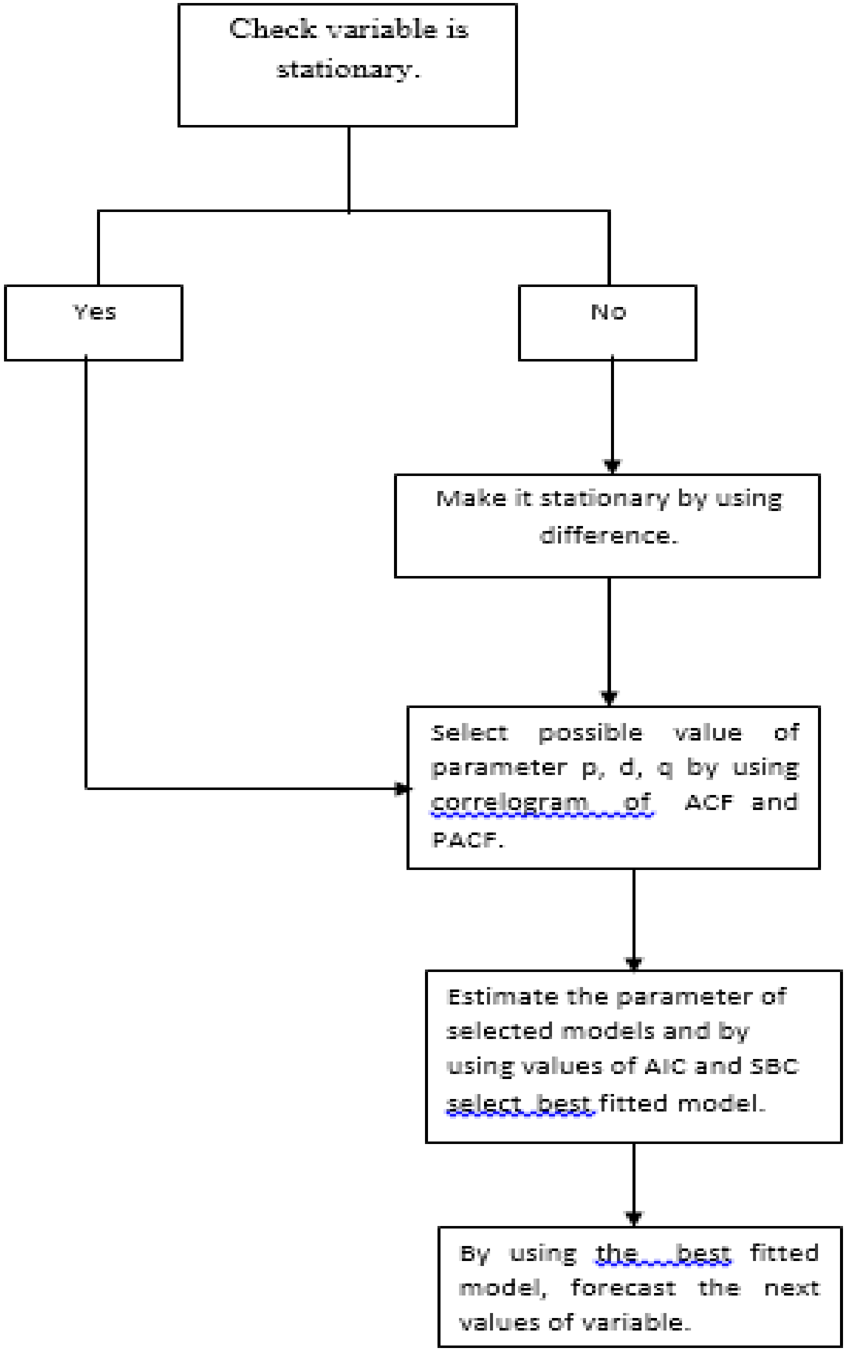
Time Series Model

Box Jenkins Methodology

ARIMA Model

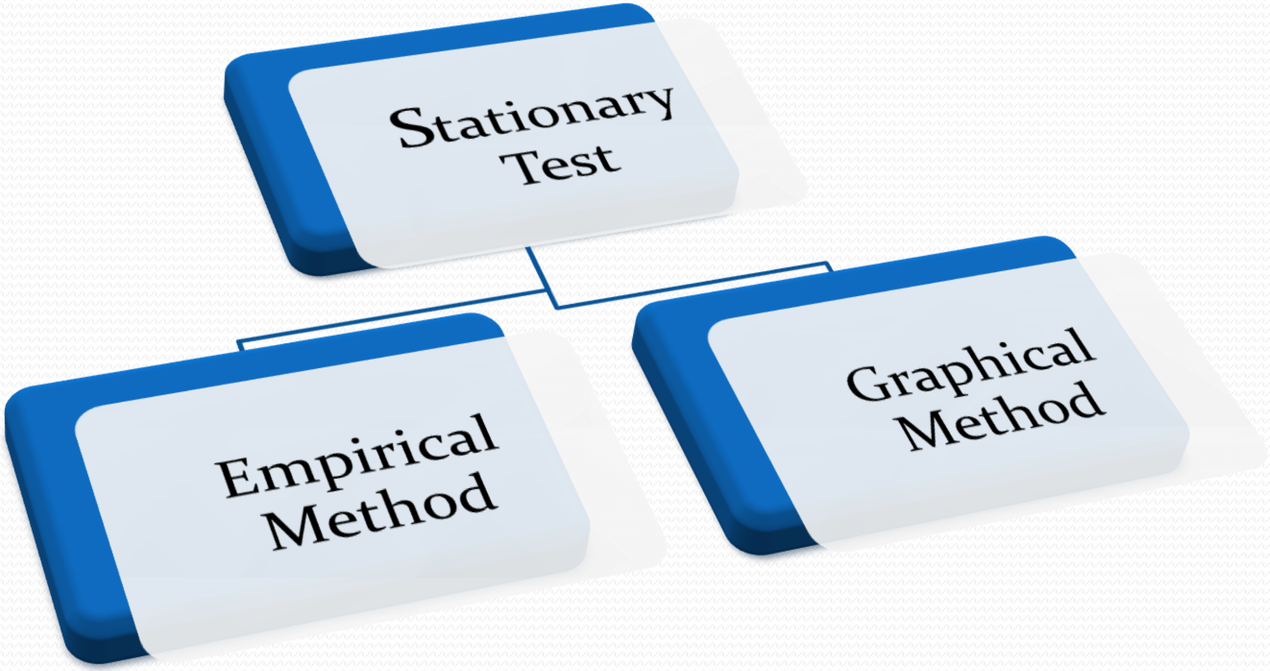
Box Jenkins Methodology

- To forecast the price of coconut oil we use time series model .There we use **Box Jenkins Method.** The box Jenkins method is applicable if it fulfill some assumption. The procedure is defined as below:


Check variable is stationary.
Yes
No
Make it stationary by using difference.
Select possible value of parameter p, d, q by using correlogram of ACF and PACF.
Estimate the parameter of selected models and by using values of AIC and SBC select best fitted model.
By using the best fitted model, forecast the next values of variable.

Stationary Test

- When the variable is no change in mean and variance for a long time, it said to be stationary. For applying Box Jenkins methodology ,variable must be stationary.



General Procedure

- Step 1 Hypothesis

  Ho: Data is not stationary.

  H1: Data is stationary.
- Step 2 Level of significance α=0.05
- Step3 Test statistic

1. Unit root test

   I. Augmented Dickey Fuller test (ADF Test)

   II. Phillip Perron test (PP Test)

2. Correlogram

- Step 4 Calculation

  On E-views& Excel

- Step 5 Critical region

On the basis of p-value. If the p-value less than level of significance reject Ho otherwise Don’t reject Ho.

