

Research Article



Forecasting the Fisheries Production in Pakistan for the Year 2017-2026, using Box-Jenkin's Methodology

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Abstract | Fisheries play a key role for national income and a source of food in Pakistan. Therefore, forecasting the production of fish is important for better production and for planning of fish export. Objective of this research is to propose suitable Autoregressive Integrated Moving Average (ARIMA) model for forecasting the production of fisheries, using Box-Jenkins's (1976) methodology. Secondary data, "50 years of Pakistan: volume-iii (1947-1997)" published by Pakistan Bureau of Statistics (PBS) and World Development Indicators World Bank (2016) from the year 1947- 2016 was used. After comparing all possible ARIMA model diagnostically, ARIMA (2, 1, 3) is the most parsimonious model with less forecast error. Forecast values for the fisheries production from 633.974 to 720.196 tons for the year 2017-2026 shows a significant increase in the fisheries production. The proposed ARIMA (2,1,3) model for forecasting is helpful for fish producers, researchers, business men, and planning their resources as well as decision making regarding the export and production of fisheries in Pakistan.

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Keywords | Autoregressive integrated moving average, Model, Error, Production, Forecast

Introduction

Fishing is an important source for the food and country economy, it is also a source of livelihood for the coastal population of the Pakistan. Fish is the cheap and most important source of animal protein for the human beings. With the increase in human population the demand for the food supply has increased. The requirement of fish and shell fish has been considerably increased because they are the excellent supply of protein. Globally people get 25% protein from fish and shell fish (Bahnasawy et al., 2009). In 2004 nearly 75% global fish was used

for straight human utilization, however in 1997 the demand increased to 57% and it will exceed to 98.6 % in 2020 (Retnam and Zakaria, 2010).

Fishing Sector contributes 3.25 percent growth in Agriculture for the year 2015-2016 and 5.75 percent growth for the year 2014-2015. In GDP fisheries share has very little but it adds through export earnings significantly to the country income. During the 2015-16 (July- March) through the fish export Pakistan earned US \$ 240.108 million, while for the 2014-15 (July-March), the export fish add US \$ 253.497 million amount to the national income. Major buyers

are China, Middle East, Thailand, Malaysia, Sri Lanka and Japan for the Pakistani fish, (Pakistan Economic Survey, 2015-16). To get the more income through fisheries and as the country population increase the demand for fish is increased. To meet the demand, better planning of fisheries production and its export management will be necessary for the country economy and fish producers. Knowledge about the production of fish in future is important for these aspects. A lot of research work is done for forecasting the different aspects of different fields during last thirty years, but a small work is done for forecasting the fisheries production in the world. It may be the first attempt to forecast the production of fisheries in Pakistan. We can predict future fish production by using the past years pattern of fish production. The objective of the study is to forecast fish production for the future applying suitable statistical model.

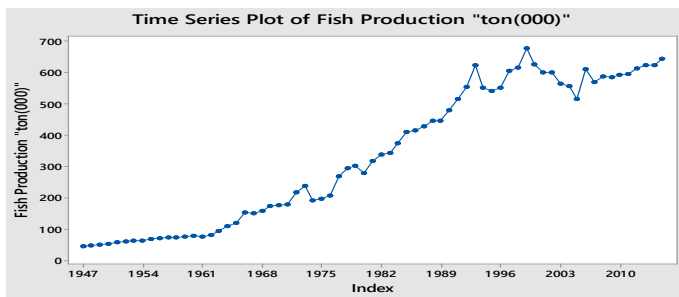


Figure 1: Time plot of the fisheries production.

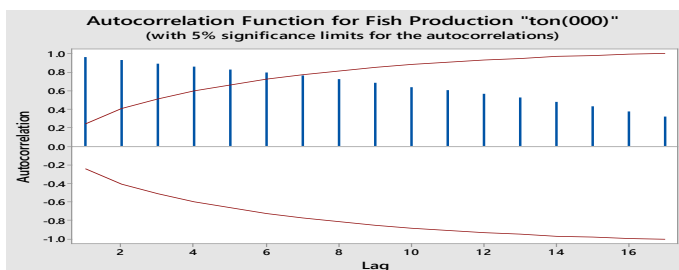


Figure 2: ACF plot for fisheries production.

