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AN ANALYSIS OF CASHEW KERNELS AND CASHEW NUT SHELL LIQUID EXPORTS FROM INDIA EMPLOYING ARIMA MODEL

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Abstract:-Cashew kernels and Cashew Nut Shell Liquid (CNSL) export from India data were analyzed by time series methods for the period of 1990-1991 to 2009-2010. Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) were calculated for the data. Appropriate Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) model was fitted. Validity of the model was tested using standard statistical techniques.ARIMA (1, 1, 0) is used to forecast Cashew kernels and Cashew Nut Shell Liquid export from India for five leading years. The results also show Cashew kernels export forecast for the year 2015 to be about 125374million tonnes with upper and lower limit 158798 and 91949 million tonnes respectively. The model also shows Cashew Nut Shell Liquid export forecast for the year 2015 to be about 10799 million tonnes with upper and lower limit 20152 and 1445.8 million tonnes respectively.

Keywords: Cashew kernels, CNSL, Export, ARIMA, ACF, PACF.

INTRODUCTION:

Cashew nut production trends have varied over the decades. African countries used to be the major producers before 1980s; India became the largest producer in 1990s, followed by Viet Nam which became the largest producer in mid 2000s. Since 2008, Nigeria has become the largest producer followed by India (Table 1). According to Director General of Commercial Intelligence and Statistics (DGCIS) statistics, India exported about USD 521 millions cashew nut during 2004-2005 accounting for almost 40% of global exports. India exports cashew kernel to over 60 countries. India also exported cashew nut shell liquid of value USD 2.5 million in 2004-05. USA is the largest importers of Indian cashew kernel, contribution 47% of India's exporters followed by Netherlands (13%), UK (5.75%), UAE (5.6%) and Japan (4%).The trend of export level will continue to remain same or it will vary; there is a doubt.So it is a necessary to find out in future export level of cashew kernels and cnsl.With this main objective this study is carried out.

Table-1 Top Ten Cashew Nuts (with shell) Producers in 2010

Country	Production (metric tonnes)	Yield (MT/ha)
Nigeria	650,000	1.97
India	613,000	0.66
Côte d'Ivoire	380,000	0.44
Viet Nam	289,842	0.85

Indonesia	145,082	0.25
Philippines	134,681	4.79
Brazil	104,342	0.14
Guinea-Bissau	91,100	0.38
Tanzania	80,000	1.0
Benin	69,700	0.29
World Total	**2,757,598**	**0.58**

Source: Food & Agriculture Organization

METHODOLOGY

The annual data on Cashew kernels and Cashew Nut Shell Liquid (CNSL) export from India for the period from 1990-1991 to 2009-2010 were used for forecasting using ARIMA models. The ARIMA methodology is also called as Box-Jenkins methodology. 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 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 during 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.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. Since the ARIMA models refer only to a stationary time series, the first stage of Box-Jenkins model is reducing non-stationary series to a stationary series by taking first order differences.

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

1.Identification
2.Estimating the parameters
3.Diagnostic checking and
4.Forecasting

Step 1: Identification: The general ARIMA (p, d, q) model is presented in simple form as

$$\varphi(B)\nabla^d X_t = \theta(B) U_t$$

where as B is the backshift operator defined by

$$B^m X_t = X_{t-m} \qquad (m = 0,1,2 \ldots p)$$

$\varphi(B)$ is autoregressive operator of order ' p' defined by

$$\varphi(B) = 1 - \varphi_1 B^1 - \varphi_2 B^2 - \ldots - \varphi_p B^p$$

∇ is the backward difference operator defined by

$$\nabla X_t = X_t - X_{t-1} = (1-B) X_t$$

∇^d means the d^{th} difference of the series values X_t, $\theta(B)$ is the moving average operator of order 'q' defined by

$$\theta(B) = 1 - \theta_1 B^1 - \theta_2 B^2 - \ldots - \theta_q B^q$$

U_t is white noise process having a normal probability distribution with mean zero and variance σ^2_u.

An example of ARIMA model is given below to clarify the general representation of the ARIMA (1,1,1) in explaining some features of the general ARIMA (p,d,q) model.