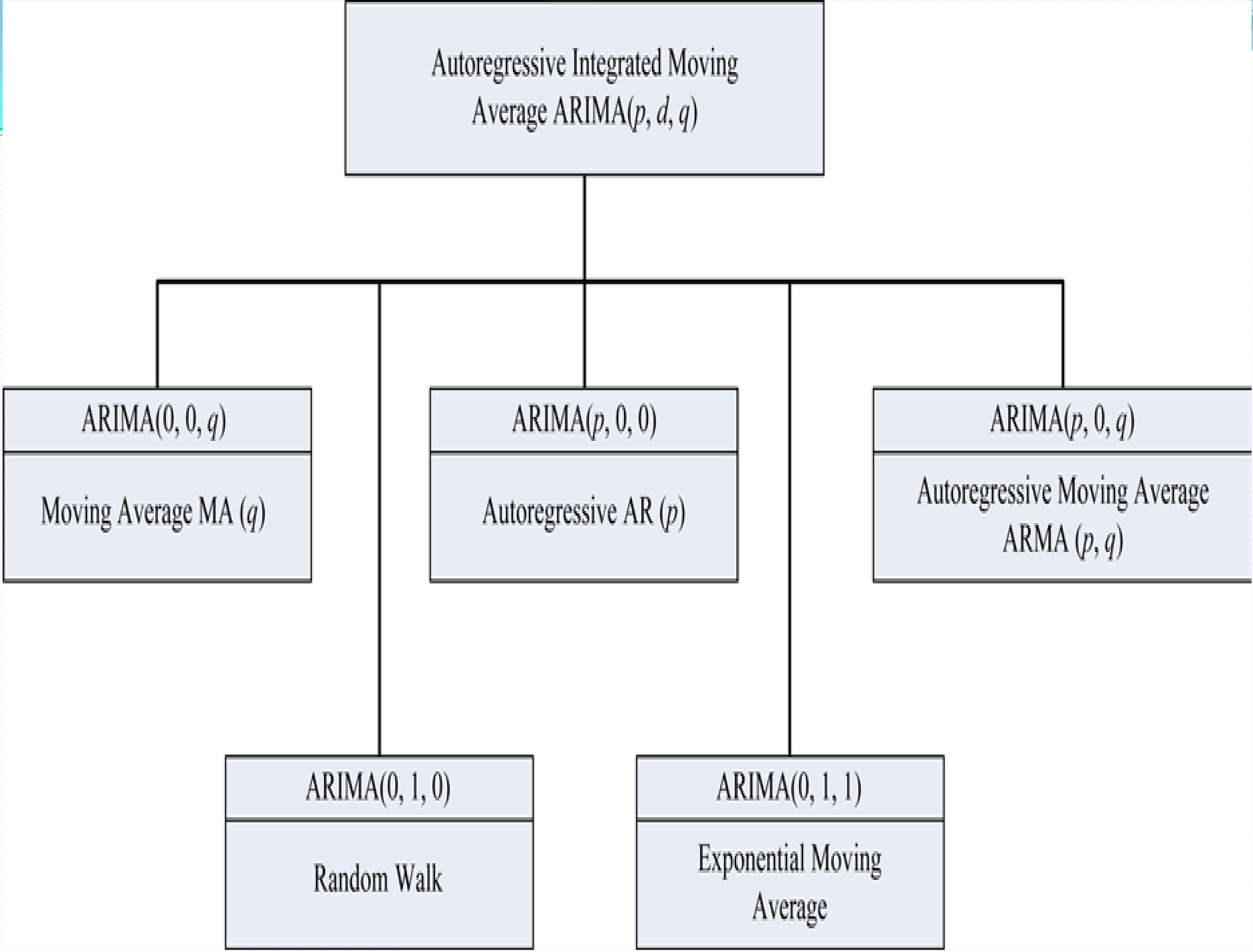
- Step6 Decision

If reject we conclude series is stationary otherwise we say series is non-stationary.

Autoregressive Integrated Moving Average (ARIMA): –

- A statistical technique that uses time series data to predict future. The parameters used in the ARIMA is (P, d, q) which refers to the autoregressive, integrated and moving average parts of the data set, respectively. ARIMA modeling will take care of trends, seasonality, cycles, errors and non-stationary aspects of a data set when making forecasts.

- Example: measuring the level of unemployment each month of the year would comprise a time series.


Autoregressive Integrated Moving Average ARIMA(p, d, q)
ARIMA(0, 0, q)
Moving Average MA (q)
ARIMA(p, 0, 0)
Autoregressive AR (p)
ARIMA(p, 0, q)
Autoregressive Moving Average ARMA (p, q)
ARIMA(0, 1, 0)
Random Walk
ARIMA(0, 1, 1)
Exponential Moving Average