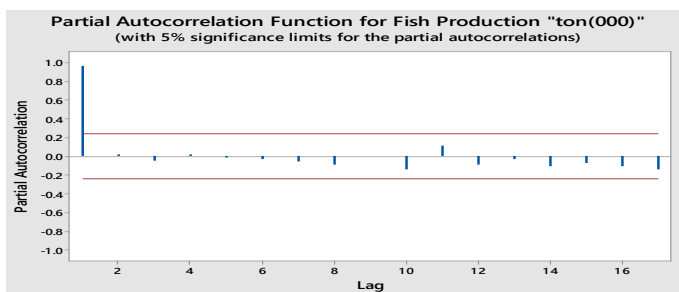


Figure 3: PACF plot of the fisheries production.

Materials and Methods

Statistical techniques and time series models are used for forecasting various phenomena of different fields

like economics, environment, meteorology, agriculture and fisheries. Secondary data, 50 years of Pakistan: volume-iii (1947-1997) published by Pakistan Bureau of Statistics (PBS) and World Development Indicators World Bank (2016) for Pakistan is used in this study. The data set covers the whole history of Pakistan and it ranges from 1947-2016.

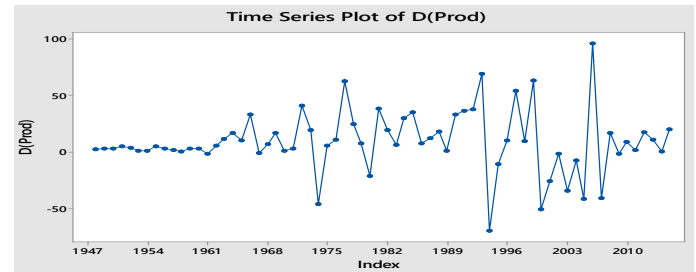


Figure 4: Plot of the first difference of production.

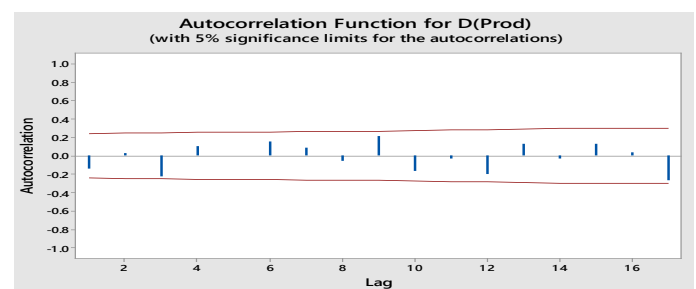


Figure 5: ACF plot of the first difference production.

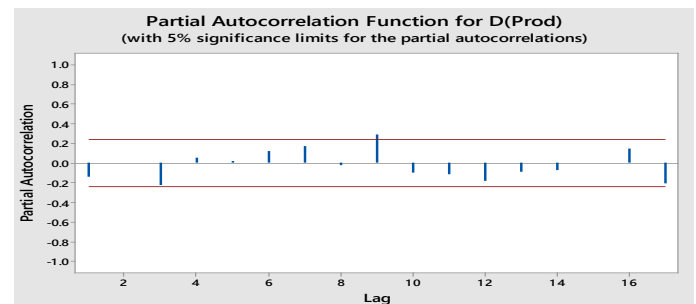


Figure 6: PACF plot of the first difference production.

Table 1: Augmented dickey fuller unit root test.

Variable	Observed ADF test	Lag level	1 st . Difference ADF test	Lag level	Order of integration
Production	-2.131817	0	-9.286278	0	I (1)

Various models have been developed to forecast future values; however, in univariate time series analysis Box-Jenkins's (1976) ARIMA model, due it's parsimonious and lowest forecast error is extensively used. Several researcher in Agriculture sectors used ARIMA model to forecast the production of different crops Muhammad et al. (1992), Allen (1994), Bajpai and Venugopalan (1996), Boken (2000), Masood and Javed (2004), Yaseen et al. (2005), Ullah et al. (2010),

Table 2: Diagnostic statistics of all possible ARIMA models.

