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Forecasting Major Fruit Production in Khyber Pakhtunkhwa, Pakistan

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ABSTRACT

The present study investigates the forecasting for major fruit production in Khyber Pakhtunkhwa. The study was based on secondary data covering a period of about 34 years i.e. starting from 1980-81 to 2013-14, whereas, ARIMA modeling has been employed to fit the best time series model for major fruit production i.e. Apple, Citrus, Peach, Pear, Plum. It reveals through the results that for major fruit production, the time series models were found to be most suitable as ARIMA (0, 1, 0), ARIMA (2, 2, 2), ARIMA (0, 1, 3), ARIMA (2, 1, 2), ARIMA (2, 1, 2) respectively having least values of forecast evaluation criteria. Hence it can be recommended that time series models were found suitable for forecasting major fruit production in Khyber Pakhtunkhwa.

Keywords: Forecast Evaluation Criteria, Diagnostics Measures, AIC, SIC, MAE, MSE, MAPE, ARIMA Modeling, Parameter Estimates, ADF test

Introduction:

Pakistan is blessed with large number of beautiful natural resources with variety of climatic conditions and having different agro-ecological zones. A large number of different varieties including tropical, subtropical, and temperate crops are sown in the favorable climatic conditions of Pakistan. Agriculture occupies a central position in Pakistan and contributes nearly 20.9% to the GDP. About 43.5% of the labor force is engaged in agriculture (Pakistan Economic Survey,

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2014-2015). The agriculture sector contributes significantly in the economy of Pakistan and is considered as the largest sector as well as the hub of economic activities. By the rapid increase in the growth rate of the population, the growth of the agriculture sector has been slowed down i.e. over 3% in 1980s while, during the year 2012-13, it was reported to be 2% which was still comparatively high. In the scenario of the current rate of increase in population growth, Pakistan will attain fifth position from the current running status of the sixth most populous country in the world ranking by the year 2050(Government of Pakistan, 2013).

Moreover, in some Northern areas of Khyber Pakhtunkhwa, there are significantly great potential for different types of fruits. Pakistan is the fifth largest producer of dates. Though the production of mangoes is in millions of tons annually, but the exported potential of the same is very low. In Khyber Pakhtunkhwa and Northern areas, there is a great potential for the promotion of peaches, citrus, apples, guava, strawberries, persimmon, apricots, plums, etc. Also, there is considerable scope for the growth and development of some different types of new fruits like strawberries, litchi, cherries, etc. in different regions of our country. Also, Government of Pakistan is playing special attention for promotion and encouragement of horticulture sector. In this scenario, Pakistan horticultural development and Export Company has also been established, to promote and support the growers for achieving self-sufficiency not only in their domestic demands, but also to boost the export sector. To embolden and bring in line the demands of international markets, there is an immense need to instruct new tools and practices to the farmers and processors, improve and implement the export marketing policies, attract the local and foreign investment, to generate an export adapted settings for the farmers to worth motivations through encouraging incentives, joint ventures arrangement for the commercial linkage with the international market companies etc. It can be attained by the use of worthy agricultural and administrative rehearses and according to the demands of international market and situational analysis. This sector has a great potential to provide opportunities for alleviation of poverty, hunger, increase income and curve down the socio-economic problems of the locality (Pakistan Horticultural Development and Export Board, 2011). Different studies have been made in the literature to forecast different phenomena. According to Ahmad and Mustafa (2006) developed an econometric model for the purpose of forecasting the exports potential of kinnow from Pakistan using time series data i.e. 1990-91 to 2002-03 for the year through 2023. They established ARIMA (2, 2, 2) as a suitable model for forecasting exports of kinnow. They argued that standard requirements by World Trade Organization (WTO) were to enhance the potential for the export demands of kinnow in the major international markets. Yusuf *et al*. (2007) studied pattern and future prospects of citrus and mango fruits production up to the year 2010 in Nigeria by using various forecasting techniques. They estimated the best ARIMA model and concluded that it can be used for short term forecasting. Also, Mehmood (2012) used uni-variate model to forecast the exports of Pakistan to SAARC and argued that the ARIMA model was appropriate one for forecasting time series data. Similarly, Ahmad *et al* (2005), Hassan and Ibnouf (2005), Dimyati(2005), Van Melle (2007), Munir and Khan (2008) estimated prospects of fruits and their related factors under various climatic conditions by using different forecasting approaches.

Material and Methods:

The present study is conducted by using time series data with effect from 1980-81 to 2013-14 i.e. time series data of 34 years, to forecast production for onward ten years regarding major fruits including Apple, Citrus, Peach, Plum, and Pear in Khyber Pakhtunkhwa, Pakistan. The time series data were collected from secondary sources of various issues of Fruits, Vegetables and Condiments Statistics, Crop Reporting Service of Khyber Pakhtunkhwa and were analyzed in Statistical Package Gretl1.9.4.

Analytical Techniques

Generally, ARIMA model technique has extensively been employed in literature to forecast the specific area as well as production related to different major crops (Munir, 2008; Gujrati, 2003).

Autoregressive Integrated Moving Average (ARIMA)

This model is a generalized form of the ARMA model introduced by Box and Jenkins (1976) which includes both autoregressive as well as moving average parameters, and also includes the differencing in the formulation of this model. ARIMA model is summarized as ARIMA (p, d, q). In ARIMA (p, d, q) model where p, d and q are the non-negative integers referred to as the order of the autoregressive integrated moving average process. It is an important part of the Box Jenkins approach to time series modeling. It can be written as;

$$\Delta^d Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots + \alpha_p Y_{t-p} + \varepsilon_t + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \cdots + \beta_q \varepsilon_{t-q} \text{-------} (1)$$

Where, Δ^d represents differencing of order d i.e. $\Delta Y_t = Y_t - Y_{t-1}$, $\Delta^2 Y_t = \Delta Y_t - \Delta Y_{t-1}$ and so forth, $Y_{t-1} \ldots Y_{t-p}$ shows lags of the variables.

Stationary Test: The first step in Box-Jenkins methodology is to find whether data is stationary or not. There are a number of tests which can be used to decide about the stationary of the variables. Augmented–Dickey–Fuller (1981), abbreviated as ADF, is the more popular test in literature due to its simplicity and powerfulness.

Mathematically,

$$\Delta y_t = a_0 + \lambda y_t + a_1 t + \sum_{i=1}^{p} \beta_i \, y_{i-1} + e_t \text{---------(2)}$$

There are three options in this equation

- a_0 is the intercept or drift parameter of the time series.
- t is the time trend in time series. There may be a downward or upward linear trend in the data.
- It is also possible that both drift and time trends exist in the data.