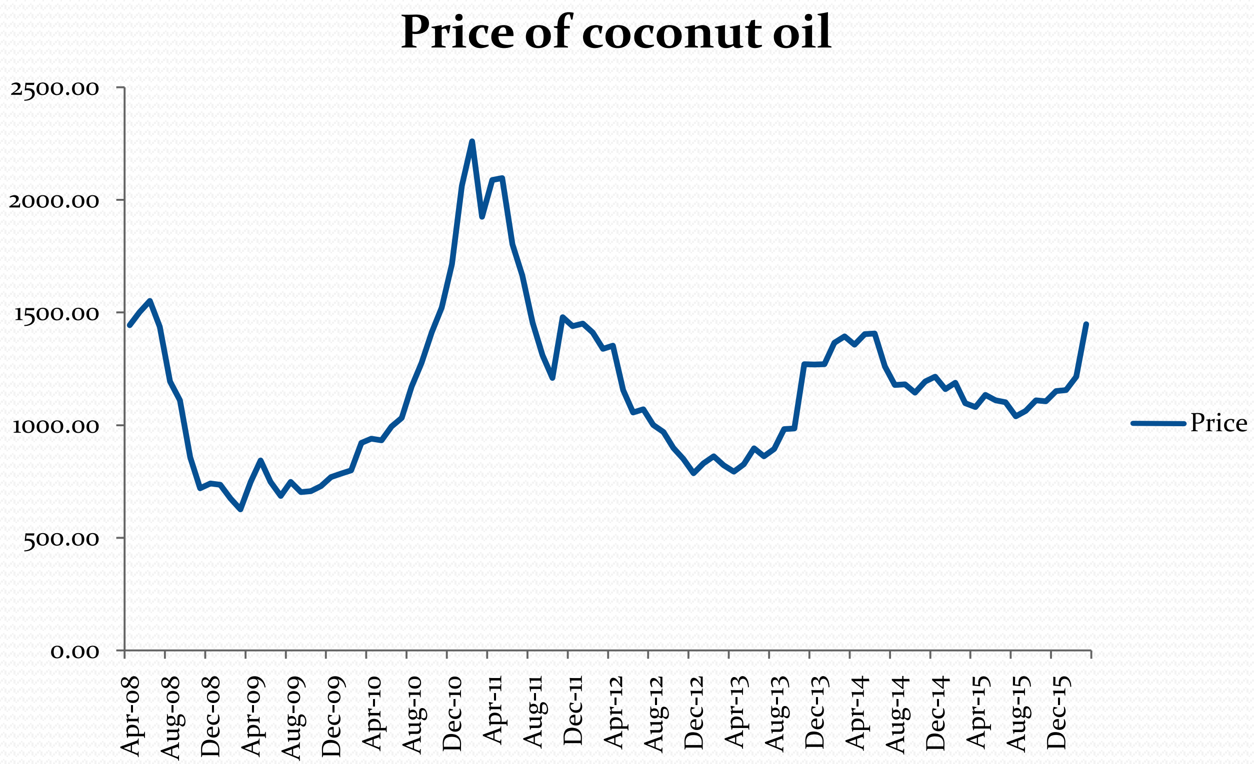
DIAGNOSTIC CHECK

- **ARMA (*p*, *q*)-model** has been fitted to a stationary time series. A diagnostic check for this model is suggested, using the estimated cross correlation function (CCF) between the observed series and the residuals.
- For **AR (*p*)-processes** the asymptotic covariance matrix of the estimated cross correlations is obtained.
- **Portmanteau statistic** for testing the adequacy of the model for various choices of m where m is the number of autocorrelations. Some of the commonly applied diagnostic checks are discussed subsequently
- For diagnostic use different tests ,**ex, unit root test,Box Jenkins test**. Make use of Box. Test() function to find p.
- If p-value is non zero then no serial correlation is there & model is fit & can be used for **forecasting purpose**

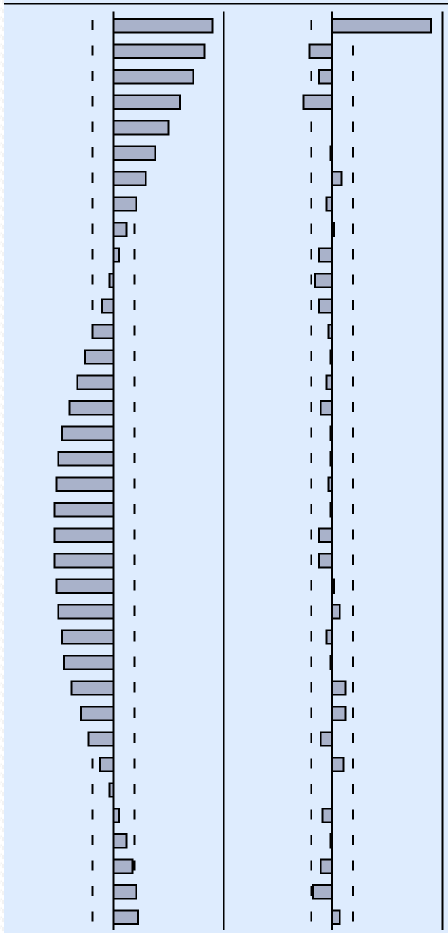
Data Analysis

- Check Stationary
- Model Identification and Parameter Estimation
- Make Possible Model
- Select best fitted Model
- Forecasting Accuracy
- For checking the accuracy of forecasting we apply forecasting checks.
- Analysis of forecasting value results
- Residual Analysis
- Conclusion

