Forecasting And Modelling Fish Production in Bangladesh Using ARIMA Model

LITON CHANDRA VOUMIK
Assistant Professor, Department of Economics, Noakhali Science and Technology University, Noakhali, Bangladesh.

Abstract-

- ***Background/ Objectives:***

Fish has excellent nutritional importance and provide high-quality protein and a spacious variety of vitamins and minerals. The fish production growth reflects the consumption of proper nutrition of a country. The fish sector is one of the top rising sectors in Bangladesh. A forecast of fish production can help the implementation of policies, strategies, and budgets to encourage entrepreneurs of food sectors within the target range. The famous forecasting method namely the ARIMA or autoregressive integrated moving average model applied in this study.

- ***Methods/ Statistical analysis:***

The purpose of the paper is to estimate the fish production growth rate (2019–2028). Secondary data analysis and forecast model are done for the available year and fish production data extracted from WDI, world bank database, and yearbook of fisheries statistics of Bangladesh and has been collected over 49 years. We applied ADF, PP, and KPSS tests to investigate the stationary character of the data. STATA and R studio software was applied to build a structure of the ARIMA method to model and forecast the fish production growth rates.

- ***Findings:***

In this study, the fish production of Bangladesh from 1970 to 2018 is modeled using ARIMA (P, I, Q) methodology. The forecast of the sample period (1970–2018) showed accuracy by the selected best ARIMA (0, 2, 1) model. The model and results were validated by the lowest values of AIC and BIC, fewer P-values, graphical arrangements of ACF, and PACF plots. Both of the post sample forecasts with ARIMA (0,2,1) showed an increasing trend of (2019–2028) fish production growth rate in Bangladesh. If the increasing trend persists, according to ARIMA (0.2.1) the forecast fish production rate for 2028 is 6013331 tons. Statistical outcomes illustrate that Bangladesh's fish production growth rate is an increasing trend that will continue growing in the future.

- ***Improvements/Applications:***

These findings will help policymakers, researchers, and academicians to formulate fish production-related strategies and policies more precisely.

Indexed Terms- Forecasting, ARIMA, fish production growth rate, National Fish Policy

I. INTRODUCTION

Fish is a significant basis of animal protein for millions of people in the world. Thousands of canals, ponds, rivers and other water bodies are available in Bangladesh. Also, the Bay of Bengal is one of the largest sources of fish. Bangladeshi people are notable for being a fish cultivating and eating nation. Around more than 60% of animal protein comes from fish through the consumption of yearly per head 18.1 kg fish (Belton et al. 2014) in Bangladesh. The fish production rate of Bangladesh gradually increases day by day due to its geographical position and rich in inland waters, river systems, a vast area in the Bay of Bengal and proper management truly supports fisheries sectors (Shamsuzzaman et al. 2017). The positive rate of fish production plays a vital role to contribute almost 3.69% in gross domestic product and 22.60% in agricultural sectors, which is essential for the sustainable growth of the national economy in Bangladesh (FRSS, 2016). Moreover, Bangladesh earns more than 2% export value through the export of different kinds of fish products in the USA, EU, Japan, China, Russia, Vietnam, Australia, India, Malaysia, and UAE (DoF, 2016). Apart from this, more than 100 fish processing industries and nearly more than 1.3

million women, and 17 million men directly depend on fish-related many sectors through farming, fishing, processing, and fish managing (BFTI, 2016). At the same time, nearly 85% of laborers in the fish processing industry are women (DoF, 2015). However, to earn more foreign currency through the fisheries sectors, to meet the demand of fish in the increased country population, and to increase the national economy need good future planning, which is very helpful to predict the future movement of fish production (Haque et al. 2005). For this purpose, time-series methodology especially the ARIMA method has been an ideal tool for forecasting the fish production rate shortly which is very helpful for decision making and sustainable management of fisheries sectors (Haque et al. 2005; Tsitsika et al. 2007; Raman et al. 2017; Mehmood et al. 2020). There are many research works in the world is done by using the ARIMA model for forecasting various aspects of different fields but very few research works have been conducted for forecasting fish production and this paper also attempted to forecast the fish production rate in Bangladesh. Consequently, the study predicts the fish production rate will increase shortly in Bangladesh by using the last five decades' sample of fish production. The main purpose of this research is to forecast the rate of fish production in Bangladesh in near future by using a suitable statistical model.