Diagnostic Measures for Selection of Best Forecasting Model

There are a few diagnostic checks that each estimated model has to fulfill and are as follows;

- Residuals are normally distributed
- The corresponding projected model is stable
- Residuals of the projected model are not serially correlated

a) The Q-Statistic: The Q-Statistic is used to test whether the set of auto correlation is significant i.e. diverse from zero. Box and Pierce (1970) make use of sample autocorrelation to form the statistics.

$$Q = T \sum_{k=1}^{s} r_k^2 \text{-------------(3)}$$

In the hypothesis testing procedure, the null hypothesis is that every value of r_k=0, and Q has asymptotically χ^2 distributed with s degrees of freedom. Moreover, it is better to use Ljung-Box (1978) in case of small samples in support of modified Q-statistic designed as;

$$Q = T(T+2) \sum_{K=1}^{S} {r_k^2}/_{T-K} \text{----------(4)}$$

It has χ^2 distribution with s degree of freedom.

b) **Jarque-Bera Test:** To check the normality of residuals Jarque-Bera (1978) test is used. It is based on the fact that skewness and kurtosis of the normal distribution are equal to zero. The corresponding test therefore an absolute value of these parameters and a measure of deviation from normal distribution. The Jarque-Bera statistic is calculated as follows;

$$Jarque - Bera = \frac{N-P}{6}\left[S^2 + \frac{(K-3)^2}{4}\right] \text{------------(5)}$$

Where S and K represents skewness and kurtosis respectively, of the distribution while p denotes estimated coefficients involved in the Jarque- Bera statistic, having asymptotic χ^2 distribution with a “2” degree of freedom.

Model Selection Criteria: Generally, the model selection criteria statistics are used to compare the fits of different forecasting and smoothing methods and also contribute a great deal of information by comparing the fits obtained through different methods. These measures include Mean absolute percentage error (MAPE), Mean absolute deviation (MAD), and Mean squared deviation (MSD). Akaike information criteria (AIC) and Schwartz information criteria (SIC). Smaller values of these accuracy measures indicate a good-fitted model with minimum forecasting error (Karim *et al*. 2010).

Results and Discussion:

1.1:-ARIMA Modeling for Apple Fruit Production: At first, it is very essential to find out the stationarity of the data for apple fruit production. It is important to consider that which order difference of time series sequence of apple fruit production satisfies the stationarity conditions. The plot of time series for apple fruit production is shown in Figure-1.1.

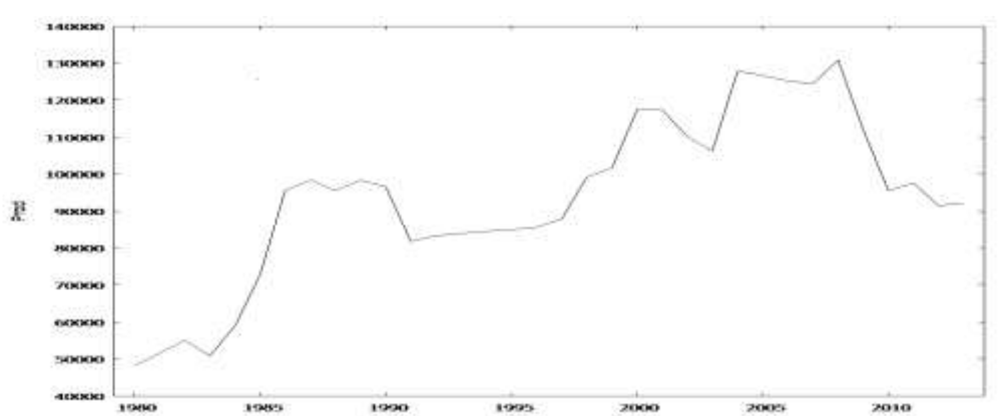


Figure-1.1:- Graph of Original series for Apple production

From the results of Dickey fuller test show that the original series is non-stationary as there is a unit root in the data presented in Table-1.1.

Table: 1.1:-Augmented Dickey Fuller Test for Apple Fruit Production

Production Series	**Null hypothesis**	**P-Value**	**Remarks**
Original series	a=1	0.2864	Non-Stationary
I[st] order difference	a=1	0.04419	Stationary

By taking the first difference, it is found that the stationarity condition is satisfied with the p-value =0.04, which strongly suggests that there is no unit root.

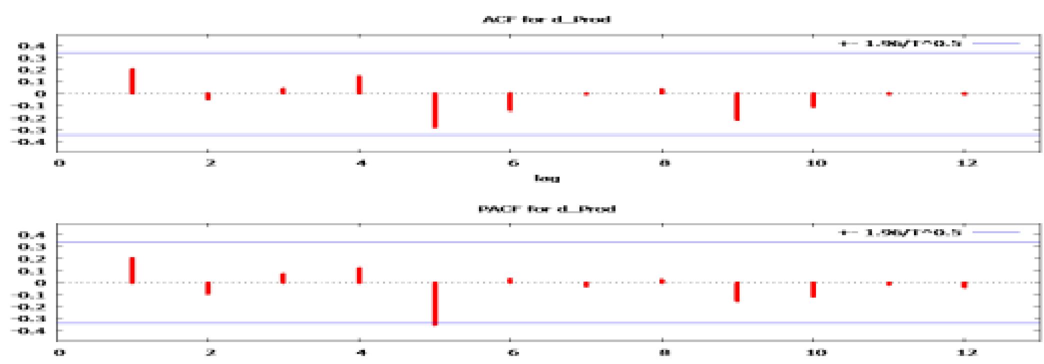


Figure-1.2:-ACF & PACF Plot of Ist order difference series for Apple Production

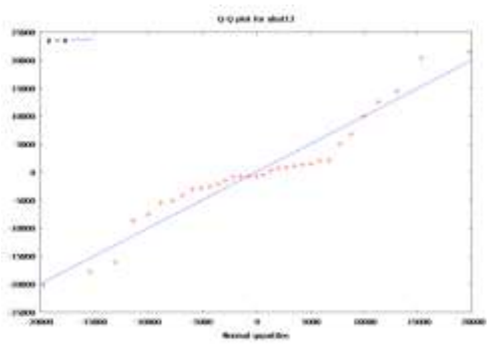
From Figure 1.2, it is evident that ACF & PACF of the differenced series the adequate tentative selected ARIMA model to forecast the apple fruit production in Khyber Pakhtunkhwa is ARIMA (0, 1, 0) at 5% level of significance. The best selected model has smallest MAE, MSE, MAPE, AIC and SIC. Table-1.2 presents model parameter estimates along with their significance.

Table:-1.2: Model: ARIMA (0, 1, 0), using observations from 1981-2013 (t = 33)

Dependent variable: Ist order difference of Apple Production

	Coefficient	*Std. Error*	*Z*	*P-value*
Const	1335.39	1582.49	0.8439	0.39875

1.2:-Model Diagnostics: To check the auto correlation assumption, the "Ljung-Box" test is used. Test statistic gives Q' = 17.34, with p-value = 0.500, which suggests that we may accept the assumption that there is no autocorrelation among the residuals of the fitted ARIMA model at 5% level of significance. To check the normality assumption, the Jarque Bera test is used resulting test statistic value = 1.1414, with p-value = 0.565129, which suggests that normality assumption of the residuals is valid. Graphical residuals diagnostics are shown in Figure-1.3 and Figure-1.4.



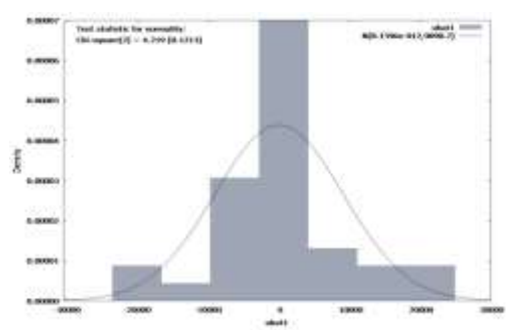


Figure-1.3:- Q-Q Plot of Residual *Figure: 1.4:-Histogram of Residual*

The Q-Q plots and histogram of residuals also show approximate normality. So, it can be concluded from the graphical and formal tests that the selected model ARIMA (0, 1, 0) is an adequate model to forecast apple production in Khyber Pakhtunkhwa.