Check Stationary At Level

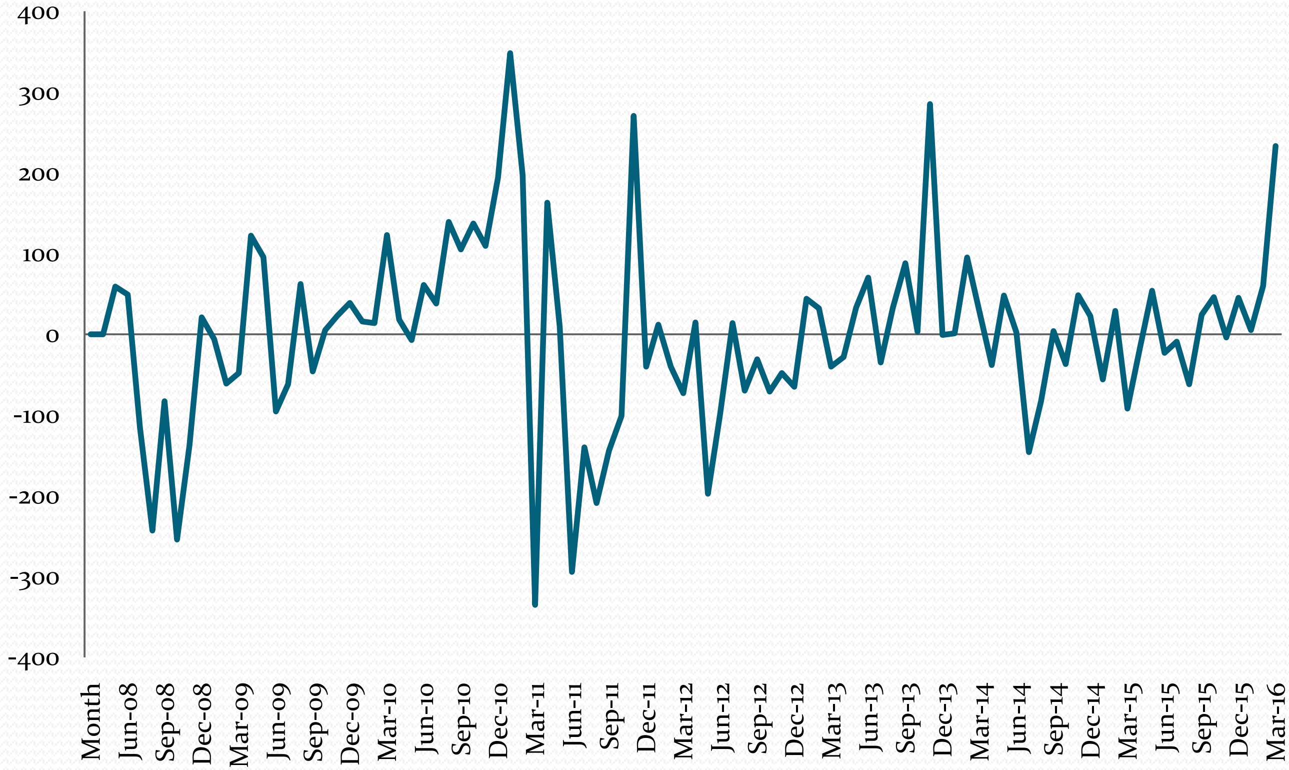


At Level



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.940	0.940	87.468	0.000
		2	0.857	-0.226	160.94	0.000
		3	0.761	-0.120	219.59	0.000
		4	0.639	-0.271	261.36	0.000
		5	0.517	-0.001	288.98	0.000
		6	0.401	-0.013	305.77	0.000
		7	0.299	0.083	315.21	0.000
		8	0.205	-0.064	319.71	0.000
		9	0.128	0.023	321.47	0.000
		10	0.054	-0.138	321.79	0.000
		11	-0.027	-0.165	321.87	0.000
		12	-0.110	-0.133	323.23	0.000
		13	-0.192	-0.043	327.41	0.000
		14	-0.270	-0.021	335.80	0.000
		15	-0.347	-0.061	349.77	0.000
		16	-0.420	-0.111	370.49	0.000
		17	-0.477	-0.014	397.53	0.000
		18	-0.516	-0.015	429.71	0.000
		19	-0.542	-0.036	465.64	0.000
		20	-0.551	-0.023	503.27	0.000
		21	-0.555	-0.118	541.87	0.000
		22	-0.558	-0.139	581.47	0.000
		23	-0.547	0.015	620.10	0.000
		24	-0.521	0.078	655.52	0.000
		25	-0.494	-0.063	687.86	0.000
		26	-0.460	-0.019	716.26	0.000
		27	-0.399	0.128	737.95	0.000
		28	-0.317	0.128	751.89	0.000
		29	-0.237	-0.110	759.79	0.000
		30	-0.139	0.109	762.54	0.000
		31	-0.036	0.007	762.73	0.000
		32	0.048	-0.089	763.06	0.000
		33	0.127	-0.009	765.47	0.000
		34	0.187	-0.099	770.77	0.000
		35	0.214	-0.183	777.85	0.000
		36	0.231	0.067	786.23	0.000

1st Difference



1st

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.260	0.260	6.6137	0.010
		2	0.120	0.056	8.0415	0.018
		3	0.285	0.259	16.190	0.001
		4	0.068	-0.074	16.662	0.002
		5	-0.037	-0.077	16.804	0.005
		6	-0.063	-0.125	17.218	0.009
		7	-0.041	0.007	17.394	0.015
		8	-0.169	-0.139	20.416	0.009
		9	-0.039	0.102	20.581	0.015
		10	0.078	0.106	21.241	0.019
		11	0.042	0.096	21.432	0.029
		12	-0.043	-0.124	21.640	0.042
		13	-0.077	-0.152	22.305	0.051
		14	0.010	-0.019	22.317	0.072
		15	-0.033	0.023	22.444	0.097
		16	-0.160	-0.109	25.431	0.063
		17	-0.139	-0.064	27.700	0.049
		18	-0.144	-0.075	30.176	0.036
		19	-0.165	-0.041	33.462	0.021
		20	-0.082	-0.010	34.287	0.024
		21	-0.041	-0.011	34.501	0.032
		22	-0.136	-0.106	36.820	0.025
		23	-0.172	-0.139	40.597	0.013
		24	-0.011	0.003	40.613	0.018
		25	-0.065	-0.072	41.167	0.022
		26	-0.243	-0.216	49.081	0.004
		27	-0.204	-0.179	54.719	0.001
		28	-0.022	0.097	54.786	0.002
		29	-0.129	-0.067	57.096	0.001
		30	-0.073	-0.021	57.845	0.002
		31	0.175	0.103	62.278	0.001
		32	0.003	-0.090	62.280	0.001
		33	0.089	0.060	63.465	0.001
		34	0.283	0.097	75.544	0.000
		35	0.185	-0.010	80.794	0.000
		36	0.108	0.019	82.619	0.000