II. DATA PREPARATION

To forecast fish production growth, data on this macroeconomic variable was collected from 1970 to 2018 from the World Development Indicators (WDI), World Bank. It is a single set of data for modeling that was comprised of annual levels of fish production in metric tons for Bangladesh. The data set consists of 49 observations. A graphical representation of data reveals that the GDP series follows an increasing pattern over this period (Figure 1).

III. MODEL SPECIFICATION

For forecasting and modeling reasons famous ARIMA method was applied (Box and Jenkins, 1994). To test stationary or non-stationary we applied the most famous several unit roots tests. STATA and R-Studio software tools help us to scrutinize important characteristics of the data such as trend, season, and cycle. A simple ARIMA model can be expressed as

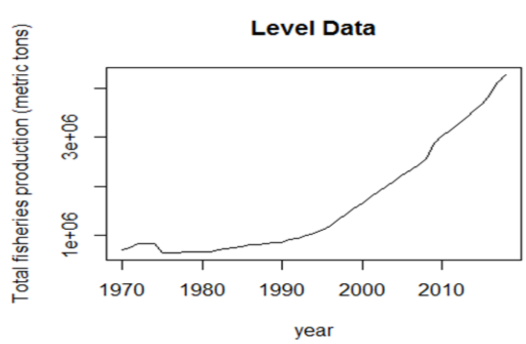
$$Y_t = \beta + \sum ø_p Y_{t-p} + \sum \theta_q \varepsilon_{t-q} \ldots \ldots (1)$$

where, Yt = Fish production in Bangladesh (metric tons) at period t, Yt-p= Fish production (metric tons) at period (t-p), θq = Random shock at period q, ε_{t-q} = Random error term at period t, and (β,øp, θq) are parameters to be estimated.

This model t is important because time trend is necessary. Y does not correlate with $Y_{t-1,}$ If the unit root is absent also differencing Y show a white-noise series in the output. (Salvatore & Reagle, 2002).

The Most standard notation of the ARIMA model is ARIMA (p,d,q). Here P is the number of autoregressive commands in the equation (1). Mainly this explains how many lags from the series are applied to forecast the future values this is autoregressive orders. d is here orders of differencing. Differencing is necessary to remove the non-stationary effects. If the time series data are a linear trend, the first order differencing needs to apply. On the other hand, if the data follows the quadratic trend, second-order differencing needs to apply. The number of moving average orders is defined by Q. Deviations from the mean of data are important to predict current and future values and it defines moving average (Jakasa et al, 2011). To build an ARIMA model stationarity is one of the compulsory conditions. When the series is non-stationary, the order of differencing (d) is estimated to reduce the series to stationary.

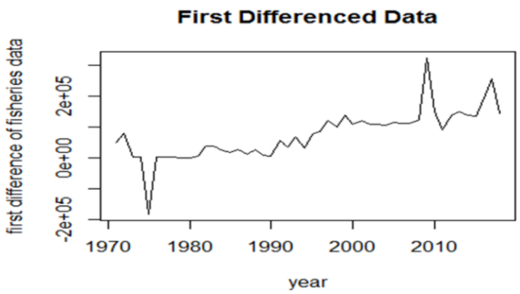
Figure 1. The fish production in Bangladesh over the five decades



Source: Authors' estimation

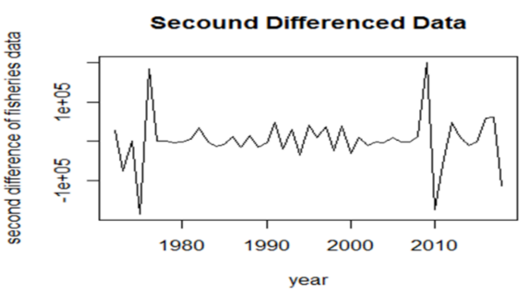
Figure 1 shows the total fish production size in Bangladesh over 49 years from 1970 to 2018. The figure was given as the value of the metric tons of fish production.

Figure 2. First Differences fish production Growth Rates in Bangladesh



Source: Authors' estimation

Figure 3. First Differences fish production in Bangladesh



Source: Authors' estimation

The above figure 1-3 shows that, various presentations of fish production (total fish production) data. figure 1 shows the level of data. On the other hand, figures 2 and 3 represent the first and second differences of data over time.

