – Auro-regressive

Diagnostic checking:

The values of these statistics are shown in Table 1. The model (2,1,1) (2,1,1) was found to be the best model for prices in Bijapur market, since it had the lowest statistic of AIC and Q statistics.

Forecasting of prices:

Both ex-ante and ex-post forecasting were done and it was compared with actual values of observations. The forecasting was done upto 2013. The results of ex- ante and ex-post forecast of prices of onion in the market are shown in Table 4 and depicted in Fig. 1. It could be seen from the graph that there were narrow variations been observed between actual and forecasted values of prices of onion in Bijapur market and the forecasted values of prices showed an increasing trend in Bijapur market. The prices of onion in the market during 2011 will be high 1530 per qtl and less 801 per qtl during the month of January and July, respectively. In 2012 the prices will be high in the month December 1328 and less during the

Table 4 : Ex-ante and Ex-post forecast of monthly prices of onion in Bijapur market

Year	Price (Rs./ Qtl)		Year	Price (Rs./ Qtl)	
	Actual	Predicted		Actual	Predicted
Jan-96	250	.	Jan-99	400	551
Feb-96	200	.	Feb-99	230	360
Mar-96	200	.	Mar-99	200	298
Apr-96	220	.	Apr-99	175	222
May-96	220	.	May-99	250	261
Jun-96	300	.	Jun-99	300	434
Jul-96	300	.	Jul-99	300	367
Aug-96	250	.	Aug-99	300	361
Sep-96	100	.	Sep-99	490	325
Oct-96	200	.	Oct-99	400	709
Nov-96	200	.	Nov-99	350	607
Dec-96	350	.	Dec-99	300	527
Jan-97	300	.	Jan-00	300	266
Feb-97	300	251	Feb-00	200	227
Mar-97	300	286	Mar-00	200	225
Apr-97	175	213	Apr-00	150	188
May-97	120	122	May-00	200	224
Jun-97	140	201	Jun-00	250	341
Jul-97	80	104	Jul-00	250	295
Aug-97	120	106	Aug-00	200	293
Sep-97	160	191	Sep-00	250	295
Oct-97	250	209	Oct-00	250	447
Nov-97	300	221	Nov-00	400	397
Dec-97	1000	898	Dec-00	400	471
Jan-98	600	671	Jan-01	400	315
Feb-98	300	433	Feb-01	400	269
Mar-98	200	351	Mar-01	200	324
Apr-98	100	124	Apr-01	200	188
May-98	200	142	May-01	200	237
Jun-98	500	355	Jun-01	300	320
Jul-98	500	376	Jul-01	300	308
Aug-98	500	418	Aug-01	400	299
Sep-98	500	377	Sep-01	350	388
Oct-98	1050	906	Oct-01	350	479
Nov-98	1200	1097	Nov-01	400	472
Dec-98	550	363	Dec-01	450	476
Jan-02	248	368	Jan-05	303	278
Feb-02	220	228	Feb-05	283	260
Mar-02	191	192	Mar-05	200	231
Apr-02	150	172	Apr-05	200	182
May-02	182	203	May-05	225	249
Jun-02	212	305	Jun-05	276	315
Jul-02	260	259	Jul-05	225	298
Aug-02	308	294	Aug-05	627	491
Sep-02	330	327	Sep-05	627	489
Oct-02	376	436	Oct-05	739	595