Make Possible Model

Model(P,d,q)						
P	d	q	R saqure	Adj. R saqure	AIC	SBC
0	1	1	0.068504	0.058488	12.25194	12.30571
1	1	0	0.07084	0.060741	12.25753	12.31164
1	1	1	0.087	0.06699	12.261	12.342
1	1	2	0.0664	0.0459	12.283	12.364
1	1	3	0.1847*	0.1667*	12.148*	12.229*
1	1	4	0.071	0.0505	12.278	12.359
2	1	1	0.0714	0.0508	12.287	12.369
2	1	2	0.0328	0.0108	12.328	12.41
2	1	3	0.1433**	0.1242**	12.206**	12.288**
2	1	4	0.024	0.0023	12.337	12.418
3	1	1	0.1366	0.11722	12.215	12.297
3	1	2	0.094	0.0737	12.263	12.345
3	1	3	0.1421	0.1229	12.208	12.29
3	1	4	0.0877	0.0672	12.27	12.352

Forecasting Accuracy

- For forecasting purposes ARIMA (1,1,3) and ARIMA (2,1,3) models are used.

$$D(CP) = c + \alpha AR(p) + \beta MA(q) + u_i$$

- In ARIMA (1,1,3) we use AR (1) and MA(3) model so its estimated equation is

$$D(CP) = 1.3159 + .2233AR(1) + .4248MA(3)$$

- In ARIMA (2,1,3) we use AR(2) MA (3) model so its estimated equation is

$$D(CP) = .1554 + .0134AR(2) + .4527MA(3)$$

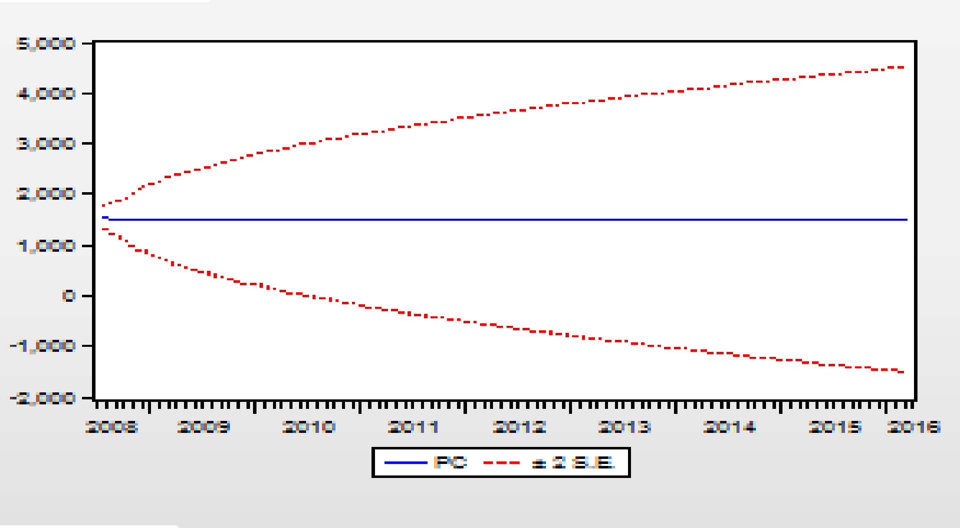
For checking the accuracy of forecasting we apply forecasting checks.

- RMSE (Root Mean Square Error)
- MAE (Mean Absolute Error)
- MAPE (Mean Absolute Percentage Error)

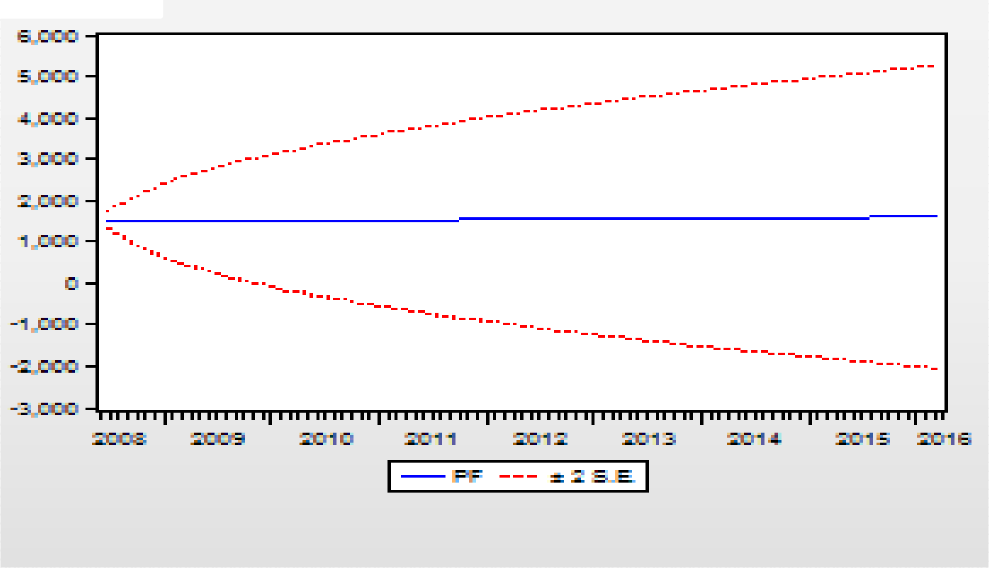
We select the model which has minimum RMSE, MAE, MAPE.