Finding the best model applying ADF Test:

> fit1 <- auto.arima(fishdata, trace=TRUE, test="adf", ic="aic")

Table1. Several ARIMA models and AIC values based on the ADF test

ARIMA (2,2,2)	: 1166.071
ARIMA (0,2,0)	: 1173.461
ARIMA (1,2,0)	: 1167.464
ARIMA (0,2,1)	: 1160.831
ARIMA (1,2,1)	: 1162.418
ARIMA (0,2,2)	: 1162.377
ARIMA (1,2,2)	: 1164.793

Best model: ARIMA (0,2,1)

> summary(fit1)
Series: fishdata
ARIMA (0,2,1)

Coefficients:
ma1
-0.6893
s.e. 0.1103

sigma^2 estimated as 2.887e+09: log likelihood=-578.42
AIC=1160.83 AICc=1161.1 BIC=1164.53

Training set error measures:
ME RMSE MAE MPE MAPE MASE ACF1
Training set 8465.061 52056.13 30018.11 0.3758178 2.598476 0.3646957 0.03810885
> jarque.bera.test(fit1$residuals)

Jarque Bera Test

data: fit1$residuals
X-squared = 142.75, df = 2, p-value < 2.2e-16

> Box.test(fit1$residuals, lag=10, type="Ljung-Box")

Box-Ljung test

data: fit1$residuals
X-squared = 3.5417, df = 10, p-value = 0.9657

Finding the best model applying PP Test:
> fit2 <- auto.arima(fishdata, trace=TRUE, test="pp", ic="aic")

Table2. Several ARIMA models and AIC values based on the PP test

ARIMA (2,2,2)	: 1166.071
ARIMA (0,2,0)	: 1173.461
ARIMA (1,2,0)	: 1167.464
ARIMA (0,2,1)	: 1160.831

ARIMA (1,2,1)	: 1162.418
ARIMA (0,2,2)	: 1162.377
ARIMA (1,2,2)	: 1164.793

Best model: ARIMA (0,2,1)

```
> summary(fit2)
Series: infantdata
ARIMA(0,2,1)

Coefficients:
         ma1
     -0.6893
s.e.  0.1103

sigma^2 estimated as 2.887e+09:  log likelihood=-578.42
AIC=1160.83   AICc=1161.1   BIC=1164.53

Training set error measures:
              ME    RMSE     MAE     MPE    MAPE
MASE       ACF1
Training set 8465.061 52056.13 30018.11 0.3758178
2.598476 0.3646957 0.03810885
> jarque.bera.test(fit2$residuals)

        Jarque Bera Test

data:  fit2$residuals
X-squared = 142.75, df = 2, p-value < 2.2e-16

> Box.test(fit2$residuals,lag=10, type="Ljung-Box")

        Box-Ljung test

data:  fit2$residuals
X-squared = 3.5417, df = 10, p-value = 0.9657
```

Finding the best model applying KPSS test:

```
> fit3 <- auto.arima(fishdata, trace=TRUE, test="kpss", ic="aic")
```

Table 3. Several ARIMA models and AIC values based on the KPSS test

ARIMA (2,2,2)	: 1166.071
ARIMA (0,2,0)	: 1173.461
ARIMA (1,2,0)	: 1167.464
ARIMA (0,2,1)	: 1160.831
ARIMA (1,2,1)	: 1162.418
ARIMA (0,2,2)	: 1162.377
ARIMA (1,2,2)	: 1164.793

Best model: ARIMA (0,2,1)

From table 1 to table 3, we got that ARIMA (0,2,1) is the most appropriate model, because of the lowest AIC value. So, we are going to apply this model in this work.

```
> summary(fit3)
Series: fishdata
ARIMA(0,2,1)

Coefficients:
         ma1
     -0.6893
s.e.  0.1103

sigma^2 estimated as 2.887e+09:  log likelihood=-578.42
AIC=1160.83   AICc=1161.1   BIC=1164.53

Training set error measures:
              ME    RMSE     MAE     MPE    MAPE
MASE       ACF1
Training set 8465.061 52056.13 30018.11 0.3758178
2.598476 0.3646957 0.03810885
> jarque.bera.test(fit3$residuals)

        Jarque Bera Test

data:  fit3$residuals
X-squared = 142.75, df = 2, p-value < 2.2e-16

> Box.test(fit3$residuals,lag=10, type="Ljung-Box")

        Box-Ljung test

data:  fit3$residuals
X-squared = 3.5417, df = 10, p-value = 0.9657
```