ARIMA model	MSE	R square	MAPE	MAE	BIC	Box-pierce test	DF	P.Value
(1, 1,0)	734.0	0.985	6.935	18.623	6.723	24.699	17	0.102
(1, 1,1)	743.1	0.99	6.899	18.643	6.789	22.651	16	0.123
(2, 1, 0)	802,2	0.99	6.906	18.598	6.799	24.247	16	0.084
(2, 1, 1)	807.4	0.99	6.907	18.526	6.866	23.817	15	0.068
(2, 1, 2)	817.0	0.99	7.574	18.939	6.922	21.938	14	0.080
(2, 1, 3)*	726.6*	0.99*	7.126	18.891	6.974	20.533	13	0.083
(3, 1, 1)	795.0	0.99	7.213	18.788	6.913	17.496	14	0.231
(3, 1, 2)	774.2	0.99	7.225	18.794	6.991	17.263	13	0.188
(3, 1, 3)	751.4	0.99	7.143	18.452	7.012	12.984	12	0.370

Amin et al. (2014), Borkar (2016). Some authors used ARIMA model to forecast the fish production Venugopalan and Srinath (1998), Tsitsika et al. (2007), Karunarathna (2017).

ARIMA model is a most suitable form of stochastic models analyzing the stationary time series data. Usually data of time series are non stationary, by taking the difference of the time series data is converted easily into stationary. ARIMA model is the combination of autoregressive (AR) term, integrated (difference) term and moving average (MA) term, it is denoted by ARIMA (p, d, q) model, where p, d and q denote orders of auto-regressive (AR) model, difference and moving average (MA) model respectively. Generally autoregressive model of order (p) is of the form:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + u_t$$

Order of the difference “d” suggested through the Augmented Dickey Fuller (ADF) unit root test (1979) as.

$$Z_t = Y_t - Y_{t-d}$$

While moving average model of order (q) is of the form:

$$Y_t = \theta_1 \mu_{t-1} + \theta_2 \mu_{t-2} + \dots + \theta_q \mu_{t-q} + u_t$$

Then, the ARIMA (p, d, q) is:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + u_t + \theta_1 \mu_{t-1} + \theta_2 \mu_{t-2} + \dots + \theta_q \mu_{t-q}$$

Where;

Y_t is the production of fisheries at time t. $Y_{t-1}, Y_{t-2}, Y_{t-3}, \dots, Y_{t-p}$ are the lag values at time $t-1, t-2, \dots, t-p$ respectively. $u_t, u_{t-1}, \dots, u_{t-q}$, are the error terms and its

lag values, while the ϕ_1, \dots, ϕ_p are the coefficients of autoregressive model and $\theta_1, \dots, \theta_q$ are the coefficients of moving average model.

Table 3: Estimates of parameters of the ARIMA (2,1,3) models.

Type	Coefficient	S.E(Coef)	t(test)	P-value
AR(1)	-1.5380	0.2347	-6.55	0.000
AR(2)	-0.7454	0.1541	-4.84	0.000
MA(1)	-1.4794	0.1849	-8.00	0.000
MA(2)	-0.6964	0.1053	-6.62	0.000
MA(3)	0.1463	0.0731	2.00	0.050
Constant	27.789	9.911	2.80	0.007

Table 4: Forecast from year 2013-14 to year 2025-26 at 95% limits.l

Periods	Forecast	Lower limit	Upper limit	Actual	% forecast error
2013-14	625.876	573.031	678.721	623.022	-0.4560%
2014-15	616.491	543.914	689.068	623.457	1.1299%
2015-16	648.648	559.413	737.884	643.164	-0.8454%
2016-17	633.974	534.851	733.097		
2017-18	660.362	546.995	773.729		
2018-19	658.504	537.146	779.861		
2019-20	669.481	537.264	801.697		
2020-21	681.772	541.416	822.128		
2021-22	682.474	533.964	830.984		
2022-23	700.021	543.212	856.829		
2023-24	700.299	536.742	863.855		
2024-25	714.580	543.239	885.921		
2025-26	720.196	542.551	897.841		

Results and Discussion

Time plot for the production of the fisheries shows the trend, which indicate the original series is

non stationary, to make the stationary of the series graphs of autocorrelation function (ACF), partial autocorrelation function (PACF), and augmented dickey-fuller (ADF) of unit root test is constructed.