	ARIMA(1,1,3)	ARIMA(2,1,3)
RMSE	117.31	161.4107
MAE	142.6127	121.2254
MAPE	11.87828	9.982363

ARIMA(1,1,3)



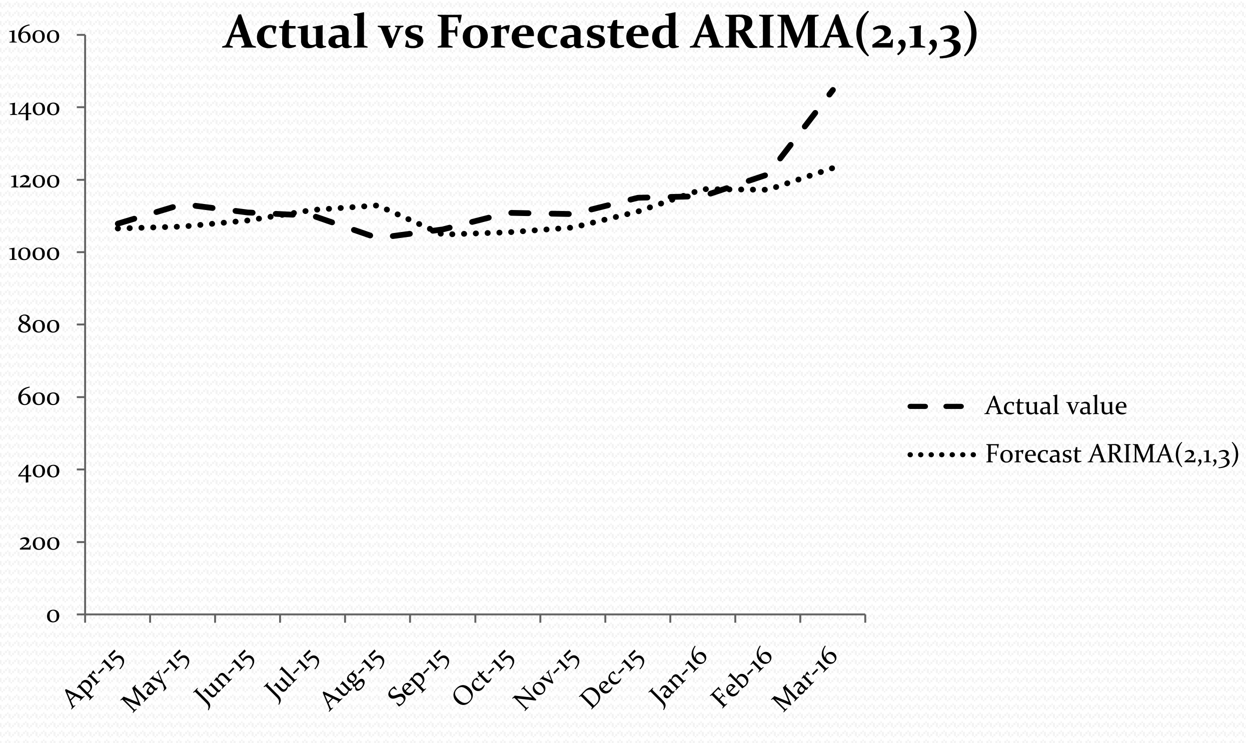
ARIMA(2,1,3)



ARIMA(1,1,3) & ARIMA(2,1,3)

Year	Actual value	Forecast ARIMA(1,1,3)	Error	Forecast ARIMA(2,1,3)	Error
Apr-15	1079	1047.34668	31.65332	1066.139152	12.86085
May-15	1133	1077.328907	55.67109	1070.703341	62.29666
Jun-15	1110	1104.452332	5.547668	1088.055767	21.94423
Jul-15	1101	1119.331555	-18.3316	1116.701167	-15.7012
Aug-15	1039	1123.662057	-84.6621	1129.051913	-90.0519
Sep-15	1063	1028.529812	34.47019	1048.968702	14.0313
Oct-15	1109	1061.595212	47.40479	1055.212224	53.78778
Nov-15	1105	1084.3306	20.6694	1068.701076	36.29892
Dec-15	1150	1119.772265	30.22774	1112.123791	37.87621
Jan-16	1155	1181.212339	-26.2123	1174.454134	-19.4541
Feb-16	1215	1165.919699	49.0803	1172.192866	42.80713
Mar-16	1448	1242.265678	205.7343	1232.37034	215.6297