Based on table 1-3, we got ARIMA (0,2,1) is the best model, because the AIC values are the minimum in all tables.

```
> forecasted.data1=forecast(fit1, h=10) # fit an ARIMA(0,2,1) model
> forecasted.data1
```

Table 4. Point forecasting for the next 10 years using ARIMA (0,2,1)

year	Forecasted values	Lo 80	Hi 80	Lo 95	Hi 95
2019	4450310	4381456	4519164	4345007	4555613
2020	4623979	4510467	4737491	4450378	4797580
2021	4797648	4638439	4956857	4554159	5041137
2022	4971317	4763848	5178787	4654020	5288614
2023	5144986	4886358	5403614	4749449	5540523
2024	5318655	5005930	5631380	4840383	5796927
2025	5492324	5122615	5631380	4926903	6057746
2026	5665993	5236497	5862033	5009136	6322851
2027	5839662	5347669	6095489	5087223	6592102
2028	6013331	5456220	6570443	5161302	6865360

Source: Author's estimation

Table 4 shows the point forecasting from ARIMA (0,2,1) based on ADF, PP, and KPSS tests.

Figure 4. fish production growth rate forecasting for 10 years

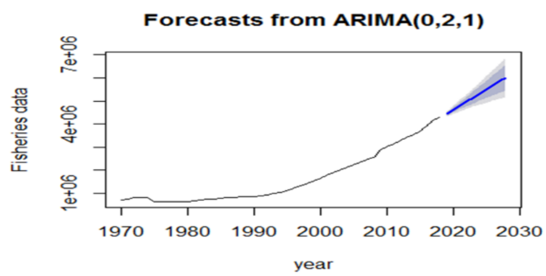
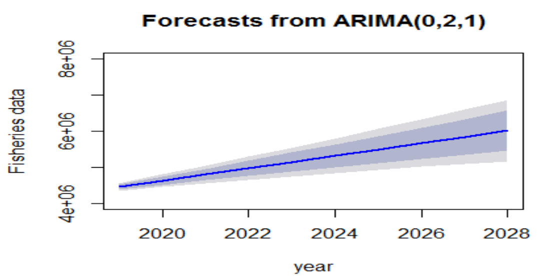


Figure 5. fish production growth rate forecasting for 10 years



Source: Author's estimation

In figures 4 and 5, forecasted growth lines are illustrated for the next ten years with an ARIMA (0,2,1) model. In the forecasted line illustrated in figure 4 and figure 5, the upper and lower bounds are included. Both figures show that the total fish production in the future follows an upward trend. So, it is clear that Bangladesh can produce, export, and consume more fish soon. Fish sectors can support to boost health and economic development if the predicted upward growth rate will remain to continue.

CONCLUSION

In the current study, around five decades of fish production time series data were used to forecast for the next 10 years. The forecasted data, based on ARIMA (0,2,1) showed that the fish production rate would increase from 36% in 2019 to 2028; unless and until more strict fish production control policies and strategies are implemented in Bangladesh. When we will get data for other years, the model can be checked for validity and probably more accurate forecasts can be performed. Overall, in this study, the ARIMA (0,2,1) model is the appropriate and suitable model to forecast fish production growth for the next decades. Among the several ARIMA models, the AIC and BIC's values for this model are the minimum. Also, P-value determines the significance of our model. Bangladesh is currently facing protein deficiency. It is recommended that government should take various policies so that total fish production will touch the total fish demand. The increasing fish production growth rates show that Bangladesh will be able to produce more fish and assemble with the total fish require. The more production of fish can play a significant and positive role in improving public health. This sector will also create more job opportunities. All findings are particularly essential for the government of Bangladesh as well as other organizations, particularly when it comes to planning for the upcoming decades. Though we forecasted fish production growth rates for one decade, it is suggested that researchers should be aware of when forecasting for more than 5 years.

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