Table 4: Contd………

Table 4: Contd………

Nov-02	407	466	Nov-05	869	679
Dec-02	300	477	Dec-05	640	732
Jan-03	209	259	Jan-06	302	541
Feb-03	180	185	Feb-06	293	320
Mar-03	177	167	Mar-06	1550	263
Apr-03	169	152	Apr-06	320	424
May-03	239	205	May-06	440	466
Jun-03	287	316	Jun-06	425	482
Jul-03	300	303	Jul-06	325	435
Aug-03	300	321	Aug-06	315	463
Sep-03	310	329	Sep-06	322	411
Oct-03	365	418	Oct-06	348	485
Nov-03	500	450	Nov-06	322	526
Dec-03	449	492	Dec-06	665	435
Jan-04	531	343	Jan-07	600	494
Feb-04	464	373	Feb-07	500	497
Mar-04	282	357	Mar-07	467	629
Apr-04	200	251	Apr-07	525	308
May-04	278	254	May-07	540	494
Jun-04	291	354	Jun-07	700	560
Jul-04	250	325	Jul-07	665	589
Aug-04	300	308	Aug-07	720	649
Sep-04	242	338	Sep-07	600	658
Oct-04	217	391	Oct-07	671	667
Nov-04	241	393	Nov-07	554	713
Dec-04	283	354	Dec-07	415	660
Jan-08	415	447	Jan-11	.	1530
Feb-08	280	317	Feb-11	.	1208
Mar-08	416	461	Mar-11	.	1049
Apr-08	330	346	Apr-11	.	824
May-08	1025	723	May-11	.	847
Jun-08	395	643	Jun-11	.	830
Jul-08	400	515	Jul-11	.	801
Aug-08	565	526	Aug-11	.	866
Sep-08	412	569	Sep-11	.	869
Oct-08	395	579	Oct-11	.	926
Nov-08	650	551	Nov-11	.	1028
Dec-08	650	653	Dec-11	.	1268
Jan-09	650	581	Jan-12	.	1056
Feb-09	634	553	Feb-12	.	942
Mar-09	300	480	Mar-12	.	938
Apr-09	313	328	Apr-12	.	802
May-09	277	313	May-12	.	884
Jun-09	369	400	Jun-12	.	899
Jul-09	391	430	Jul-12	.	890
Aug-09	516	532	Aug-12	.	968
Sep-09	620	531	Sep-12	.	975
Oct-09	536	665	Oct-12	.	1035
Nov-09	885	673	Nov-12	.	1139
Dec-09	1127	1007	Dec-12	.	1328

Table 4: Contd……….

Table 4: Contd……….

Jan-10	825	876	Jan-13	.	1145
Feb-10	598	722	Feb-13	.	1040
Mar-10	422	646	Mar-13	.	1044
Apr-10	300	410	Apr-13	.	912
May-10	280	485	May-13	.	999
Jun-10	360	436	Jun-13	.	1015
Jul-10	383	447	Jul-13	.	1008
Aug-10	464	546	Aug-13	.	1087
Sep-10	584	544	Sep-13	.	1095
Oct-10	709	650	Oct-13	.	1156
Nov-10	867	1208	Nov-13	.	1260
Dec-10	2366	1881	Dec-13	.	1449

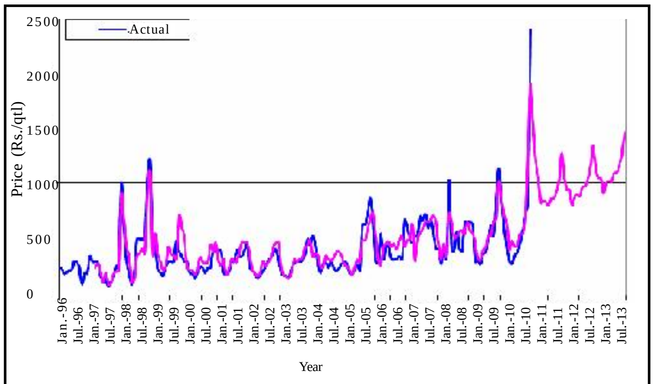

Fig. 1: Ex-ante and ex-post forecast of manthly prices of onion in Bijapur

month of April 802. Similarly, in 2013 the prices will be high in the month December 1449 and less during the month of April 912.

Conclusion:

Lot of variations were observed in the prices of onion over the study period. In this market, it was observed that there was sudden increase in the prices during 1998, 1999, 2010 and 2011. The year-wise alternate decrease in production and adequate storage facilities might be the reasons for such sudden increase in the price. The forecasted price values showed an increasing trend in the next coming years. Hence, farmers' needs to plan the production process in such a way that a good price for the produce can be expected.

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