As could be seen in ARIMA(1,1,1) model where p=1, d=1, q=1

$\varphi(B) = 1 - \varphi_1 B^1$
$\nabla^1 = (1-B)^1 = 1 - B$ and
$\theta(B) = 1 - \theta_1 B^1 = 1 - \theta_1 B^1$

Thus the model becomes

$(1-\varphi_1 B)(1-B) X_t = (1-\theta_1 B^1) U_t$
i.e. $(1 - \varphi_1 B^1)(X_t - X_{t-1}) = U_t - \theta_1 U_{t-1}$
i.e. $X_t - \varphi_t X_{t-1} - X_{t-1} + \varphi_t X_{t-2} = U_t - \theta_1 U_{t-1}$
i.e. $(X_t - X_{t-1}) - \varphi(X_t - X_{t-1}) = U_t - \theta_1 U_{t-1}$
i.e. $W_t - \varphi_1 W_{t-1} = U_t - \theta_1 U_{t-1}$

φ1 and θ1 are the parameters of the model ARIMA (1, 1, 1). Similarly φ i (i = 1,2,….p) and θj (j = 1,2…q) are the parameters of the general ARIMA (p, d, q) model. φi (i = 1,2…p) are the Autoregressive (AR) parameters and θj (j = 1,2…q) are the moving average (MA) parameters

The Autoregressive (AR) operator φ (B) is assumed to be stationary and θ(B), the moving average (MA) operator is assumed to be invertible, {aj} is sequence of independent and identically distributed random variables with mean zero and variance 2, , and the ARIMA(p, d, q) process becomes ARMA (p, q) process by suitable transformation of the variables and is given by $\varphi(B) wt = \theta(B) at$

$$\text{i.e.,} \quad w_t = \sum_{i=1}^{p} \varphi_i w_{t-i} - \sum_{j=1}^{q} \theta_j a_{t-j} + a_t$$

Where, wt consists of (n – d) observations.

Appropriate values of p, d and q are found first. The tools used for identification are the Autocorrelation Function (ACF), the Partial Autocorrelation Function (PACF) and the resulting correlograms and partial correlograms.

Step 2: Estimation: Having identified p and q values estimation of parameters of the autoregressive and moving average terms are estimated using simple least squares. The least square criterion for AR (1) is furnished below.

$(1-\varphi_1 B) X_t = U_t$

$(1-\varphi_1 B)(X_t - \mu) = U_t$ (Since ($X_t = X_t - \tilde{\mu}$))
$X_t - \varphi_1 X_{t-1} - \mu + \varphi_1 \mu = U_t$
$X_t = \varphi_1 X_{t-1} + \mu - \varphi_1 \mu + U_t$
$X_t = \mu(1 - \varphi_1) + \varphi_1 X_{t-1} + U_t$
Where $\mu(1 - \varphi_1)$ is the constant term

Step 3: Diagnostic checking: Having chosen a particular ARIMA model and having estimated its parameters the fitness of the model is verified. One simple test is to see if the residuals estimated from the model are white noise, if not we must start with other ARIMA model. The residuals were analyzed using Box-Ljung Statistic.

Step 4: Forecasting: One of the reasons for the popularity of the ARIMA modeling is its success in forecasting. In many cases, the forecasts obtained by this method are more reliable than those obtained from the traditional econometric modeling, particularly for short-term forecasts. An Autoregressive Integrated Moving Average Process model is a way of describing how a time series variable is related to its own past value. Mainly an ARIMA model is used to produce the best weighted average forecasts for a single time series (Rahulamin and Razzaque 2000).The accuracy of forecasts for both Ex-ante and Ex-post were tested using the following tests (Markidakis and Hibbon, 1979) such as Mean square error (MSE) and Mean Absolute percentage error (MAPE).

RESULTS AND DISCUSSION

In this study, we used the data for cashew kernels and cashew nut shell liquid export from India for the period from 1990-1991 to 2009-2010. As we have earlier stated that development of ARIMA model for any variable involves four steps: Identification, Estimation, Verification and Forecasting. Each of these four steps is now explained for cashewnut cultivated areas and production as follows.