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1.3:-Forecasting for Apple Fruit Production: The selected model is used for forecasting apple fruit production. In Table 1.3 the predicted values, standard errors, and lower and upper confidence limits for ten years onward values are given, for Khyber Pakhtunkhwa based on the sample data.

Table: 1.3:-Forecast for Apple Fruit Production

Year	Predicted Production	Std. Error	95% interval
2014	93603.39	9090.698	75785.95 - 111420.83
2015	94938.79	12856.188	69741.12 - 120136.45
2016	96274.18	15745.550	65413.47 - 127134.89
2017	97609.58	18181.395	61974.70 - 133244.46
2018	98944.97	20327.418	59103.96 - 138785.98
2019	100280.36	22267.571	56636.73 - 143924.00
2020	101615.76	24051.725	54475.24 - 148756.27
2021	102951.15	25712.376	52555.82 - 153346.48
2022	104286.55	27272.093	50834.22 - 157738.87
2023	105621.94	28747.310	49278.25 - 161965.63

By comparing the original and forecasted series it is obvious that the original series of Apple production shows increasing tendency in apple production with the passage of time and then decreases production following the same pattern in the next stages and finally showing decreasing pattern. Similarly the forecasted series shows the same pattern. In the forecasted plot in sample and out sample forecasting part is shown in Figure-1.5.

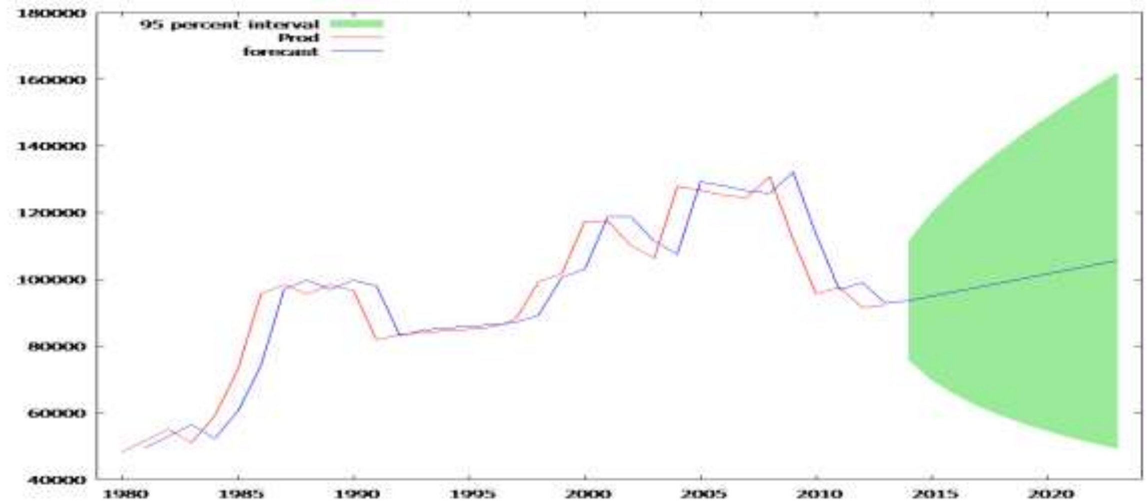

Figure 1.5: Forecast plot for Apple Production

2.1:-ARIMA Modeling for Citrus Production: Firstly, it is important to check the stationarity of the series by using the Dickey-Fuller unit root test. Also, it is worthwhile to consider which order difference of the time series sequence of citrus fruit production satisfies the stationarity conditions. The time series plots of citrus fruit production are shown in Figure 2.1.

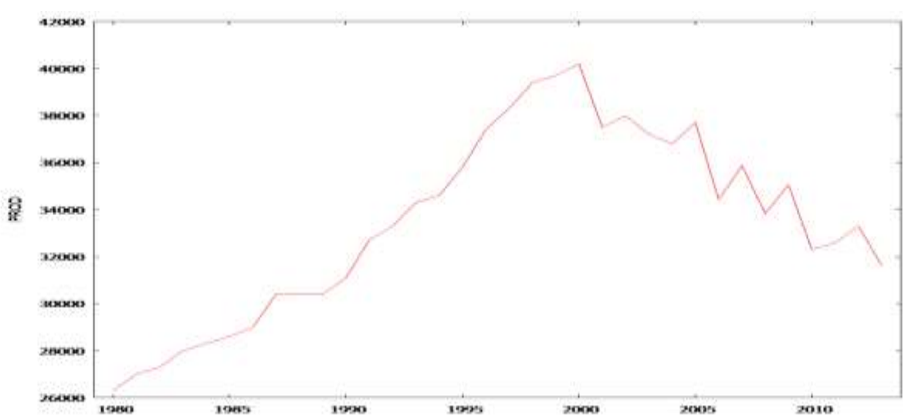

Figure-2.1:-Graph of original series for Citrus Production

By Augmented Dickey Fuller unit root test, it is evident that the original and first order difference series of citrus production do not show stationarity. The detailed results of the Augmented dickey fuller unit root test are presented in Table 2.1.

Table: 2.1:- Augmented Dickey-Fuller Test for Citrus Production

Production Series	Null hypothesis	P-value	Remarks
Original Series	a=1	0.1369	Non-stationary
Ist order difference	a=1	0.6049	Non-stationary
2nd order difference	a=1	0.00001	Stationary

From the Dickey fuller test it is found that stationarity is achieved at second order difference (p-value= 0.00001)

In Figure-2.2, it is clear that from the ACF and PACF plot, a tentative selected ARIMA model to forecast the citrus production in Khyber Pakhtunkhwa is ARIMA (2, 2, 2).

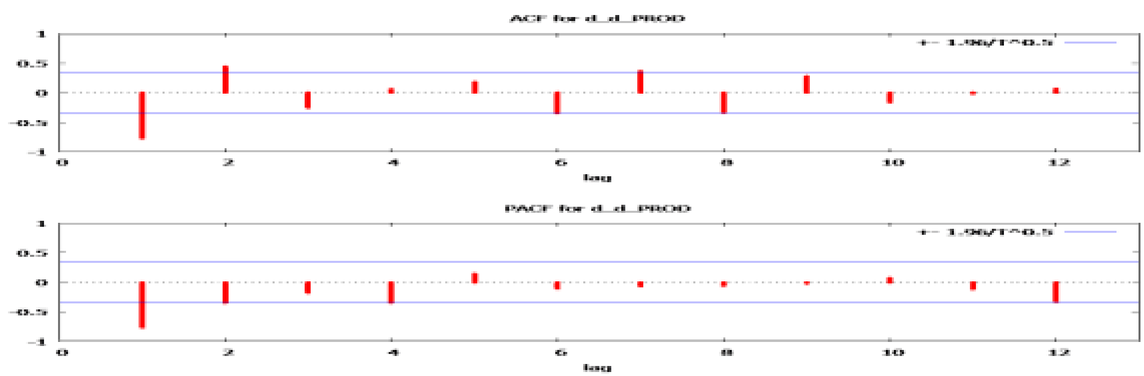

Figure-2.2:- ACF & PACF Plot Of Second Order difference series for Citrus Production

Among various fitted models, ARIMA (2, 2, 2) is found to be the best model for forecasting citrus fruit production in Khyber Pakhtunkhwa. The selected model has the smallest MAE, MSE, MAPE, AIC and SIC.