The stationary of the data is tested by both graphs and augmented dickey-fuller (ADF) unit root test. From the graphs of autocorrelation function (ACF), partial autocorrelation function (PACF), and augmented dickey-fuller (ADF) of unit root test, first difference is necessary to make the stationary of the above series. First order difference, $Z_t = Y_t - Y_{t-1}$ is taken from the observed data series of the fisheries production.

Graph of first difference of the original fisheries production shows the stationary of the data.

There is no negative spike in the graph of autocorrelation function, zero order of moving average (MA) model is suggested, and there is one positive spike in the graph partial autocorrelation function, first order of autoregressive (AR) model is considered. So, tentative autoregressive integrated moving average (ARIMA) model is ARIMA (1, 1, 0) is used. In this study best forecast ARIMA (p, d, q) model is chosen by comparing all possible fitted model diagnostically starting from ARIMA (1, 1, 0).

Mean square error is minimum and value of R-Square for the ARIMA (2, 1, 3) model is better than the other all possible ARIMA models. Box-Pierce (Ljung-Box) chi-square statistic is satisfy for the proposed model. Parameters of ARIMA (2, 1, 3) model given in Table 3 are also significant. As the series become stationary after the difference of first order, therefore it is written with the help of back shift operators.

$$(1 - B)(1 - \phi_1 B - \phi_2 B^2)Y_t = (1 - \theta_1 B - \theta_2 B^2 - \theta_3 B^3)e_t$$

$$Y_t = (1 + \phi_1)Y_{t-1} - (\phi_1 + \phi_2)Y_{t-2} - \phi_2 Y_{t-3} - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \theta_3 e_{t-3} + e_t$$

$$Y_t = (1 - 1.5380)Y_{t-1} - (-1.5380 - 0.7454)Y_{t-2} - (-0.7454)Y_{t-3} - (-1.4794)e_{t-1} - (-0.6964)e_{t-2} - 0.1463e_{t-3} + e_t$$

$$Y_t = -0.538Y_{t-1} + 2.2834Y_{t-2} + 0.7454Y_{t-3} + 1.4794e_{t-1} + 0.6964e_{t-2} - 0.1463e_{t-3} + e_t$$

By adding the constant term, it can be written as follows.

$$Y_t = 27.789 - 0.538Y_{t-1} + 2.2834Y_{t-2} + 0.7454Y_{t-3} + 1.4794e_{t-1} + 0.6964e_{t-2} - 0.1463e_{t-3} + e_t$$

After comparing all possible models ARIMA (2, 1, 3) is proposed as a best forecast model for fisheries production. Graphically diagnostic checks of

ARIMA (2, 1, 3) model in the Figures 7 and 8 are the residual plot for the autocorrelation and partial autocorrelation functions, which shows that all of the autocorrelations and partial autocorrelations lie between the 95% confidence interval. Normal probability plot for residuals in Figure 9 shows that the residuals lie along a straight line. From all the diagnostic checks the model is parsimonious and correctly specified.

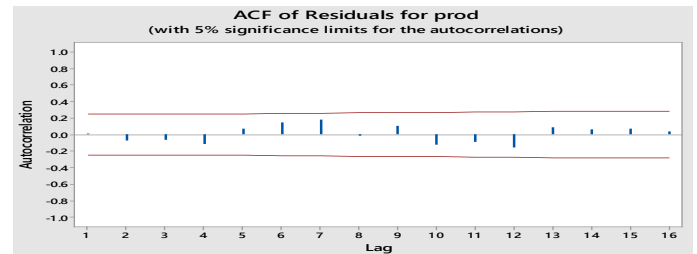


Figure 7: Plot of ACF of residual for production.