Model Identification

For forecasting cashew kernels and cashew nut shell liquid exports, ARIMA model estimated only after transforming the variable under forecasting into a stationary series. The stationary series is the one whose values vary over time only around a constant mean and constant variance. There are several ways to ascertain this. The most common method is to check stationarity through examining the graph or time plot of the data. Non-stationarity in mean is connected through appropriate differencing of the data. In this case difference of order 1 was sufficient to achieve stationarity in mean.

The newly constructed variable Xt can now be examined for stationarity. The graph of Xt was stationary in mean. The next step is to identify the values of p and q. For this, the autocorrelation and partial auto correlation coefficients of various orders of Xt are computed.The Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) (Fig 1 and Fig 2) show that the order of p and q can at most be 1. We entertained three tentative ARIMA models and chose that model which has minimum AIC (Akaike Information Criterion) and SBC (Schwartz Bayesian Criterion). The models and corresponding AIC and SBC values are

	ARIMA (p, d, q)	AIC	SBC
1. Cashew kernels exports	**110**	**402.24**	**404.13**
	111	404.37	407.21
	112	406.59	410.38
2. CNSL	**110**	**344.33**	**346.21**
	111	345.53	348.36
	112	348.01	351.79

So the most suitable model is ARIMA (1, 1, 0) for cashew kernels and cashew nut shell liquid exports has the lowest AIC and SBC values.

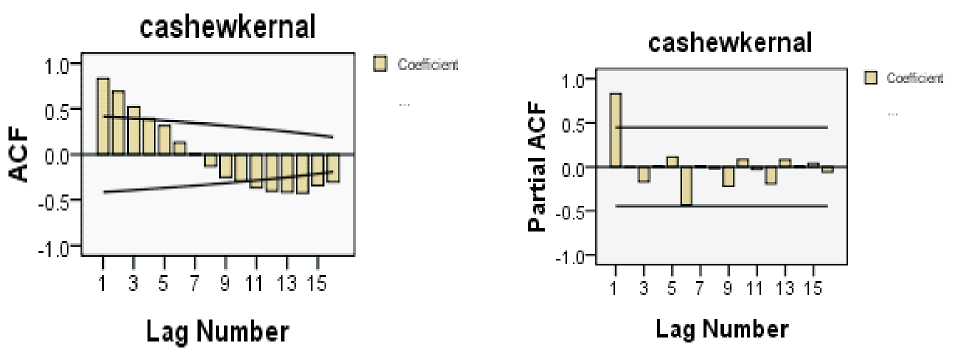

Fig.1 ACF & PACF of cashew kernal exports

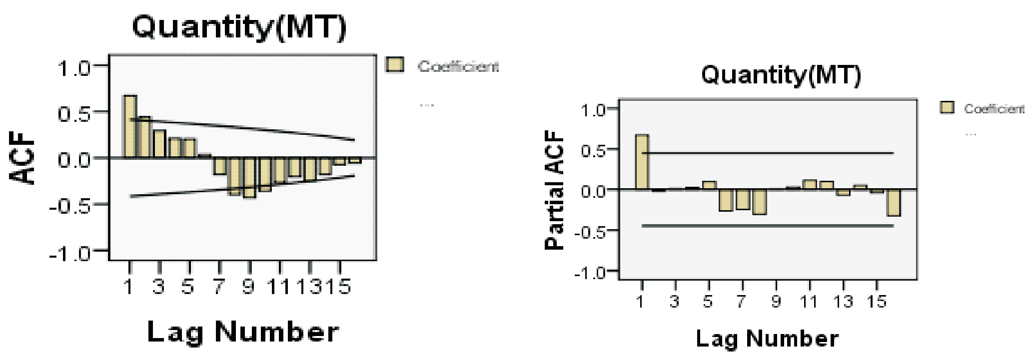

Fig.2 ACF & PACF of CNSL exports

Model Estimation and Verification

Cashew kernels and cashew nut shell liquid exports model parameters were estimated using SPSS package. Results of estimation are reported in Table 2 and Table 3. The model verification is concerned with checking the residual of the model to see if they contain any systematic pattern which still can be removed to improve the chosen ARIMA. This is done through examining the auto correlations and partial auto correlations of the residuals of various orders. For this purpose, the various correlations up to 16 lags were computed and the same along with their significance which is tested by Box-Ljung test provided in Table 4 and Table 5. As the results indicated none of these correlations significantly different from zero at a reasonable level for cashew kernels and cashew nut shell liquid exports. This proves that the selected ARIMA model is an appropriate model. The ACF and PACF of the residual (Fig 3 and Fig 4) also indicate "good fit" of the model.