Table 2.2 presents model parameter estimates along with their significance;

Table:2.2:-Model : ARIMA(2,2.2), using observations from 1982-2013 (t = 32)

Dependent variable: Second Order difference of Citrus Series

	Coefficient	*Std. Error*	*Z*	*p-value*	
Const	-28.0732	54.2835	-0.5172	0.60505	
phi_1	-1.61746	0.168194	-9.6166	<0.00001	***
phi_2	-0.737406	0.168941	-4.3649	0.00001	***
theta_1	0.42665	0.27054	1.5770	0.11479	
theta_2	-0.459045	0.244969	-1.8739	0.06095	*

2.2:-Model Diagnostics: Furthermore, that Ljung- Box Q' =15.85, with p-value = 0.322. This suggests that there is no autocorrelation among the residuals of the fitted ARIMA model at 5% level of significance. To check the normality assumption, "Jarque-Bera" test is used. The Jarque-Bera test = 0.141889 having p-value = 0.931514, which indicates that the normality assumption of the residuals is valid.

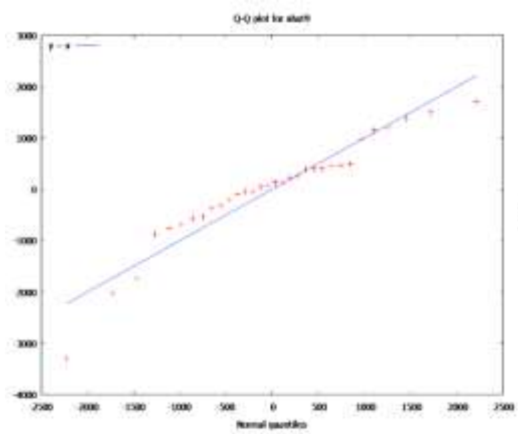

Figure-2.3:-Q-Q Plot of Residual

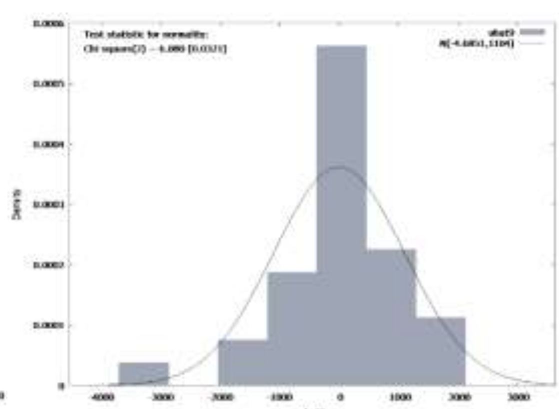

Figure- 2.4: Histogram of Residual

The Q-Q plot and histogram of residuals in Figure-2.3 and Figure-2.4 show picture of approximate normality for residuals. Thus our fitted model ARIMA (2, 2, 2) is an adequate model for forecasting citrus fruit production in the Khyber Pakhtunkhwa.

2.3 :-Forecast for Citrus Fruit Production: After selecting the best-fitted model the next stage is to forecast citrus production for onward ten years based on the available sample data. Also, the predictions, standard error, and lower and upper confidence limits for onward ten years are given in Table 2.3.

Table-2.3:-Forecast for Citrus Fruit Production

Year	Predicted Production	Std. Error	95% interval
2014	32801.61	1008.565	30824.86 - 34778.36
2015	30937.95	1297.403	28395.09 - 33480.82
2016	31802.09	1879.273	28118.79 - 35485.40
2017	30397.43	2467.072	25562.06 - 35232.81
2018	30556.79	3046.434	24585.89 - 36527.69
2019	29765.26	3806.065	22305.51 - 37225.01
2020	29264.26	4456.724	20529.24 - 37999.27
2021	28900.34	5300.882	18510.80 - 39289.88
2022	28006.27	6055.179	16138.34 - 39874.20
2023	27774.43	6946.549	14159.45 - 41389.42

Moreover, it is also possible to compare the original and predicted citrus production graphically as given in Figure 2.5. In the forecasted plot, in-sample and out-sample forecasting parts are shown. The original citrus fruit production shows initially an upward tendency but with time, it shows a downward tendency. The forecast for citrus production represents generally a downward tendency in the onward time period of ten years.

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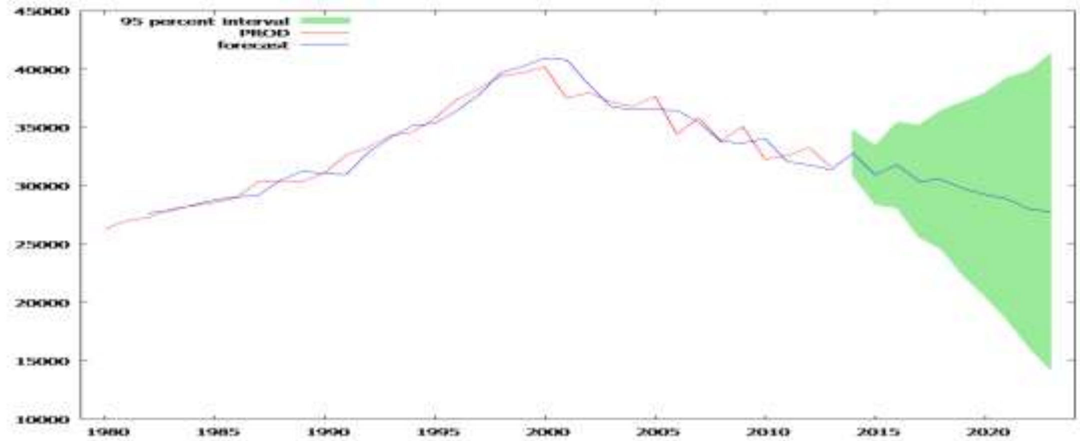


Figure-2.5: Forecast plot for Citrus fruit Production

3.1:-ARIMA Modeling for Peach Production: The time series plot for peach production is presented in Figure-3.1 indicates trend in data and does not show constant mean and variance over time i.e. up-ward trend initially and then down-ward trend in the end which indicates non-stationarity, after removing two extreme outliers from the data. The first order difference of the data makes the series stationary.

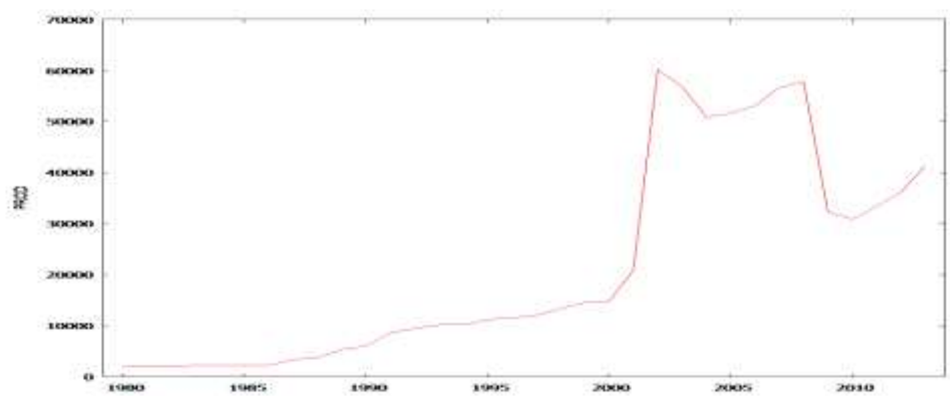


Figure: 3.1:-Graph of Original Series for Peach production

The results of Dickey fuller unit root test, show stationarity at first order difference as its p-value = 0.003267, which suggest that there is no unit root at first order difference and have constant variance as shown in Table-3.1.