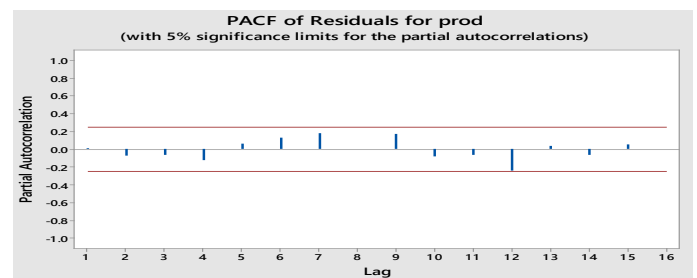


Figure 8: Plot of PACF of residual for production.

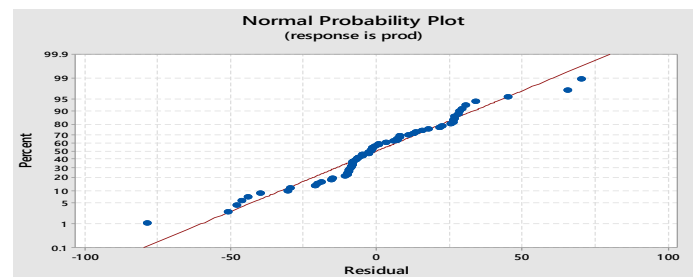


Figure 9: Residuals normal probability plot.

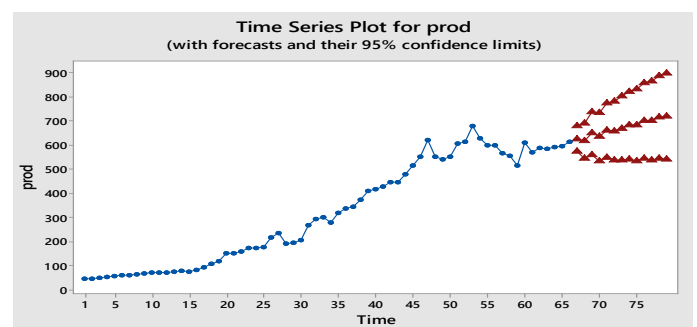


Figure 10: Time plot fisheries forecast production for year 2017-2026.

After specification of the adequate model it is necessary to utilize it for forecasting the fisheries production. In forecasting objective of research is to

predict the future values of the fisheries production for the year 2017-2026. Figure 10 shows the time plot for the forecast values of fisheries production and table number 4 provide the forecast values for the year 2017-2026 at 95% confidence interval.

Conclusions and Recommendations

Forecasting results of ARIMA (2, 1, 3) model, suggested through Box-Jenkin's Methodology are best for forecasting the production of fisheries for the year 2017-2026. Forecasting accuracy and comprehensiveness of different ARIMA models are also supported by Amin et al. (2014), Senol (2015) and Şenol and Sengul (2018). Forecast error -0.4560, 1.1299 and -0.8454 percent is very minimum for the proposed model. These forecasting results show a significant increase, from 619.624 to 724.750 tons of fisheries production from the year 2017-2026. The prediction of this study may provide help to policy makers make their macro-level policies for food security, better planning for the fisheries production and fish export policies to earn more national income. It also provides help, micro level policies for marine and inland fish production, to solve the problem of the coastal population of the Pakistan. Proposed ARIMA (1, 1, 0) model for forecasting is recommended for government exports, researchers, business men, and fish producers for information and planning their resources as well as decision making regarding the production of fisheries in Pakistan.

Author's Contribution

Qaisar Mehmood: Idea, complete write up and management of the research.

Maqbook Hussain Sial and Saira Sharif: Help in discussion of the results.

Abid Hussain: Help in data in selection of data.

Muhammad Riaz and Nargis Shaheen: Help in model fitting

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