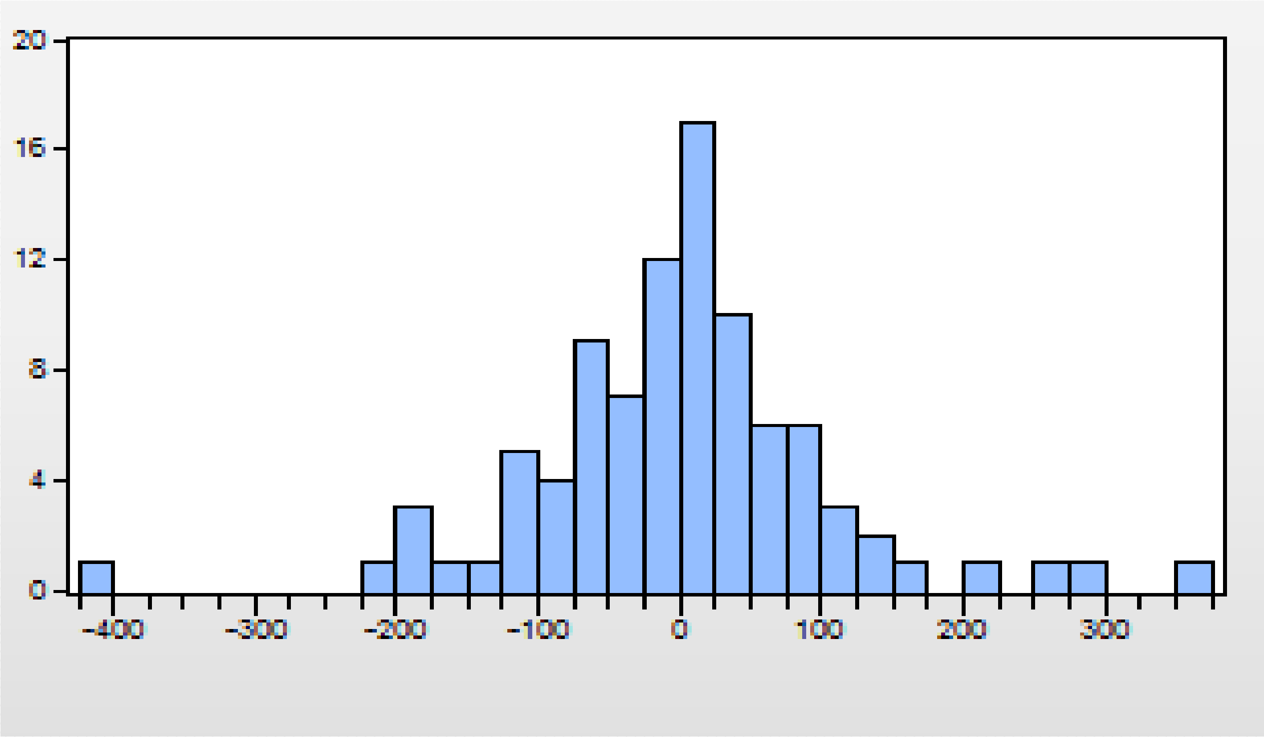
Actual Vs Forecast graph



Residual Analysis

- In Box-Jenkins methodology residual of best fitted model must be IID(Independent Identically Normally Distributed). For justifying the assumption we make its histogram & correlogram.

Histogram



Correllc

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.048	0.048	0.2195	
		2	0.184	0.182	3.5182	
		3	0.143	0.132	5.5369	0.019
		4	0.027	-0.015	5.6084	0.061
		5	0.091	0.044	6.4480	0.092
		6	0.021	-0.003	6.4914	0.165
		7	0.011	-0.016	6.5031	0.260
		8	0.272	0.266	14.199	0.027
		9	-0.038	-0.056	14.347	0.045
		10	0.074	-0.021	14.933	0.060
		11	0.047	-0.003	15.172	0.086
		12	-0.057	-0.068	15.530	0.114
		13	-0.049	-0.097	15.792	0.149
		14	-0.061	-0.032	16.203	0.182
		15	-0.080	-0.046	16.922	0.203
		16	-0.105	-0.161	18.178	0.199
		17	-0.109	-0.044	19.553	0.190
		18	-0.115	-0.083	21.113	0.174
		19	-0.101	-0.070	22.336	0.172
		20	-0.067	0.026	22.885	0.195
		21	-0.052	0.043	23.216	0.228
		22	-0.075	-0.034	23.913	0.246
		23	-0.108	-0.063	25.390	0.231
		24	0.053	0.177	25.754	0.262
		25	-0.117	-0.071	27.547	0.233
		26	-0.094	-0.064	28.704	0.231
		27	-0.025	0.052	28.790	0.273
		28	-0.002	0.045	28.790	0.321
		29	0.072	0.067	29.507	0.337
		30	-0.047	-0.043	29.822	0.372
		31	0.008	-0.009	29.830	0.423
		32	0.173	0.080	34.168	0.274
		33	-0.005	0.045	34.171	0.318
		34	0.053	-0.005	34.595	0.345
		35	-0.037	-0.153	34.800	0.382
		36	-0.044	-0.095	35.103	0.416

Conclusion

- In this study, a univariate time series model is selected by using the data of the monthly coconut price from Pakistan Web site. We apply Box-Jenkins methodology for forecasting the monthly coconut price. By using the Line Diagram, correlogram, ADF and PP Test we found that our data is stationary at the 1st difference. After the estimation of models, and by comparing the values of R square adjusted R square AIC and SBC we conclude that ARIMA (1,1,3) and (2,1,3) are very close to each other so we use both models for forecasting purposes. After forecasting the values, we check the accuracy by using MAE, MAPE, and RMSE. From the above study, it is found that ARIMA (2,1,3) is more efficient than ARIMA (1,1,3).