Table:3.1:- Augmented Dickey Fuller Test for Peach Production

Production Series	Null hypothesis	P-value	Remarks
Original Series	a=1	1	Non-stationary
I[st] order difference	a=1	0.003267	stationary

The tentative model based on ACF and PACF plot are given in Figure-3.2 is ARIMA (0, 1, 3).

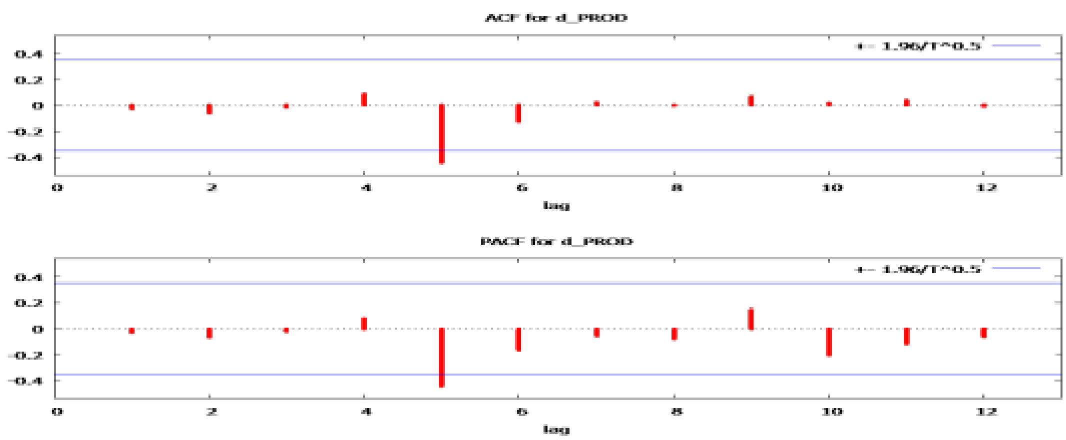


Figure-3.2:- ACF & PACF Plot of first Order difference series for Peach Production

Also, various neighbor models when fitted give the best fitted model as (0, 1, 3) having lowest accuracy measures i.e. MAE, MSE, and MAPE as compared to other subset models. Table 3.2 presents model parameter estimates and their significance.

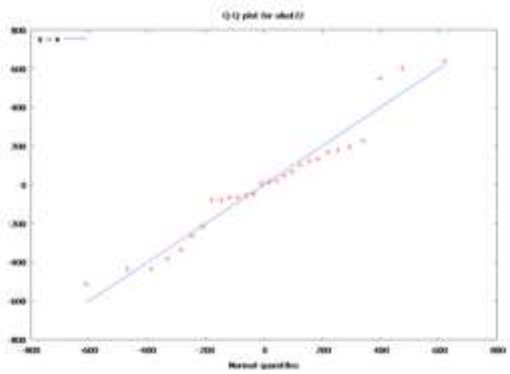
Table :-3.2:- Model: ARIMA(0,1,3), using observations from 1982-2013 (t = 32)

Dependent variable: First-order difference for Peach Production

	Coefficient	Std. error	Z	P-value
const	1626.10	305.881	5.316	1.06e-07 ***
theta_1	-0.114589	0.246979	-0.4640	0.6427
theta_2	-0.452306	0.150408	-3.007	0.0026 ***

theta_3	-0.433105	0.186973	-2.316	0.0205	**

3.2:- Model Diagnostics: The Ljung- Box test Q' = 12.002 has p-value= 0.800 suggesting that there is no autocorrelation among the residuals of the fitted ARIMA model at a 5% level of significance after removing two extreme outliers from the data. By applying the Jarque-Bera normality test of residuals it is found that Jarque-Bera test = 4.9737 has a p-value = 0.0832 which indicates that the normality assumption of residuals is valid.



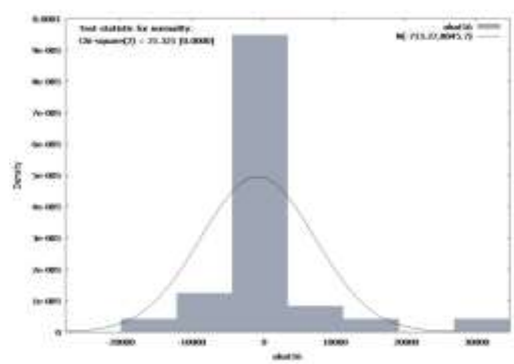


Figure: 3.3:- Q-Q Plot of Residual

Figure: 3.4:-Histogram of Residual

The Q-Q plot and histogram in Figure-3.3 and Figure-3.4 show picture of approximate normality for residuals after removing two extreme outliers from the data. Thus our fitted model ARIMA (0, 1, 3) is an adequate model for forecasting peach fruit production in Khyber Pakhtunkhwa.

3.3:-Forecast for Peach Production: The selected model is used to forecast the peach production for onward period of ten years i.e. from 2014 to 2023. The predicted values, standard errors, and lower and upper confidence limits are presented in Table 3.3.

Table-3.3:-Forecast for Peach fruit Production

Year	Prediction	Std. Error	Confidence Interval

2014	47511.89	14067.824	19939.47 - 75084.32
2015	49660.31	16244.124	17822.41 - 81498.20
2016	51860.60	18161.483	16264.75 - 87456.46
2017	54112.79	19894.908	15119.49 - 93106.10
2018	56416.87	21488.956	14299.29 - 98534.45
2019	58772.84	22972.661	13747.25 - 103798.43
2020	61180.70	24366.186	13423.85 - 108937.55
2021	63640.45	25684.215	13300.31 - 113980.58
2022	66152.08	26937.832	13354.90 - 118949.26
2023	68715.61	28135.648	13570.75 - 123860.47

Moreover, it is possible to compare the original (after removing two extreme outliers) and predictions for peach production are graphically given in Figure 3.5. By comparing the original and forecasted peach production, it is quite clear that peach production shows an upward production tendency and the forecasted series also shows the same upward production tendency. The in-sample and out-sample forecasting shows same pattern for forecasting peach production in Khyber Pakhtunkhwa.