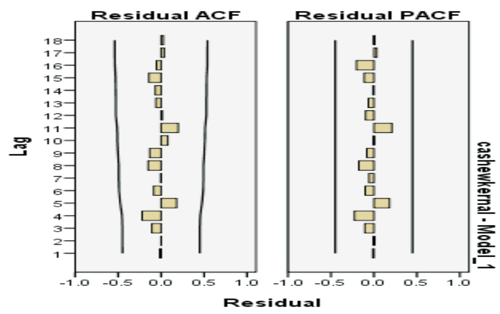

Fig 3 ACF and PACF of residuals of fitted ARIMA model for Cashew kernal exports

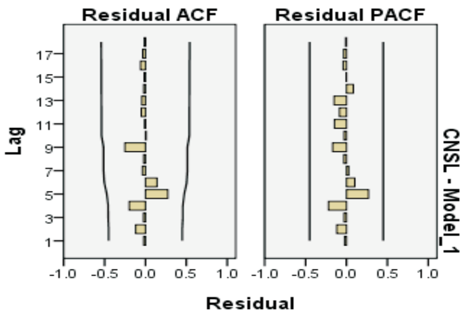

Fig 4 ACF and PACF of residuals of fitted ARIMA model for CNSL exports

Table:-2 Estimates of the fitted ARIMA model for Cashew kernal exports

Model Fit statistics						Box- Ljung Q- statistic	
St. R-sq.	R-sq.	RMSE	MAPE	MAE	Max. APE	Statistics	Sig
.13	.85	9060	8.08	7180	20.24	10.10	.89

Table:-3 Estimates of the fitted ARIMA model for CNSL exports

Model Fit statistics						Box- Ljung Q- statistic	
St. R-sq.	R-sq.	RMSE	MAPE	MAE	Max APE	Statistics	Sig
.02	.53	1977	62.54	1419	430.8	7.83	.97

St. R-sq.-Stationary R-Square, R-Sq.- R-Square, RMSE-Root Mean Square Error,

MAPE-Mean Absolute Percentage Error, MAE- Mean Absolute Error, MaxAPE-Maximum Absolute Percentage Error, MaxAE- Maximum Absolute Error

Forecasting with ARIMA model

ARIMA models are developed basically to forecast the corresponding variable. To judge the forecasting ability of the fitted ARIMA model important measure of the sample period forecasts accuracy was computed. The Mean Absolute Percentage Error (MAPE) for cashew kernel export turns out to be 8.08 and CNSL export turns out to be 62.5. This measure indicates that the forecasting inaccuracy is low. The table 6 shows forecasts for cashew kernel export and CNSL export during 2011 to 2015showing increasing trend are also given in Fig5 and Fig 6.

Table:- 4 ACF and PACF of residuals for Cashew kernal exports

Lag	ACF	Std. Error	Box-Ljung Statistic			PACF	Std. Error
			Value	df	Sig.		
1	-.369	.212	3.016	1	.082	-0.369	0.229
2	.143	.206	3.494	2	.174	0.008	0.229
3	-.042	.200	3.538	3	.316	0.015	0.229
4	-.244	.194	5.116	4	.276	-0.296	0.229
5	.293	.187	7.557	5	.182	0.139	0.229
6	-.214	.181	8.964	6	.176	0.040	0.229
7	.114	.173	9.398	7	.225	0.034	0.229
8	-.131	.166	10.019	8	.264	0.153	0.229
9	-.077	.158	10.253	9	.330	0.101	0.229
10	.044	.150	10.338	10	.411	0.108	0.229
11	.130	.142	11.180	11	.428	0.213	0.229
12	-.015	.132	11.192	12	.513	0.000	0.229
13	-.045	.123	11.328	13	.583	0.095	0.229
14	.000	.112	11.328	14	.660	0.020	0.229
15	-.092	.100	12.181	15	.665	0.022	0.229
16	-.026	.087	12.274	16	.725	0.234	0.229