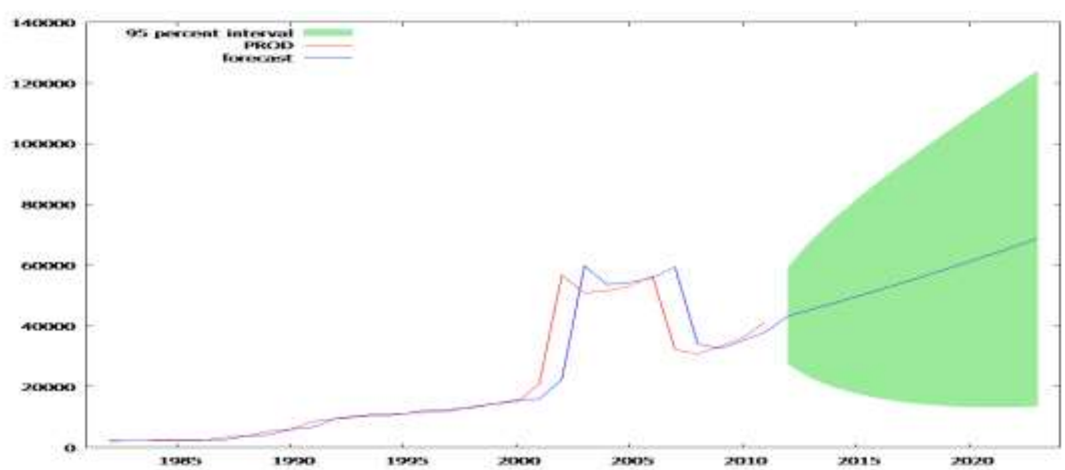


Figure-3.5: Forecasting Plot for Peach Production

4.1:-ARIMA Modeling for Pear Production: The original time series graph is shown in Figure-4.1 indicates trend in data and does not show constant mean and variance over time. It shows upward trend initially and then downward trend with the passage of time, which indicates non-stationarity in the data.

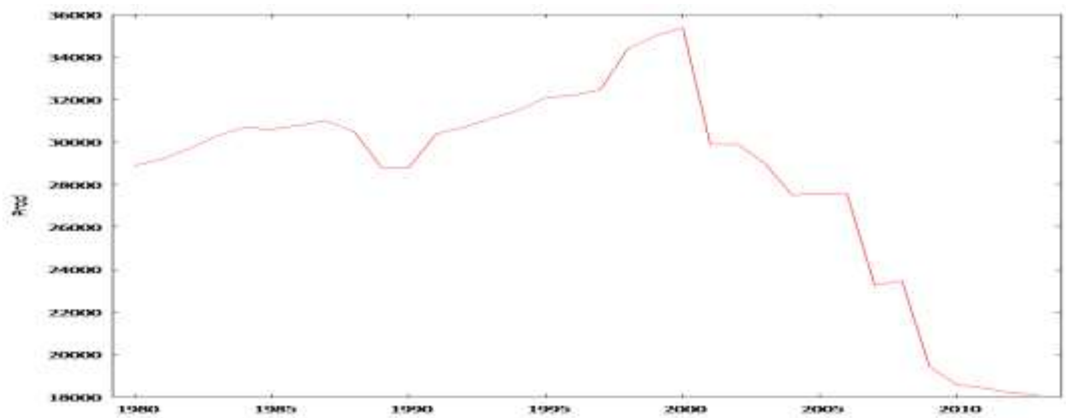


Figure: 4.1:- Graph of Original Series for Pear Production

To check the stationarity of data, Dickey fuller unit root test is used. From the Dickey fuller test it is evident that stationarity condition is not satisfied for original pear production series as presented in Table-4.1.

Table:4.1:- Augmented Dickey Fuller Test for Pear Production

Production Series	**Null hypothesis**	**P-value**	**Remarks**
Original Series	a=1	0.3218	Non-stationary
Ist order difference	a=1	0.001108	Non-stationary

By first order differencing, it is found in Figure-4.2, that stationarity is achieved with the p-value = 0.0001108, which suggests that there is no unit root at first order difference for pear production. So, it is obvious that at first order difference the series has become stationary.

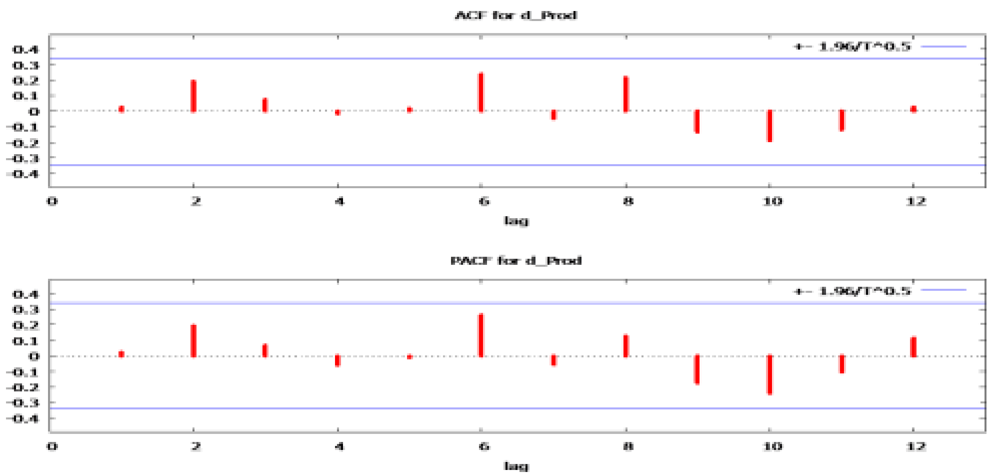


Figure-4.2:-ACF and PACF Plot of Ist Order Difference of Pear Production

From the tentative analysis, the selected ARIMA model to forecast the pear fruit production in Khyber Pakhtunkhwa is ARIMA (2, 1, 2) based on forecast evaluation criteria.

Table 4.2 presents the model parameters summary along with their significance

Table: 4.2:-Model : ARIMA(2,1,2), using observations from 1981-2013 (t = 33)

Dependent variable: Ist order difference of Pear Production

	Coefficient	**Std. error**	**Z**	**P-value**
const	-312.150	302.892	-1.031	0.3027
phi_1	0.557703	0.225187	2.477	0.0133**
phi_2	-0.663643	0.151622	-4.377	1.20e-05***
theta_1	-0.578509	0.134684	-4.295	1.74e-05***
theta_2	1.00000	0.149411	6.693	2.19e-011 ***

4.2:-Model Diagnostics: To check out the Auto correlation assumption the “Ljung-Box” test is used. From the test, it is found that Ljung-Box Q'= 4.64 with p-value = 0.990, which suggests that there is no autocorrelation among the residual of the fitted ARIMA model at a 5% level of significance. To check the normality assumption, the Jarque Bera test is used. The Jarque-Bera test

= 5.167 having p-value =0.0755, which indicates that the normality assumption of the residuals is valid. Graphical representations of residuals diagnostics are shown in Figure 4.3 and Figure 4.4

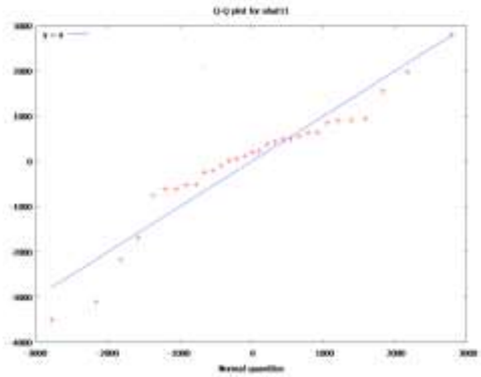


Figure: 4.3:- Q-Q Plot of Residual

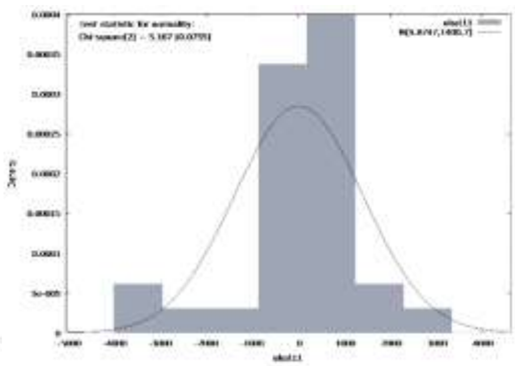


Figure: 4.4:- Histogram of Residual

The Q-Q plot and histogram in Figure 4.3 and Figure 4.4 show a picture of approximate normality for residual. Thus our fitted model ARIMA (2, 1, 2) is an adequate model to forecast Pear production in Khyber Pakhtunkhwa.

4.3:-Forecasting Pear Fruit Production: The selected model is used for forecasting the pear production for onward ten years in Khyber Pakhtunkhwa along with their respective predicted values, standard errors, and lower and upper confidence limits, based on the sample data are shown in Table 4.3.

Table-4.3:-Forecast for Pear Fruit Production

Years	Predicted Production	Std. Error	95% interval
2014	17811.14	1364.076	15137.60 - 20484.68
2015	30937.95	1297.403	28395.09 - 33480.82
2015	17834.37	1909.132	14092.54 - 21576.20
2017	30397.43	2467.072	25562.06 - 35232.81
2016	17696.46	2609.311	12582.30 - 22810.61
2019	29765.26	3806.065	22305.51 - 37225.01
2017	17258.91	3314.934	10761.76 - 23756.06
2021	28900.34	5300.882	18510.80 - 39289.88
2018	16761.19	3820.277	9273.59 - 24248.80

2023	27774.43	6946.549	14159.45 - 41389.42

By comparing the original and predicted pear production, it is evident that the original pear production series shows increasing tendency with the passage of time i.e. with effect from year 1980-1995. But with the passage of time, it shows decline in pear production with effect from year 1996 to onward. Similarly, predicted period also shows the same declining pattern. In the predicted plot, in sample and out sample forecasting part is shown in Figure 4.5. The forecast for pear production represents generally a downward tendency in the onward time period of ten years.

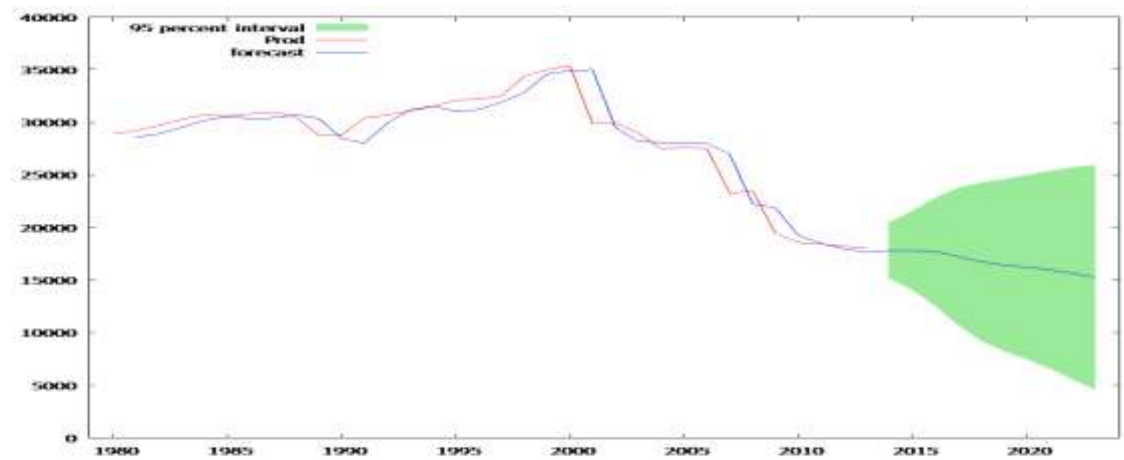


Figure-4.5: Forecasting Plot for Pear Production

5.1:-ARIMA Modeling for Plum Production: In plum fruit production as shown in Figure-5.1, the time series plot indicates the trend in data and does not show constant mean and variance over the given period. It shows an upward trend initially and then a down-ward tendency with effect from 2001-02 which indicates non-stationarity.

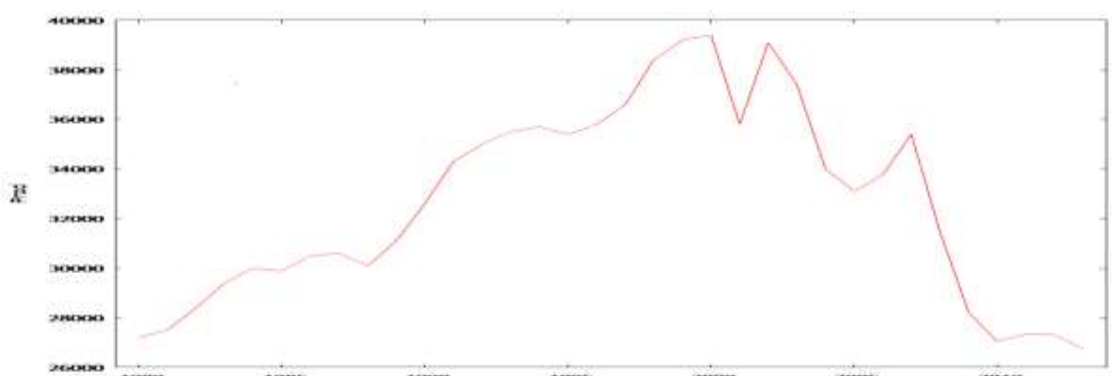


Figure: 5.1:-Graph of Original Series for plum production

To check stationarity in the plum production series, augmented dickey fuller unit root test is used. It shows that the original series is non-stationary as there is unit root in the data. By taking first-

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order difference, it is found that stationarity is achieved with p-value = 0.005062, which suggests that there is no unit root as presented in Table 5.1.

Table: 5.1:- Augmented Dickey-Fuller Test for Plum Production

Production series	Null hypothesis	P-value	Remarks
Original series	a=1	0.6721	Non-stationary
I[st] order difference	a=1	0.005062	Non-stationary

Moreover, it is clear from ACF and PACF plot of the first order differenced series that a tentative selected ARIMA (2, 1, 2) is an adequate time series model to forecast plum production in Khyber Pakhtunkhwa on the basis of forecast evaluation criteria.