Table 5:- ACF and PACF of residuals for CNSL exports

Lag	ACF	Std. Error	Box-Ljung Statistic			PACF	Std. Error
			Value	df	Sig.		
1	-.157	.212	.549	1	.459	-0.157	0.229
2	-.092	.206	.749	2	.688	-0.120	0.229
3	.029	.200	.769	3	.857	-0.007	0.229
4	-.237	.194	2.269	4	.686	-0.254	0.229
5	.279	.187	4.483	5	.482	0.218	0.229
6	.101	.181	4.793	6	.571	0.136	0.229
7	-.055	.173	4.895	7	.673	0.043	0.229
8	.029	.166	4.927	8	.765	0.002	0.229
9	-.251	.158	7.449	9	.591	-0.168	0.229
10	.049	.150	7.556	10	.672	-0.030	0.229
11	-.010	.142	7.561	11	.752	-0.139	0.229
12	-.044	.132	7.674	12	.810	-0.080	0.229
13	-.032	.123	7.740	13	.860	-0.172	0.229
14	-.014	.112	7.755	14	.902	0.062	0.229
15	-.008	.100	7.762	15	.933	0.011	0.229
16	-.052	.087	8.128	16	.945	-0.037	0.229

Table:-6 Forecasted values of Cashew kernels and Cashew Nut Shell Liquid (CNSL) exports with 95%Confidence Level (CL)

Year	Cashew Kernel (million tonnes)	LCL	UCL	CNSL Export (million tonnes)	LCL	UCL
2010-11	112990.8	93901.8	132079.7	9903.9	5624.0	14183.8
2011-12	115592.5	92946.7	138238.4	10135.6	4390.6	15880.7
2012-13	119015.1	92026.4	146003.8	10355.7	3295.5	17416.0
2013-14	122140.8	91838.5	152443.0	10577.6	2333.8	18821.4
2014-15	125373.8	91949.6	158798.0	10799.2	1445.8	20152.7

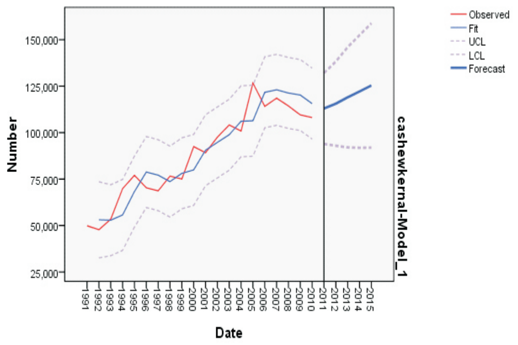

Fig.5 Trend in Cashew kernels Export

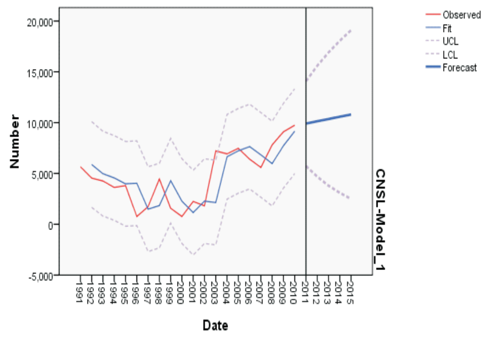

Fig.6 Trend in CNSL Export

CONCLUSION

In our study the developed model for cashew kernels and cashew nut shell liquid exports was found to be ARIMA (1, 1, 0). From the forecast available by using the developed model, it can be seen that forecasted cashew kernels and cashew nut shell liquid exports increases the next five years. The validity of the forecasted value can be checked when the data for the lead periods become available. The model can be used by researchers for forecasting cashew kernels and cashew nut shell liquid exports in India. However, it should be updated from time to time with incorporation of current data.

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