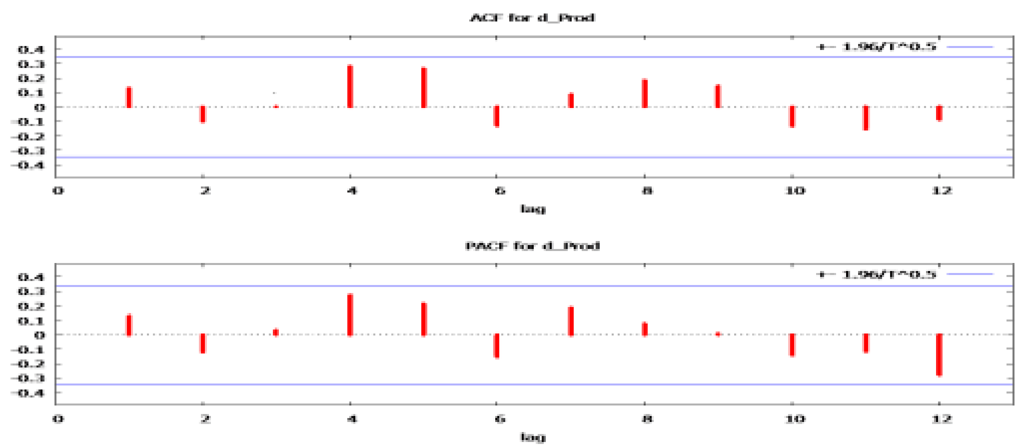

Figure-5.2:- ACF and PACF Plot of I[st] Order Difference for Plum Production

Table-5.2 presents model parameter estimates along with their significance

Table: 5.2:-Model : ARIMA(2,1,2), using observations from 1981-2013 (t = 33)
Dependent variable: I[st] Order difference of Plum Production

	coefficient	std. error	z	p-value	
const	-11.3913	214.744	-0.05305	0.9577	
phi_1	-0.0189013	0.170139	-0.1111	0.9115	
phi_2	-0.942464	0.147409	-6.394	1.62e-010	***
theta_1	0.139206	0.240436	0.5790	0.5626	
theta_2	0.891072	0.253863	3.510	0.0004	***

5.2:-Model Diagnostics: The Ljung-Box test is used to check Autocorrelation assumption, that is Ljung-Box Q' =11.37 with p-value = 0.657. This suggests that there is no autocorrelation among the residuals of the fitted ARIMA model at 5% level of significance. To check the normality assumption, "Jarque-Bera" test is used, the Jarque-Bera test = 5.46007 having p-value 0.0652169 which indicates that the normality assumption of the residuals is valid.

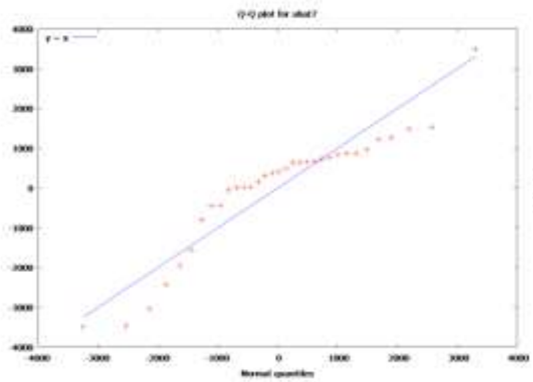

Figure:-5.3:- Q-Q Plot of Residual

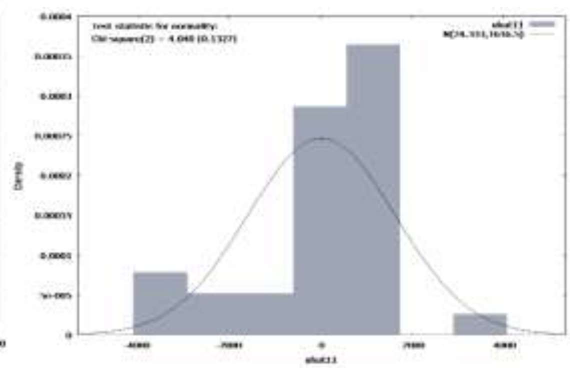

Figure:-5.4:-Histogram of Residual

The Q-Q plot and histogram presented in Figure 5.3 and Figure 5.4 show a picture of approximate normality for residuals. Thus our fitted model ARIMA (2, 1, 2) is an adequate model for forecasting plum fruit production in the Khyber Pakhtunkhwa.

5.3:-Forecasting Plum Fruit Production: After selecting the best-fitted model, the next stage is to forecast plum production for onward ten years based on the available sample data. Also, the forecast for onward ten years with their corresponding predicted values, standard errors, and lower and upper confidence intervals i.e. from 2014 to 2023 are given in Table 5.3.

Table 5.3:- Forecast for Plum Fruit Production

Year	Predicted Production	Std. error	95% interval
2014	27155.79	1479.476	24256.07 - 30055.51
2015	28017.90	2221.719	23663.41 - 32372.39
2016	27597.76	2725.130	22256.60 - 32938.92
2017	26770.85	3069.132	20755.47 - 32786.24
2018	27160.10	3411.605	20473.48 - 33846.73
2019	27909.73	3787.489	20486.39 - 35333.08
2020	27506.37	4099.453	19471.59 - 35541.15
2021	26785.15	4339.651	18279.59 - 35290.71

2022	27156.60	4591.089	18158.23 - 36154.97
2023	27806.96	4873.061	18255.93 - 37357.98

Moreover, it is also possible to compare the original and predicted plum production graphically as given in Figure-5.5. In the forecasted plot, in sample and out sample forecasting parts are shown. The original plum fruit production shows patterns initially up-ward tendency with effect from year 1980 to 2005 but after year-2005-06, it shows downward tendency rapidly. The forecasting for plum fruit production represents generally a downward tendency in the onward time period of ten years.

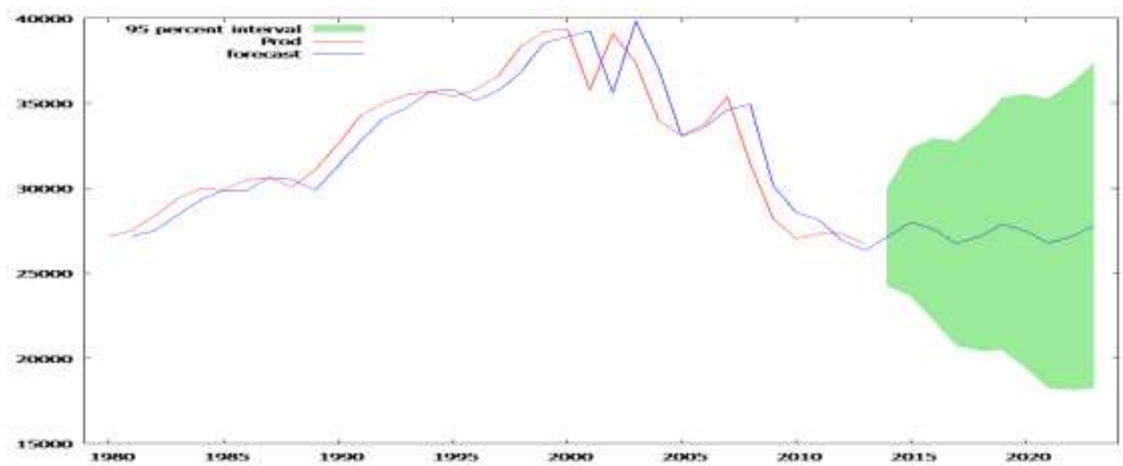

Figure-5.5:- Forecasting Plot for Plum Production

Conclusions and Recommendations:

The instant results suggest that the time series modeling for each major fruit production was appropriate and gave best forecast for onward ten years From the results of analyzed data it can be concluded that for each major fruit crop i.e. apple, citrus, peach, pear and plum the forecasting models ARIMA(0, 1, 0), ARIMA(2, 2, 2), ARIMA(0, 1, 3), ARIMA(2, 1, 2) and ARIMA(2, 1, 2) respectively were found adequate for forecasting purpose based on forecast evaluation criteria. Hence, it can be recommended that these selected models could be used by researchers, business men, policy makers and fruit producers for information, planning their resources as well as decision making regarding fruit production in Khyber Pakhtunkhwa. Also, at the same time Box-Jenkins ARIMA model give good representation of short time forecasting.

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